MANAGEMENT RECOMMENDATIONS FOR WASHINGTON'S PRIORITY SPECIES – VOLUME IV: BIRDS

Washington
Department of
FISH and
WILDLIFE

Eric M. Larsen, Jeffrey M. Azerrad, and
Noelle Nordstrom, Technical Editors

May 2004

Management Recommendations for Washington's Priority Species

Volume IV: Birds

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Washington Department of Fish and Wildlife
600 Capitol Way N
Olympia, WA 98501-1091

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ACKNOWLEDGMENTS

INTRODUCTION

Fish and wildlife are public resources. Although the Washington Department of Fish and Wildlife (WDFW) is charged with protecting and perpetuating fish and wildlife species, the agency has very limited authority over the habitat on which animals depend. Instead, protection of Washington's fish and wildlife resources is currently achieved through voluntary actions of landowners and through the State Environmental Policy Act (SEPA), Growth Management Act (GMA), Forest Practices Act (FPA), Shoreline Management Act (SMA), and similar planning processes that primarily involve city and county governments. Landowners, agencies, governments, and members of the public have a shared responsibility to protect and maintain fish and wildlife resources for present and future generations; the information contained in this document is intended to assist all entities in this endeavor.

The Washington Department of Fish and Wildlife has identified those fish and wildlife resources that are a priority for management and conservation. Priority habitats are those habitat types with unique or significant value to many fish or wildlife species. Priority species are those fish and wildlife species requiring special efforts to ensure their perpetuation because of their low numbers, sensitivity to habitat alteration, tendency to form vulnerable aggregations, or because they are of commercial, recreational, or tribal importance. Descriptions of those habitats and species designated as priority are published in the Priority Habitats and Species (PHS) List.

PHS Management Recommendations

The department has developed management recommendations for Washington's priority habitats and species to provide planners, elected officials, landowners, and citizens with comprehensive information on important fish, wildlife, and habitat resources. These management recommendations are designed to assist in making land use decisions that incorporate the needs of fish and wildlife. Considering the needs of fish and wildlife can help prevent species from becoming extinct or increasingly threatened and may contribute to the recovery of species already imperiled.

Agency biologists develop management recommendations for Washington's priority habitats and species through a comprehensive review and synthesis of the best scientific information available. Sources include professional journals and publications, symposia, reference books, and personal communications with professionals on specific habitats or species. Management recommendations are reviewed within the Department and by other resource professionals and potential users of the information. The recommendations may be revised if scientists learn more regarding a priority habitat or priority species.

Because PHS management recommendations address fish and wildlife resources statewide, they are generalized. Management recommendations are not intended as site-specific prescriptions but as guidelines for planning. Because natural systems are inherently complex and because human activities have added to that complexity, management recommendations may have to be modified for on-the-ground implementation. Modifications to management recommendations should strive to retain or restore characteristics needed by fish and wildlife. Consultation with fish and wildlife professionals is recommended when modifications are being considered.

The locations of priority habitats and species are mapped statewide. The maps represent WDFW's best knowledge of Washington State's fish and wildlife resources based on research and field surveys conducted over the past 20 years. Management recommendations should be addressed whenever priority habitats and species occur in a particular area whether or not the WDFW maps show that occurrence. These maps can be used for initial assessment of fish and wildlife resources in an area, but they should also be supplemented with a field survey or local knowledge to determine the presence of priority habitats or priority species. The PHS data show WDFW's knowledge of important fish and wildlife resources but cannot show the absence of these resources.

In summary, management recommendations for Washington's priority habitats and species...

Are:	**Are not:**
Guidelines	Regulations
Generalized	Site specific
Updated with new information	Static
Based on fish and wildlife needs	Based on other land use objectives
To be used for all occurrences	To be used only for mapped occurrences

Goals

Management recommendations for Washington's priority habitats and species are guidelines based on the best available scientific information and are designed to meet the following goals:

- Maintain or enhance the structural attributes and ecological functions of habitat needed to support healthy populations of fish and wildlife.
- Maintain or enhance populations of priority species within their present and/or historical range in order to prevent future declines.
- Restore species that have experienced significant declines.

Format

Management recommendations for each priority species are written in six primary sections:

General Range and Washington Distribution – Summarizes information on the geographic extent of the species in Washington and throughout its range.

Rationale – Outlines the basis for designating the species as priority.

Habitat Requirements – Delineates the species' known habitat associations.

Limiting Factors – Specifies factors that may limit the species' distribution and abundance in Washington.

Management Recommendations – Provides management guidelines based on a synthesis of the best available scientific information.

Key Points – Summarizes the most important elements of the species' biology and associated management recommendations.

Management recommendations for Washington's priority habitats and species are intended to be used in conjunction with mapped and digital data which display important fish, wildlife, and habitat occurrences statewide. Data can be obtained by calling the PHS Data Request Line at (360) 902-2543. For more information visit the PHS Website at http://wdfw.wa.gov/hab/phspage.htm. Questions and requests for additional PHS information may be directed to:

> Priority Habitats and Species
> WDFW Habitat Program
> 600 Capitol Way N
> Olympia, WA 98501-1091

SPECIES STATUS DEFINITIONS

State Listed and Candidate Species

State Endangered - Any wildlife species native to the state of Washington that is seriously threatened with extinction throughout all or a significant portion of its range within the state. Endangered species are legally designated in WAC 232-12-014.

State Threatened - Any wildlife species native to the state of Washington that is likely to become endangered within the foreseeable future throughout a significant portion of its range within the state, without cooperative management or the removal of threats. Threatened species are legally designated in WAC 232-12-011.

State Sensitive - Any wildlife species native to the state of Washington that is vulnerable or declining and is likely to become endangered or threatened in a significant portion of its range within the state, without cooperative management or the removal of threats. Sensitive species are legally designated in WAC 232-12-011.

State Candidate - Wildlife species that are under review by the Department for possible listing as endangered, threatened or sensitive. A species will be considered for State Candidate designation if sufficient evidence suggests that its status may meet criteria defined for endangered, threatened or sensitive in WAC 232-12-297. Currently listed State Threatened or State Sensitive species may also be designated as State Candidate species if evidence suggests that their status may meet criteria for a higher listing of State Endangered or State Threatened. State Candidate species will be managed by the Department, as needed, to ensure the long-term survival of populations in Washington.

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE REGIONAL CONTACTS

For assistance with PHS information specific to your county, contact the following WDFW representative.

If you live in...   Contact...

Asotin, Columbia, Ferry, Garfield, Lincoln,   Kevin Robinette
Pend Oreille, Spokane, Stevens, Walla Walla, Whitman   8702 N. Division St.
                                                                     Spokane, WA 99218-1199
                                                                     Phone: (509) 456-4082

Adams, Chelan, Douglas, Grant, Okanogan   Tracy Lloyd
                                                                     1550 Alder St. NW
                                                                     Ephrata, WA 98823-9699
                                                                     Phone: (509) 754-4624

Benton, Franklin, Kittitas, Yakima   Ted Clausing
                                                                     1701 24th Ave.
                                                                     Yakima, WA 98902-5720
                                                                     Phone: (509) 575-2740

Island, King, San Juan, Skagit, Snohomish, Whatcom   Rich Costello
                                                                     16018 Mill Creek Blvd.
                                                                     Mill Creek, WA 98012
                                                                     Phone: (206) 775-1311

Clark, Cowlitz, Klickitat, Lewis, Skamania, Wahkiakum   Steve Manlow
                                                                     2108 Grand Blvd.
                                                                     Vancouver WA 98661
                                                                     Phone: (360) 696-6211

Clallam, Grays Harbor, Jefferson, Kitsap, Mason, Pacific, Pierce,   Steve Kalinowski
Thurston   48 Devonshire Rd.
                                                                     Montesano, WA 98563
                                                                     Phone: (360) 249-4628

Common Loon
Gavia immer

Last updated: 1999

Written by Jeffrey C. Lewis, Ruth Milner, and Morie Whalen

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Common loons breed in North America from the Aleutian Islands and Bering Sea coasts, east throughout Canada and south to the northern tier of the lower 48 United States. In western North America, common loons winter along the Pacific coast from southern Alaska to Baja California.

Migrant loons arrive from the north to winter along Washington's coast, the Columbia and Snake rivers, and on lakes in northeastern Washington. Summer populations are very small (see Figure 1). Single breeding pairs have been confirmed on lakes in King, Whatcom, Chelan, Ferry, and Okanogan counties.
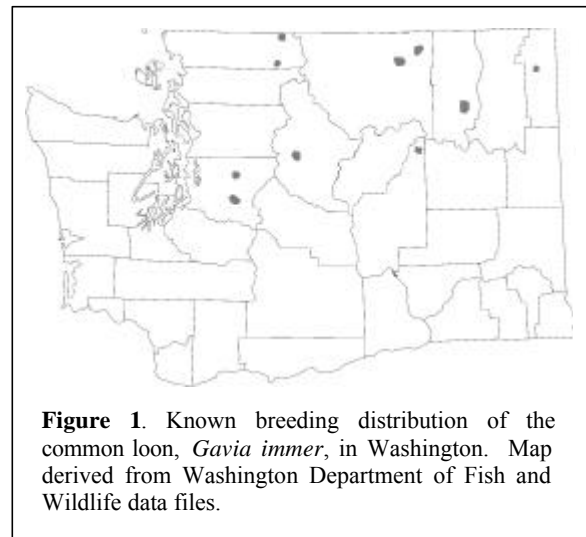

Figure 1. Known breeding distribution of the common loon, *Gavia immer*, in Washington. Map derived from Washington Department of Fish and Wildlife data files.

RATIONALE

The common loon is a State Candidate species. This species is vulnerable to shoreline alteration and development, fluctuation of water levels during nesting (e.g., reservoir draw downs and filling), human disturbance in the vicinity of nesting areas, and encroachment by logging and road building.

HABITAT REQUIREMENTS

Nesting and Brood Rearing

Common loons breed on larger lakes (>12 ha [29.6 acres] in Alaska; Ruggles 1994) in forested areas and nest on shorelines of islands and the mainland. Nesting also may occur within 1.5 m (5 ft) of shore on masses of emergent vegetation (Vermeer 1973, Strong et al. 1987). Loons may use several types of nests, including nests constructed of vegetation; nests located on hummocks, stumps, and beaver lodges; artificial platforms; and nests scraped out of sand, gravel, or leaves (Belant and Anderson 1991). Several studies have shown that loons prefer to nest on islands (Vermeer 1973, McIntyre 1975, Ream 1976, Titus and Van Druff 1981), and breeding success may be higher on insular sites (McIntyre and Mathisen 1977, Titus and Vandruff 1981). Nest site fidelity has been reported (Strong et al. 1987). In Alaska, reproductive pairs were often found on lakes that were hydrologically connected to other lakes, had medium to high macrophyte cover, and had >50% of the shoreline suitable as nesting habitat (Ruggles 1994). Brood or nursery habitat used by adults and loon chicks is comprised of shallow, protected areas of lakes with abundant aquatic vegetation near the shore (McIntyre 1983).

Feeding

Common loons require a healthy fish population on which to feed. Studies of loon feeding habits on their breeding grounds are limited, though Vermeer (1973) found that lakes where breeding loons were present were also used by successful anglers. Common loons were absent from many lakes and sloughs that offered poor fishing to anglers.

LIMITING FACTORS

Loon abundance and reproductive success is dependent upon the availability of undisturbed shoreline or island nesting sites. Fluctuations of water levels and other disturbances at nest sites have been responsible for nest failures, and therefore limit reproductive success. Protection of the forage base and water quality is essential.

Human Impacts

Heavy recreational use may be a key factor in the decline of loon productivity because the birds are susceptible to disturbance during nesting. Titus and Vandruff (1981) found that loons nesting on lakes where motorboats were absent had greater egg-hatching rates than those nesting on lakes where motorboats occurred. Vermeer (1973) found more breeding pairs in areas with fewer resorts, cottages, and campsites. Heimberger et al. (1983) showed that breeding success declined as the number of cottages within 150 m (492 ft) of nests increased. Lake size may affect the influence human disturbance has on loon nesting. Some studies have shown that loons have equal or greater reproductive success on larger lakes with substantial human disturbance than smaller lakes with little or no human disturbance (Jung 1991, Caron and Robinson 1994, Ruggles 1994). It appears that loons may acclimate to heightened disturbance levels while occupying the greater number of undisturbed coves and bays of larger lakes.

Loons appear susceptible to heavy metal poisoning (especially mercury in low pH lakes) through consumption of contaminated fish (Scheuhammer and Blancher 1994, Meyer et al. 1995). Fortunately, much of this mercury is sequestered into feathers during the molt and shed in the succeeding molt (Burger et al. 1994). However, heightened levels of mercury can negatively affect loon reproductive success (Burger et al 1994, Scheuhammer and Blancher 1994, Meyer et al. 1995).

MANAGEMENT RECOMMENDATIONS

Protection of loons and their habitat during pair-bonding, egg laying, and initial brood rearing (1 April through 15 July) is important for reproductive success. Brood-rearing areas or nurseries are also important to protect after 15 July. Because common loons may re-use nests from year to year, protection of known nesting and brood-rearing areas is essential. Camping on islands can adversely affect loon productivity and may cause nest abandonment (Ream 1976). Campers and other visitors should be prevented from approaching within 150 m (492 ft) of nesting sites from 1 April through 15 July. A 150 m (492 ft) disturbance buffer is also recommended for brood-rearing areas (nursery pools) from 15 July to 1 September (R. Spencer, personal communication). Building within 150 m (492 ft) of a loon nest should be avoided year-round to maintain a permanent buffer around nests.

The absence of suitable nesting islands may limit the breeding activity of common loons. In areas where natural islands are unavailable, artificial islands can be provided. McIntyre and Mathisen (1977) created nesting islands by obtaining sedge mats from boggy lakes and binding the mats' edges with poles. Cedar log rafts were also found to be effective. Artificial nest sites have been used in Washington, primarily in reservoirs with fluctuating water levels (R. Spencer, personal communication). As breeding pairs of loons are not abundant in Washington, protection of all nest sites is important. Consequently, reservoirs where loons nest should maintain constant water levels when loons are laying and incubating eggs (a 30 day period).

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PERSONAL COMMUNICATIONS

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Washington Department of Fish and Wildlife
Mill Creek, Washington

KEY POINTS

Habitat Requirements

- Common loons breed on large lakes in forested areas.
- A healthy fish population is required as a prey base.
- Nests are situated on shorelines, islands, or floating structures within 1.5 m (5 ft) of shore.
- Nests may be constructed on emergent vegetation, and nest sites may be reused.
- Common loons are very susceptible to nest disturbance. They are intolerant of recurrent disturbance within 150 m (492 ft) of nest sites.

Management Recommendations

- Protect known nest and nursery sites.
- Restrict disturbance of nest sites from 1 April to 15 July and brood-rearing nursery pools from 15 July to 1 September. Maintain a 150 m (492 ft) disturbance buffer around brood-rearing areas (nursery pools) from 15 July to 1 September.
- Erect no structures within 150 m (492 ft) of nesting sites. Avoid building within this distance year round to maintain a permanent buffer around nests.
- Provide artificial nesting islands (e.g., sedge mats and cedar log rafts) where appropriate (e.g., reservoirs).
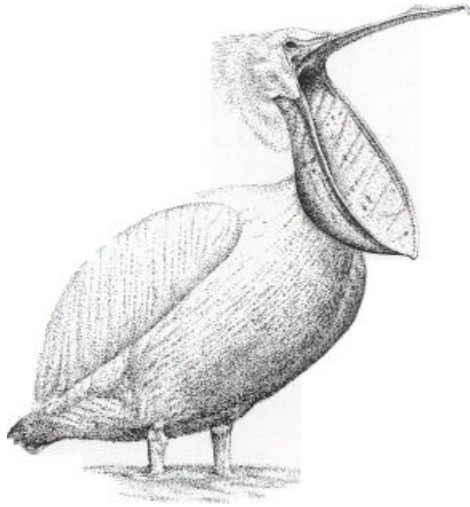
American White Pelican
Pelecanus erythrorhynchos

Last updated: 1998

Written by Patrick J. Doran, Morie Whalen, Karen Riener, and Lisa Fitzner

GENERAL RANGE AND WASHINGTON DISTRIBUTION

American white pelicans occur throughout the western, central, and southern parts of North America. These pelicans are colonial nesters, breeding primarily in the western and central United States and Canada, and wintering along the southern coast of the United States and in Mexico. Canada supports the largest population of breeding American white pelicans, with colonies located in Alberta, British Columbia, Manitoba, Ontario, and Saskatchewan. In the United States, breeding colonies are located in California, Colorado, Idaho, Minnesota, Montana, Nevada, North Dakota, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming (Ackerman 1994; Sidle et al. 1985; J. Annear, personal communication).

Figure 1. Range of the American white pelican, Pelecanus erythrorhynchos, in Washington. Map derived from Washington Department of Fish and Wildlife data files.

The population can be roughly split into 2 groups based upon differences in their ranges. The western group, which includes American white pelicans occurring in Washington state (see Figure 1), breeds to the west of the Rocky Mountains and winters along the Pacific Coast from central California to Mexico, mainly along Baja California and the western coast of Mexico (U. S. Fish and Wildlife Service 1984). Additionally, small numbers of American white pelicans winter on inland waters in Oregon and Washington (U. S. Fish and Wildlife Service 1984; L. Fitzner, personal communication; R. Friesz, personal communication). The migratory route of the western population takes in all states west of the continental divide and Mexico (U. S. Fish and Wildlife Service 1984).

Historically, American white pelicans were known to occur and presumed to have bred in eastern Washington on inland waters such as Sprague and Moses Lakes (Dawson and Bowles 1909). The first nesting record is from 1926 at Moses Lake, Grant County (Brown 1926). Jewett et al. (1953) stated that the Moses Lake colony continued for several years. From 1926 through 1994 there were no published records of American white pelicans breeding in Washington. In 1994 a breeding colony was established on Crescent Island, which was constructed for nesting birds in the Columbia River, Walla Walla County in 1985 (Ackerman 1994). American white pelicans have continued to nest on Crescent Island up to the date of this publication. In 1994 an estimated 30 nests produced approximately 50 juveniles, and in 1996 an estimated 25 nests produced approximately 35 young (Ackerman 1997). Nests and young were not counted in 1995. However, breeding was confirmed on the island and numbers were estimated to be similar to those in 1994 (Ackerman 1997). In 1997, the colony initiated nesting on nearby Badger Island. After high water

destroyed some of the nests, a portion of the colony returned to Crescent Island and initiated a second nesting attempt. At the time of this publication, American white pelicans were nesting on both Badger and Crescent Islands (Ackerman 1997).

In addition to the breeding colonies present on Crescent and Badger Islands, the inland waters of eastern Washington support a significant number of non-breeding American white pelicans throughout the year. Non-breeding American white pelicans can be found along the Columbia River from the Dalles through Chief Joseph pool. Numbers of these pelicans vary greatly during the summer, with peaks of up to 2000 birds observed in the potholes region of the Columbia Basin during late summer (R. Friesz, personal communication; J. Tabor, personal communication). Numbers of summer residents have declined substantially since 1990 (L. Fitzner, personal communication). Wintering concentrations, ranging from 40-300 birds, occur along the Columbia River from the mouth of the Walla Walla River to Priest Rapids (L. Fitzner, personal communication; E. Nelson, personal communication). Therefore, areas within Washington state may play an important regional role in sustaining non-breeding summer residents and birds which have dispersed from their breeding grounds in adjacent states and provinces.

RATIONALE

The American white pelican is a State Endangered species. In Washington, colonies of American white pelicans have disappeared from historical breeding areas (Dawson and Bowles 1909, Johnsgard 1955). Currently, only one breeding colony exists in Washington (Ackerman 1994, 1997). Suitable nesting habitat that is free from human disturbance is rapidly declining (Motschenbacher 1984), thus there are few opportunities for breeding populations of American white pelicans to become reestablished. Additionally, non-breeding and wintering populations occur in Washington throughout the year (R. Friesz, personal communication; L. Fitzner, personal communication).

HABITAT REQUIREMENTS

American white pelicans are colonial nesters that breed most often on isolated islands in freshwater lakes and occasionally on isolated islands in rivers. Islands free from human disturbance, mammalian predators, flooding, and erosion are required for successful nesting (U. S. Fish and Wildlife Service 1984, Koonz and Rakowski 1985). At 11 American white pelican breeding sites near Washington state, Motschenbacher (1984) reported a minimum nest island size of 0.3 ha (0.75 ac). The United States Fish and Wildlife Service (USFWS) recommends a minimum nest island size of 0.4 ha (1.0 ac) (U.S. Fish and Wildlife Service 1984). Preferred nesting substrates include gravel, sand, and soil (Evans and Knopf 1993). American white pelicans have also been known to nest on rocky outcroppings and dense stands of aquatic vegetation (e.g., hardstem bulrush [*Scirpus lacustris*]) (U. S. Fish and Wildlife Service 1984; Motschenbacher 1984). If vegetation is present within the nesting colony, it primarily consists of grasses, forbs, and shrubs (U. S. Fish and Wildlife Service 1984). At the Crescent Island colony in Washington, American white pelicans placed their nests on bare ground under willows (S. Ackerman, personal communication). Similar sites are used for loafing by both breeding and non-breeding birds.

American white pelicans require shallow water for foraging. Most feeding occurs between water depths of 0.3-2.5 m (1-8.3 ft) (Anderson 1991). Feeding mostly takes place along lake or river edges, in open areas within marshes, on or below rapids, and occasionally in deep waters of lakes and rivers (Evans and Knopf 1993). American white pelicans feed largely on nongame or "rough" fish, amphibians, and crustaceans (Brittell et al 1976, Lingle and Sloan 1980). Hall (1925) reported that adult pelicans consume 1.8 kg (4.8 lbs) of food per day. Therefore, an abundant prey base predominantly consisting of warm water fish is essential for American white pelican survival (Smith et al. 1984). Although foraging sites close to their breeding area are more advantageous than ones further away, American white pelicans are known to travel 50-80 km (31-50 mi) from nesting colonies to feed (Motschenbacher 1984, U.S. Fish and Wildlife Service 1984).

LIMITING FACTORS

The USFWS identifies 3 major factors that limit the success of breeding and non-breeding American White pelican populations: habitat destruction, utilization of wetlands and lakes for other purposes (e.g., irrigation, hydroelectricity, waterfowl production), and intentional or unintentional human disturbance of nesting colonies. They also cite several other potential factors that may limit American white pelican populations, including decreases or fluctuations in food supply and availability, shooting, mammalian predation at breeding colonies (especially coyotes), pesticide contamination, and powerline collisions (U.S. Fish and Wildlife Service 1984).

Habitat destruction and human disturbance appear to be the most important factors limiting American white pelican populations in Washington (Motschenbacher 1984). Currently, all 5 sites where breeding colonies were thought to have historically been located no longer exist or are in areas of high human activity (Motschenbacher 1984). Additionally, pool fluctuations on the Columbia River and other water bodies, which result in inconsistent water depths, may adversely affect habitat quality. Finally, American white pelicans are susceptible to pesticides and other toxic contaminants. Organochlorine pesticide residues and mercury concentrate in adult tissues and in pelican eggs (Evans and Knopf 1993). Aquatic pollution contribute to accumulations of toxic compounds in warm water fish species, which can adversely affect pelicans (Boellstorff et al. 1985; L. Blus, personal communication).

MANAGEMENT RECOMMENDATIONS

In Washington, management of American white pelican populations should focus on protection of breeding colonies and protection of feeding and loafing areas of both breeding and non-breeding birds.

Disturbance

Disturbance of nesting colonies may result in: abandonment of nests and colonies; egg breakage; depredation of nests by avian predators; exposure of young to temperature stress; and trampling of young (U. S. Fish and Wildlife Service 1984). In order to reduce the impacts of human disturbance at nesting sites, mangers should:

- Close nest islands to trespass during the breeding season from 15 March through 31 August (U. S. Fish and Wildlife Service 1984).
- Establish a buffer zone of 400-800 m (0.25-0.5 mi) and up to 1600 m (1.0 mi) from the nesting island which is closed to human activity such as boating (especially power boating), fishing, water skiing, discharge of fire arms, wildlife observation (Knopf 1975, U. S. Fish and Wildlife Service 1984).
- Restrict air traffic to an altitude of 610 m (2000 ft) above breeding colonies to reduce disruption of nesting (U. S. Fish and Wildlife Service 1984).
- Close channels with dikes to restrict boating/fishing in breeding areas, creating sanctuaries.
- Retain stable water levels during the nesting season so that flood waters do not inundate nests, and low water levels do not allow the emergence of mainland to island bridges that can be crossed by predators (Findholt and Diem 1988).
- Protect nesting areas and potential nesting islands from mammalian predators such as coyotes (U. S. Fish and Wildlife Service 1984).

In addition to protecting active nest colonies, such as the Crescent and Badger Island sites, land managers should identify and protect loafing/roosting and feeding areas of both breeding and non-breeding birds. The availability of adequate foraging areas is also vital to the success of American white pelican populations. These pelicans are known to commute between 50-80 km (31-50 mi) between nesting and foraging sites (U. S. Fish and Wildlife Service 1984). In areas surrounding American white pelican colonies or in primary feeding areas for non-breeding, wintering, or migrating birds, managers should:

- Identify and survey American white pelican foraging areas to determine presence and abundance of fish species that may serve as a prey base for pelican populations (U. S. Fish and Wildlife Service 1984).

- Maintain and manage American white pelican foraging areas for the prey base fish species (U. S. Fish and Wildlife Service 1984).
- Maintain shallow water between 0.3-2.5 m (1.0-8.3 ft.) in depth at foraging areas (U.S. Fish and Wildlife Service 1984). Deeper waters may be necessary where water level fluctuations occur.
- Maintain abundant fish populations and a diversity of water bodies, such as lakes, sloughs, rivers, and marshes (Smith et al. 1984, Findholt and Anderson 1995a,b).
- Limit disturbance at foraging areas from hunting and fishing activities, boating, and other recreational activities (U. S. Fish and Wildlife Service 1984).

Reestablishment of Breeding Colonies

With the recent establishment of breeding colonies in Washington, the presence of large numbers of non-breeding summer birds, and population increases on a continental scale, there exists the potential for American white pelicans to become regular breeders in this state. In order to reestablish American white pelican nesting sites in Washington, sanctuaries that protects the birds from human disturbance are needed (Motschenbacher 1984). The sanctuary should contain a nesting island of at least 0.1 ha (0.25 ac), and preferably 0.4 ha (1.0 ac) or larger (U. S. Fish and Wildlife Service 1984) if water level fluctuations are common. Additionally, protected foraging areas with a sufficient prey base must be provided. Buffer zones, which exclude all human activities including boating, fishing, and water skiing, should be established as suggested above.

Contaminants

American white pelicans are susceptible to pesticides and other toxic contaminants. Currently, pesticide and mercury levels are not thought to be a significant problem in American white pelican populations. However, the U.S. Fish and Wildlife Service (1984) recommends monitoring of such contaminants. Fish, pelican eggs, and other biota should be sampled and analyzed for pesticides, dioxins, and other toxicants. Sources of these pollutants should be identified and regulated if necessary. Biocides, including those used in fish rehabilitation programs, should be avoided in American white pelican feeding areas, especially those near nesting colonies (L. Blus, personal communication).

Avoid using any insecticide (Smith 1987) or herbicide (Santillo et al. 1989) in American white pelican nesting or foraging habitat. Organochlorine, organophosphate, and carbamate insecticides can be highly toxic to birds and fish and should be avoided (McEwen et al. 1972, Grue et al. 1983, Grue et al. 1986, Smith 1987). If insecticide or herbicide use is planned for areas where this species occurs, review Appendix A, which lists contacts that may be helpful when assessing pesticides and their alternatives.

Appropriate buffer widths for insecticide spray application near sensitive riparian and wetland areas range from 30-500 m (100-1650 ft) (Kingsbury 1975, Payne et al. 1988, Terrell and Bytnar-Perfetti 1989). When possible, leave a 500 m (1650 ft) (Kingsbury 1975) buffer around American white pelican nesting and foraging areas that is devoid of pesticides (Brown 1978, Smith 1987). Larger buffer areas may be necessary in areas where pesticide runoff affects a large area.

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KEY POINTS

Habitat Requirements

- Foraging occurs in shallow water 0.3-2.5 m (1.0-8.3 ft) deep.
- Breeding and stopover areas are clear of dense shrubbery or trees, include open aquatic habitats, and are free from human disturbance.
- American white pelicans nest on soil or sod.
- An abundant source of prey is essential, such as fish, amphibians, and crustaceans.

Management Recommendations

- Develop site-specific management plans for breeding areas.
- Identify, monitor, and protect primary feeding and loafing areas of breeding and non-breeding American white pelicans.
- Identify and survey American white pelican foraging areas to determine presence and abundance of fish species that may serve as a prey base for pelican populations.
- Maintain shallow water between 0.3-2.5 m (1.0-8.3 ft) in depth at foraging areas. Deeper waters may be necessary where water level fluctuations occur.
- Maintain or restore abundant fish populations in areas where American white pelicans feed.

- Prohibit boats and other human access within 400-800 m (0.25-0.5 mi) and up to 1,600 m (1 mi) of important foraging and breeding areas.
- Close nest islands to trespass during the breeding season from 15 March through 31 August.
- Restrict air traffic to an altitude of 610 m (2000 ft.) above breeding colonies to reduce disruption of nesting.
- Keep water levels stable during breeding season to protect nests from inundation or from predators which may cross land bridges during low water.
- Protect nesting areas and potential nesting islands from mammalian predators such as coyotes.
- Monitor for pesticides, dioxins, and other toxicants in prey fish.
- Avoid pesticide use in American white pelican habitat. If insecticide or herbicide use is planned for areas where this species occurs, review Appendix A that lists contacts that may be helpful when assessing pesticides and their alternatives.
- When possible, leave a 500 m (1650 ft) buffer around American white pelican nesting and foraging areas that is devoid of pesticides. Larger buffer areas may be necessary in areas where pesticide runoff affects a large area.
- Appropriate buffer widths for insecticide spray application near sensitive riparian and wetland areas range from 30-500 m (100-1650 ft).
- Breeding sanctuaries should contain:

  ➢ a nesting island of at least 0.1 ha (0.25 ac), and preferably 0.4 ha (1.0 ac) or larger if water level fluctuations are common.
  ➢ protected foraging areas with sufficient prey
  ➢ buffer zones that exclude human activities.

Great Blue Heron

Last updated: 2012

Written by Jeffrey M. Azerrad

GENERAL RANGE AND REGIONAL DISTRIBUTION

The Great Blue Heron's North American breeding range runs from southeast Alaska east to Nova Scotia and south to northwestern Mexico, the Yucatan Peninsula in Belize and Mexico, the West Indies, and Galapagos Islands (*7*). Herons overwinter from southern British Columbia, south to Venezuela.

Herons are a permanent resident in all of Washington except the higher Cascade and Olympic ranges (Figure 1). In British Columbia, they are permanent residents along the entire coast and throughout Vancouver Island and the Haida Gwaii Archipelago[1]. They also are residents in south-central British Columbia. Although herons breed at elevations as high as 1,100 meters (3,600 ft; *14*), they mainly nest at lower elevations.

The region's largest colonies are within the range of the Pacific Great Blue Heron (*A. h. fannini*). This subspecies differs from inland herons and from herons near south-coastal Washington (*A. h. herodias*) in that they are smaller in size. They also generally begin breeding earlier in the spring (*54*). The range of these birds is isolated by the mountains east of Puget Sound and Georgia Basin. Pacific Great Blue Herons mostly occur close to the coast and inland along large rivers from Prince William Sound to Puget Sound (*54*).

Figure 1. The hatched area is the year-round range of the Great Blue Heron (*Ardea Herodias*) in Washington and British Columbia (*55*).

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[1] This publication was written in cooperation with the Great Blue Heron Working Group. Because the group is a made up of experts from Washington and British Columbia, we present information and guidance relevant to Washington and British Columbia.

RATIONALE

Great Blue Herons are highly vulnerable to human disturbance, predation, and competition for nesting habitat (*40*). Their habit of nesting in large groups makes herons especially susceptible to these types of impacts. A single event involving human disturbance can lead an entire colony to terminate a nesting attempt (*21*, *54*, *55*). Because herons breed in colonies of up to 500 nests (*21*), early termination of even one breeding attempt can lead to a considerable loss of offspring. This is especially a problem in Puget Sound and the Georgia Basin, where half the breeding population is concentrated into four large colonies (*21*). Recently the size of these large colonies in Puget Sound has increased as birds began to move out of smaller colonies (*22*).

Although herons are not a state-listed species in Washington, they are a species of special concern in British Columbia due to a decline in productivity, where the number of fledglings per active nest fell by nearly half since the 1970s (*54*). Although habitat loss and disturbance negatively impact individual colonies, we need more surveys to assess whether these factors are having an impact on regional heron populations.

HABITAT REQUIREMENTS

Great Blue Heron foraging, breeding, and pre-nesting habitats usually are in close proximity to each other (*24*). Foraging habitat often is adjacent to or within a few kilometers of the nesting colony. Before nesting begins, herons will often congregate close to where they nest. The inter-relationships among these habitats require consideration to effectively protect a nesting colony.

PRE-NESTING HABITAT

Prior to nesting, herons may gather in groups. Surveyors have observed pre-nesting groups close to many of the region's heron colonies (A. Eissinger and I. Moul, personal communications). There is some debate as to how prevalent these groups are in the region. Although birds may not exhibit this behavior at every colony, more survey and research during the pre-nesting period will help us better understand these habitats.

The breeding season begins when adult herons gather at these pre-nesting sites (*21*). Along the coast, herons may occupy these sites while waiting for the tides to descend enough for food to become accessible (I. Moul, personal communication). Although not all of a colony's nesting birds will be found in a pre-nesting congregation area, the number of birds seen at these sites seems to correspond to the size of the nearby colony (A. Eissinger, personal communication).

Herons form pre-nesting congregations in various types of habitats. They congregate in both vegetated areas and on built structures (e.g., rooftops near Stanley Park and in Seattle's Kiwanis Ravine). Although in interior British Columbia and eastern Washington far fewer pre-nesting groups have been reported, Gebauer and Moul (*24*) noted interior-nesting herons gathering at larger lakes, wetlands, and watercourses prior to nesting. In coastal areas, herons often congregate in large estuaries and mudflats (*24*). At one of Washington's largest colonies at Birch Bay, pre-nesting congregations occur in fallow fields adjacent to the colony. Herons also assemble in day roosts near colonies in the pre-nesting period (*21*).

BREEDING AND NESTING HABITAT

Great Blue Herons often assemble in large and conspicuous colonies. Although some will nest as isolated pairs, most form colonies of a few pairs to many hundreds of birds (*10*). Larger and more productive colonies tend to form near large areas of high quality foraging habitat (*5*, *25*, *27*, *31*), and especially near eelgrass beds (*11*, *54*). Although herons sometimes nest on the ground, hu-

man-made structures, cliffs, and in shrubs (*7*, *10*, *28*; H. Ferguson, personal communication), nesting mostly occurs in trees like alder, cedar, hemlock, pine, Douglas-fir (*Pseudotsuga menziesii*), spruce, hawthorn, bigleaf maple (*Acer macrophyllum*), and cottonwood (*Populus balsamifera*). A shortage of suitable trees may lead herons to nest in shrubs or near the ground (*28, 54*). In coastal Washington and British Columbia, nesting largely occurs in areas with deciduous trees (M. Tirhi and R. Vennesland, personal communications). In British Columbia's interior Columbia River Basin, herons showed no preference for nesting in conifer or deciduous trees (*35*).

Ideal nesting habitat typically consists of mature forest (*24*). Although most colonies are found in forests free of human disturbance, some nesting occurs in areas of persistent human activity (*10*). An explanation for this may be that some areas lack undisturbed forest close to foraging habitat. In these places herons may be forced to select a disturbed forest because it is close to rich foraging habitat (*31*). In some regions they may select the best available habitat when optimal habitat is altogether lacking. Some herons may also become more acclimated to people (*52*). Although herons nest in disturbed areas, the presence of people has been linked to reduced nesting productivity (*16*, *24*, *49*, *53*). Colony abandonment has also resulted from activities like land development and repeated human intrusions (*43*, *49, 53*).

BREEDING SEASON FORAGING HABITAT

During the breeding season herons feed in the shallow margins of various coastal and freshwater habitats (*24*). Herons primarily nest near abundant sources of food (*31*). Although most colonies are within 3 kilometers (1.9 mi) of key foraging grounds, herons can nest anywhere within 10 kilometers (6.2 mi) of where they are foraging (*9*).

The presence of a nearby food source influences a colony in various ways. Food accessibility influences when a heron colony will begin breeding each year (*8*). Food also influences the size of nesting bird's clutch and brood (*41*, *42*, *47*). Although few have studied the relationship between food abundance and nesting, numbers of breeding herons likely decline with waning food supplies. A reliable food source also seems to affect reproductive performance (*10*, *31*).

Along the coast, eelgrass meadows and other estuarine ecosystems supply most of the food that adult and juvenile herons require during the breeding season (*10, 20*). These herons feed on various small fish and marine invertebrates (*10*) such as gunnels, sculpin, shiner perch, mud shrimp, isopods, and crabs. Butler (*9*) concluded that coastal-nesting herons forage most efficiently in late spring when the tides are at their lowest levels and when prey tends to be abundant (*10*). This timing also corresponds to when the energy demands of juvenile herons hit their peak (*1*). Although coastal herons rely mainly on marine and estuarine waters for foraging, freshwater habitats also serve as an important source of food (*24*).

In contrast to coastal herons, interior herons feed alone and in small groups. This may be a result of foraging in areas of less abundant food. In southeast British Columbia and eastern Washington, breeding herons feed in wetland complexes, large rivers and creeks, and small lakes (*35*; H. Ferguson, personal communication). In southeast British Columbia, palustrine wetland complexes comprise 40% of the waters near colonies, while rivers, small lakes, and reservoirs made up another 50% (*35*). Given the proximity, herons may have an affinity for feeding in these waters.

NON-BREEDING SEASON FORAGING HABITAT

Although breeding season foraging more directly influences heron nesting, areas used for foraging outside the breeding period are also important. In fall and early winter, adult and juvenile herons often prey on small mammals in fallow, freshly plowed, or mowed fields and in grasslands

(*9, 24*; H. Ferguson and S. Pinnock, personal communications). Close to the coast, herons feed in ditches, old fields, marshes, and wetlands just following their dispersal from breeding areas (*10*). In October and November adults closer to the coast feed in marshes while juveniles feed in old-fields (*5*). These coastal herons later move back to tidal areas beginning in February and March. Great Blue Herons in interior areas forage along ice-free waters like creeks and lake shorelines. Non-breeding season foraging habitat may be a limiting resource for interior herons when frozen waterbodies or snow-covered fields restrict their access to prey (*24*).

LIMITING FACTORS

Activities like forestry and development have lead to the loss and degradation of heron habitat, disturbance to nesting and foraging grounds, and to direct mortality (*10, 40, 49*). Forest removal and urban and industrial development are the chief causes of habitat loss in the Pacific Northwest (*24, 51, 60*). Increased human disturbance at breeding and foraging sites can lead to increased predation, lower breeding success, nest failure, and less efficient foraging (*10, 24, 53*). Although herons can nest in disturbed urban areas, disturbance can lead birds to terminate breeding attempts, especially when a disturbance occurs early in the nesting period or when it is a large or novel event (*37, 52*).

Avian predators also kill herons and compete for habitat. Bald Eagles are the heron's primary predator (*10, 24, 53*). A sharp increase in eagle populations has lead to more colony incursions (*55*). In some areas, eagle predation and disturbance has lead to an increase in nest and colony failure (*13, 53*). Depredation in particular appears on the rise in coastal heron colonies (*50, 53*) and attacks on adult herons may be leading to the temporary or permanent colony abandonment (*21*). Annual monitoring of colonies in interior British Columbia has shown eagles to be a cause of mortality and depredation (*35*). Eagles may also affect colony size further from the coast (H. Ferguson, personal communication). Although the recent rise in Bald Eagle abundance following their recovery has apparently exacerbated impacts at heron colonies, historically herons persisted when eagles were more common than they are today (*46*). But because interactions now occur in an altered landscape, there is uncertainty as to how herons will respond to the increased influence of eagles.

Other birds also seem to impact herons. The considerable ecological overlap of Double-crested Cormorants (*Phalacrocorax auritus*) and herons in interior British Columbia and eastern Washington suggests they potentially compete for limited nesting habitat (*35*; D. Norman, personal communication). Crows and ravens also prey on heron eggs and young (*45*).

Climate change will likely influence heron nesting and distribution. While we still do not know how severe the impacts will be, rising sea level and sea temperatures could affect nesting and foraging resources. A rise in sea level could inundate shallow coastal marshes (*12*), displacing herons from rich foraging grounds. Changing weather may also alter wading bird distributions (*33*).

MANAGEMENT RECOMMENDATIONS

HERON MANAGEMENT AREA

These recommendations are intended for use in what we have termed the Heron Management Area (HMA). An HMA consists of the nesting colony, year-round and seasonal buffer, and foraging habitat (Figure 2). The HMA core zone consists of the colony and year-round buffer. Pre-nesting congregation areas are also part of the HMA. You should protect all these areas as disturbance to any part of an HMA can harm a colony.

The following guidelines will help you identify, map, and manage an entire HMA. We suggest you use the guidelines to protect any colony, no matter its size or status. Although you should not underestimate the value of smaller colonies, larger colonies generally merit highest priority. Give colonies with at least 20 nests close to coastal and estuarine habitat or along large rivers that drain into an estuary high priority (*30*). Since colonies inland tend to be smaller, regard all inland nesting aggregations as high priority.

Figure 2. Depiction of all the components of a HMA.

CORE ZONE IDENTIFICATION AND MAPPING

You should gather baseline information when planning a project near a heron colony. Because gathering data can lead to serious disturbance including failed nesting attempts (*49, 56*), you should only collect data in the core zone during the non-breeding season (Figure 3) when herons are absent. Although the non-breeding period generally runs from the beginning of September to mid-February, breeding activity can begin in late January and can conclude as late as mid-September (*21*; K. Stenberg, personal communication). Also, specific stages within the breeding season can vary geographically as well as from one colony to the next. For example, young in colonies south of Seattle often hatch in late March and fledge in June (*38*; K. Stenberg, personal communication). The fledging period in some colonies can also run for longer durations than the range shown in Figure 3 (K. Stenberg, personal communication). Because of this variability, draw on local knowledge of a colony to determine its true breeding period.

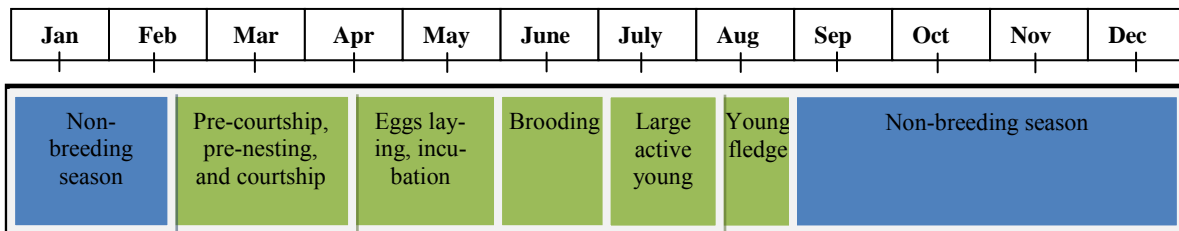| Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Non-breeding season	Pre-courtship, pre-nesting, and courtship		Eggs laying, incubation		Brooding	Large active young	Young fledge	Non-breeding season			

Figure 3. Chronology of the Great Blue Heron breeding and non-breeding periods (*6, 10, 20, 21*).

Just after the breeding season is the ideal time for nest counts and collecting habitat data. When a non-breeding season survey is impossible, you should not collect data in the core zone before the brooding period because colonies are more sensitive at that time (*52*). Conduct breeding season surveys late in the day when birds are less likely to leave their nests (*56*).

Begin your survey by locating all trees and structures with nests. Mark all nest trees at the colony's outer perimeter with flagging. Then mark their location on a map. Also flag and map trees with canopies overlapping a nest tree. You will use the marked trees to identify the colony's boundary. Knowing the location of the boundary will also help with post-project monitoring.

Because some nests occur in trees with canopies that overlap with other trees, locate which of the overlapping trees are furthest from the center of the colony for each outer perimeter nest. Using these peripheral trees as your guide, delineate the colony's outer boundary (Figure 4). Although there will be some subjectivity as you map this boundary, these nests will serve as your primary guide.

In some heron colonies outlying nests can be found in locations distant from where most of the colony's nests are concentrated. These satellite nests are typically represented by no more than a small handful of active or inactive nests located far[1] from the nearest neighboring nest in the heart of the colony. Although satellite nests are considered a part of the larger nesting colony, they usually will not be used to map the colony's outer boundary. But they should be protected. The best way to do this is by using them to identify the location of an alternate nesting stands. Alternate nesting stands serve important functions. We later discuss how to use satellite nests to identify a suitable location for an alternate nesting stand.

Figure 4. Boundary of the nesting colony demarcated using outer perimeter nests as a guide.

Buffers protect colonies by putting some distance between a colony and a potentially harmful activity (*3, 7, 43, 51, 57*). Some heron colonies require a relatively wide buffer given people as far as 250 meters (820 ft) away can cause birds to flush, and in some instances terminate a nesting attempt (*3*). Consequently, anyone working on a project near an existing colony should designate a buffer area to protect the colony.

Because colonies closer to human activity may tolerate more disturbance than colonies in a more undisturbed area (*2, 52, 59*), our recommended buffer widths vary with the surrounding levels of development. To delineate the year-round buffer, draw a circle around each outer nest tree using the buffer distances in Table 1. The outermost edge of each circle forms the outer limit of the year-round buffer (Figure 5)[2].

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[1]   For the purpose of this publication, a satellite nest is any nest located a distance of no less than twice the length of the colony's year-round buffer from its nearest neighboring nest.

[2]   Mapping needs periodic updating since colonies are dynamic and the outer boundary of a colony can move over time.

Table 1. Recommended buffers for nesting colonies

Year-round Buffers [a]			
Meters	**Feet**	**Setting**	**Percent built within a ¼ mile of the nest colony** [c]
300	984	Undeveloped	0 - 2%
200	656	Suburban/Rural	2 - 50%
60 [d]	197	Urban	≥ 50%
Seasonal Buffers [e]			
Meters	**Feet**	**Land Use Activity**	**Time of Year**
200	656	Unusually loud activities [f]	February to September
400	1,320	Extreme loud activities like blasting	

a   Buffer guidelines based on *3, 4, 7, 15.*
b   Rationale for setting-specific buffers based on observed heron tolerance variations associated with land use levels (*49, 52*)
c   Cutoff percentages among undeveloped, urban, and suburban/rural as defined in *36, 49.*
d   When birds in an urban area exhibit behavior indicative of a low tolerance to people, assign the 300 meter buffer regardless of setting.
e   Seasonal buffer begins at the outer edge of the year-round buffer when specified land uses occur near a colony in the breeding season.
f   These activities generates sounds exceeding 92 decibels when the sound reaches the outer boundary of the nesting colony (*58*).

CORE ZONE MANAGEMENT

A colony with an adequate buffer and with room to move or expand increases its longevity and productivity (*16, 21*). A buffer acts as a physical and visual barrier to potentially intrusive activities. Buffers can also protect nest trees from being blown down (*34*). The buffer area also provides habitat that birds can use when they need to move from one nest tree to another.

For the greatest protection, certain actions should not occur near a colony. Specifically, clearing vegetation, grading, and construction should never occur in the core zone (*24, 49, 51*).   Trails should also be directed away from the core zone or be closed off to access in the breeding season.

Although these activities are not recommended in the year-round buffer, when you have exhaustedall options we strongly recommend you do the following when situating your project in a colony's core zone. First, you should site your project as far as possible from nests. You should also find a location where the nests will receive the greatest visual screening possible from all project distur-bances. Screeing is important as it helps ensure disturbance is minimized by removing visual cues (R. Vennesland, personal communication). Because disturbance is linked to reduced nesting prod- uctivity (*16, 24, 49, 53*), screening should provide some added protection. You should also carry out your project during the non-breeding season and mitigate for your project's infringement into the core zone.

Limited low impact recreation such as hiking, trail biking, or dog walking can occur in a core zone. However, these activities should only occur in the non-breeding season when no herons are present. Although we do not encourage any vegetation removal in the core zone, limited vegetation removal may be acceptable so long as it is part of a project primarily intended to enhance wildlife habitat (e.g., eradicating invasive understory vegetation) or to treat a fire-prone stand. Although vegetation removal may be okay in these limited instances, avoid these activities during the breeding season. Forest enhancement should also be done under the careful supervision of a wildlife biologist who understands heron behavior and ecology. When treating an overstocked or densely vegetated fire-prone stand, aim to avoid noticeable loss of visual screening to the nests.

We recommend using fences to exclude human entry into the colony's core zone (*16*, *51*). But with that in mind make sure the fence will not cut off access to other wildlife (see Fencing with Wildlife in Mind). Construct your fence in the non-breeding season and with minimal disturbance to vegetation. You can also plant of dense thickets of vegetation to keep people out of a colony's core zone (see Appendix B for thicket-forming plants). Place signs around the outer edge of the year-round buffer explaining why entry is discouraged. Although we encourage the use of fencing or a vegetation barrier, we recognize these may not be feasible options for colonies surrounded by multiple small landowners.

Great Blue Herons are less tolerant of disturbance in the pre-courtship and courtship periods (mid-February to mid-April). They progressively becoming less likely to leave or abandon a nesting attempt after their eggs hatch (*2*, *32*, *43*, *52*). Consequently, we discourage disturbance early in the breeding period. Where a core zone contains pre-existing structures like a home or a road, the type and level of use should not exceed intensities that customarily have occurred in the breeding period (*51*).

Any activity situated between the outer edges of the year-round and breeding season buffers should begin with a plan to identify where it will cause the least disturbance. Because herons seem most sensitive to actions in their line of sight, keep any work that will increase the presence of people, domestic animals, or vehicles out of view of the colony. To accomplish this, you should site your project where it will receive the greatest screening by way of vegetation or topography. Screening is especially vital when you have sited your project near the outer perimeter of the year-round buffer area. The best trees for screening will be at least as tall as a colony's tallest nesting tree. Whenever possible, these trees should also be of the same species as the dominant nesting trees. This way they will not only serve as a screen, but will provide the secondary benefit of being potential nesting trees.

SEASONAL BUFFER, PRE-NESTING AREAS, AND ALTERNATE NEST SITES
Other components of the HMA are the seasonal buffer, pre-nesting habitat, and alternate nesting stands. Identify these important areas whenever planning for a project in the vicinity of a colony. Because WDFW has not mapped pre-nesting congregation areas and alternate nesting stands in our Priority Habitat and Species database, you should identify these sites during the development of a habitat management plan (HMP).

Demarcate a seasonal "quiet" buffer of 200 meters (656 ft) if any unusual or loud activity will occur in the breeding season (Table 1; *3*). This seasonal buffer begins at the outer edge of the year-round buffer. If blasting (or any similarly loud activity) will occur in the breeding season, we recommend you designate a 400 meter buffer (1,320 ft; *48*).

The presence of a pre-nesting congregation of herons often signals the start to the breeding season. These congregations generally are close to the nesting colony (≤ 1 km) and are discernable by a concentration of birds outside the nesting colony between February and March, and as early as January. You should map any known pre-nesting use area. Because we know little as to how pre-nesting habitat disturbance affects a colony, you should take a precautionary approach to managing these areas. We recommend minimal disturbance of any area where herons congregate prior to nesting due to their greater sensitivity early in the breeding season (*2*, *52*, *57*).

Although our recommendations focus on protecting the active colony, you also should identify and conserve potential nesting stands to preserve active nesting colonies in an area. Nesting herons periodically relocate their colonies and alternate nesting stands provide places to relocate

(*51*). We recommend retaining several forested alternate nesting stands of at least 4 hectares (10 ac) with dominant trees at least 17 meters (56 ft) high near breeding colonies (*29, 39*).

There are several strategies for finding the ideal places for an alternate nesting stand. Because herons sometimes nest in outlying trees away from where most nesting birds are concentrated, alternate nesting stands can be centered on these remote satellite nests. The satellite nest typically is represented by one, two, or several active or inactive nests located well beyond the nearest neighboring nest. We recommend using satellite nests to site an alternate nesting stand when they are located at least twice the year-round buffer distance from the nearest neighboring nest.

Another strategy is using former heron colony sites. When these sites are near an active colony, they may be designated as alternate nesting stands. But before choosing a former nesting site, consider the circumstances of the former colony site's demise. Above all, it probably is not suitable to designate a former nesting site if the site was likely vacated because of a nearby disturbance with permanent (e.g., housing development) or long-term (e.g., clear cut) effects.

If you cannot find a former nesting site or satellite nest, identify all nearby forest stands where structure and tree species composition is similar to the active nesting stand. The alternate nesting stand should be within a kilometer of the active colony and within 3 kilometers (1.9 mi) of foraging habitat. Preferably this should be the same foraging habitat used by the active colony.

FORAGING HABITAT
Because breeding herons need nearby foraging habitat, conserving potential foraging habitat is key. Similar to pre-nesting concentration areas and alternate nesting habitat, identify foraging habitat when developing your HMP. Although some herons forage further away, most herons feed within 3 kilometers (1.9 mi) of their colony.

Map all bodies of water within a 3 kilometer (1.9 mi) radius of a nesting colony (up to 10 km from colonies with ≥100 nests) as an initial step to identify potential foraging habitat. The perimeter and shallow portion of waterbodies are especially important for foraging. Although herons will not feed along every nearby waterbody, these waters will likely include foraging habitat. For colonies in the outer coast, Puget Sound, and Georgia Basin, publicly available data can help you pinpoint potential marine nearshore foraging habitat (Table 2). WDFW's multiyear heron foraging count in Puget Sound gives a snapshot of foraging during the 2003-04 breeding season. This is the region's only survey specifically of nearshore marine and estuarine foraging habitat.

Land use activities along the nearshore can adversely affect habitat where herons feed in concentrations. These habitats include eelgrass and kelp beds, shorelines, and wetlands (*23*). Dredging, filling, grading, or otherwise altering nearshore and riparian habitat can interrupt feeding and harm food supplies (*23*). Therefore, we recommend you not disturb key foraging habitat between March and September (R. Butler, personal communication). To protect foraging habitat, establish adequate riparian buffers such as those recommended by Knutson and Naef (*34*). You should also minimize certain activities where herons feed:

- removal of aquatic vegetation, especially native eelgrass.
- use of all watercraft within 180 meters (590 ft) of shallow waters where herons forage (*44*).
- logging mature forest close to nearshore foraging habitat (*24*).
- removing perch trees adjacent to foraging areas (*51*).
- draining, filling, or dredging wetlands or marshes (*3*).
- building close to riparian shorelines (*34*).

In addition to these measures, the Aquatic Habitat Guidelines Working Group's recommendations offer ways of limiting nearshore disturbances from overwater structures, shoreline armoring, and riparian alterations in Puget Sound (see Envirovision et al. 2010). Because these activities affect the species that herons feed on, you should review this publication before beginning one of these activities within 3 kilometers of any Puget Sound heron colony.

Because inland herons tend to feed in a dispersed manner, their foraging habitat often is not as obvious as in coastal areas. Although inland breeding herons do not restrict their foraging at one or two areas of concentrated feeding, the shallow margins of lakes, rivers, and wetlands that they do use are still vital. In fact, these habitats not only are important to herons, but to most of the region's other species as well (*34*). Consequently, we recommend using WDFW's PHS Riparian management recommendations and Washington Department of Ecology's Wetland's Guidance Manual to protect riparian habitats along lakes, rivers, and wetlands.

Table 2. Sources of GIS data that can aid in locating potential nearshore Great Blue Heron foraging habitat.

Database [a]	Description	Data Limitations [b]	Acquiring Data
Washington			
Priority Habitat and Species database	Documented locations of eelgrass beds and other nearshore habitats.	• Database only includes a small subset of the locations of nearshore priority habitats in Washington.	PHS on the Web
Shorezone Washington	Inventory of Washington's saltwater shorelines from 1994-2000. Information was collected by helicopter at low tide.	• Not designed to capture small features. • Shoreline units divided based on geology, not biology. Thus, biotic elements (e.g., eelgrass) may occur in the middle of a unit, or span several units. • If biota is recorded as present, a user can be confident the feature was present during the flight. If a feature is *not* recorded, it is not necessarily absent.	Washington Department of Natural Resource Data Web Portal
WDFW Puget Sound Heron Foraging Count	Aerial foraging count carried out in Puget Sound from 2003-2004.	• A static dataset with no confirmed timeline for an update.	Contact Data Steward for WDFW's Washington Survey Data Management (WSDM) system
Skagit and Whatcom county Intertidal Habitat Inventories	Vegetation classified using multispectral imagery from 1995-1997: eelgrass, brown algae, kelp, green algae, mixed algae, salt marsh, spit and berm vegetation, and red algae.	• Vegetation type was classified using dominant vegetation. Other vegetation types may be present in abundances <30%. • Low density vegetative cover (<25%) likely escaped detection. • Subtidal vegetation that does not form a canopy may not be distinguished and conclusions regarding the presence or absence of this vegetation should not be drawn based on this data set. • Vegetation patches < 16 m^2 are likely not detected.	Washington Department of Natural Resource Data Web Portal
National Wetland Inventory	Information on the extent and status of wetlands in the United States.	• Prepared from analysis of high altitude imagery. • Accuracy of interpretation depends on image quality, experience of image analyst, and amount of ground-truthing conducted.	Wetlands Mapper
British Columbia			
Shorezone British Columbia	Tool for identifying coastal biological communities in BC	• Similar to Shorezone Washington data limitations.	ess.info@gov.bc.ca
Coastal Resource Information System	Locations of kelp and eelgrass beds in BC		British Columbia CRIS Web Portal
Eelgrass Bed Mapping Application	Locations of kelp and eelgrass beds in BC	• Details at www.cmnbc.ca/atlas_gallery/eelgrass-bed-mapping	Community Mapping Network
Eelgrass mapping review: eelgrass mapping initiatives in coastal BC	A report of known eelgrass mapping and monitoring projects in BC	• Surveys and mapping carried out after 2003 are not identified in the report. • Report likely to have inadvertently left out some pre-2003 eelgrass mapping efforts.	Dunster 2003

[a] These inventories should be used only as screening tools. They are not site-specific, and should not replace site-specific surveys. However, they can all complement site-specific surveys by providing regional context.

[b] Each of these databases represent a snapshot over a given time period and do not show changes in condition or status over time.

FORMER NESTING COLONIES

Because herons occasionally move back to seemingly abandoned nesting sites, we recommend you protect these sites. In Washington, documented re-nesting has occurred in sites over 10 years after being "abandoned" (C. Anderson, personal communication). Although entry for uses that will not alter the look of the habitat like hiking and dog walking is okay when no nesting herons are present, all other recommendations applying to an active colony should remain in effect for at least 10 years after nesting has ceased at the site of any former colony.

MANAGEMENT OF URBAN COLONIES

Although herons mostly nest away of urban settings, colonies occur in urban areas in Washington, British Columbia, and throughout the species' North American range. Herons may tolerate everyday human activities, but in general birds often suspend nesting when they perceive the activity is a threat (*17, 49*). Although we do not know the threshold for what constitutes a threat, a seemingly benign stimulus like a pedestrian can lead a colony to terminate a nesting attempt (*53*).

In this update to the Great Blue Heron management recommendations we have further recognized differences in managing urban versus non-urban colonies. The primary approach is the tiered set of buffers (Table 1). In urban and suburban landscapes project planners should learn of any existing disturbances before beginning a project near a heron colony. That way a planner can identify an appropriate size and scope for a project. As a rule of thumb, new activities should not add to the intensity of disturbance a colony has historically tolerated and adapted to.

To see if a project will increase the level of disturbance from historical levels, we recommend you begin by documenting the intensity of all existing disturbances. We do not recommend any new activities that will lead to an increase in the intensity of disturbance. An increase in intensity can occur when a new activity is sited closer to a colony than that of existing activities. Increased intensity can also happen when the magnitude of a proposed disturbance is out of pro-portion to all existing disturbances located the same distance from a colony. To illustrate this point, consider a colony where herons have historically persisted where the footprint of the closest home is 60 meters from the colony. If a new home is sited 30 meters away, this would constitute an increase in intensity because the new home's influence on the colony would be greater than that of the existing home. Other ways of increasing the intensity of disturbance include upzoning or changing or converting to a more intensive land use practice.

Where development already exists within our recommended year-round buffer zone (Table 1), we do not recommend any further infringement within this zone. Where further infringement will occur, new disturbances should not take place in the breeding season and we do not recommend large or novel events occurring at any time (*52*). Any further infringement should not happen without first developing a plan to mitigate for the loss of habitat.

CARRYING OUT THE HERON RECOMMENDATIONS

These guidelines are to be applied wherever herons nest in Washington. They may also be applicable throughout the heron's North American breeding range. To protect heron colonies, these guidelines should be incorporated into the regulatory and non-regulatory framework of local communities throughout the region. Another for way of protecting habitat is through land acquisition by organizations (e.g., land trusts) whose mission includes wildlife habitat conservation.

Two of Washington's laws most influential to regulating Great Blue Heron habitat at the local level are the Shoreline Management Act and the Growth Management Act. Counties and cities

are encouraged to designate Great Blue Heron as a species of local importance and to adopt these management recommendations to support protection of this priority species.

Although effective heron conservation requires regulatory protections, non-regulatory incentives should also be put in place to protect herons. Some non-regulatory options in Washington include transfer of development rights[1] (TDR), current use taxation (via the development of a Public Benefit Rating System), and Conservation Futures. Local land trusts[2] can also help property owners protect heron habitat through incentives such as conservation easements.

Each of these options can protect herons by giving landowners monetary or other incentives to avoid harmful activities. Communities with TDR programs allow certain landowners to transfer their right to develop in exchange for monetary compensations. In this program landowners with important wildlife habitat could receive eligibility to transfer their development rights to a less environmentally sensitive location. Participants in a PBRS program could also receive an economic incentive for limiting certain land use activities for the purpose of protecting a colony. Conservation Futures or other conservation funding or easement programs may also be designed to give preference points to properties with nesting herons. Counties and cities should adopt some or all of these options as a way to balance regulatory with non-regulatory protections for the Great Blue Heron and other sensitive species.

While many local governments protect the nesting colony, habitats that indirectly benefit a colony sometimes go unprotected. To protect pre-nesting habitat, alternate nesting stands, and foraging habitat, incentives can provide a set of useful tools. Local governments should offer incentives to landowners who want to permanently protect any type of breeding season habitat. Specifically, proposals near breeding season habitat deserve high priority when choosing between candidates for new Conservation Futures sites. Land trusts should also consider these areas when developing their conservation portfolios.

Habitat Management Plans. – A habitat management plan (HMP) should be developed whenever a land use proposal is submitted for an area in or near the core zone of an HMA. An HMP is a detailed report that outlines and documents where there is habitat, any planned incursions or habitat impacts, and a strategy for limiting impacts. Using our management recommendations as a guide, an HMP should describe the:

- resources, including active or historical nesting sites, pre-nesting congregation areas, and potential foraging sites.
- past, present, and future land uses.
- habitat features and processes potentially impacted by the proposal.
- habitat enhancement or mitigation measures, including quantitative goals and objectives.
- objectives that carefully balance the needs of the species with that of the landowner.
- implementation plan with maps, as-built drawings, and operation and maintenance plan.
- specific prescriptions and project timing to best meet the species' needs and to promote the health of their habitat.
- a schedule for periodic monitoring, and a contingency plan with corrective actions if conservation or mitigation actions do not lead to a desired outcome.

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[1] In Canada TDRs are more commonly referred to as Transfer of Development Credits.

[2] A list of land trusts in British Columbia can be found at http://landtrustalliance.bc.ca/members.html.

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GLOSSARY

Breeding Season
This is the period when herons begin gathering in pre-nesting aggregations near the colony and concludes when young of the year have fledged.

Brood
A collective term for the offspring produced by an individual breeding female.

Brooding Period
The first days of a juvenile bird's life.

Clutch
Collection of eggs in a single nest.

Core Zone
This encompasses the area where herons are nesting as well as the adjacent year-round buffer zone.

Habitat Management Plan
A detailed report that outlines and documents the location of the important habitat area, any incursions or impacts into the habitat by a proposed land use action, and ways to limit any impacts to the habitat and to associated species.

Heron Management Area
This is the area that includes all key elements needed to sustain a colony of nesting Great Blue Herons. This includes the area where herons are nesting, year-round and seasonal buffer areas, the pre-nesting concentration area(s), and the foraging habitat that nesting herons are using during the breeding season.

Nesting Colony
The area where a group of heron nests are located.

Seasonal "Quiet" Buffer
An area just adjacent to the outer edge of the year-round buffer. Within this area certain loud activities such as blasting or the use of chain saws is not recommended.

Pre-nesting Habitat
Where herons gather in groups prior to initiating nesting. Pre-nesting often occurs along larger lakes, wetlands, watercourses, and fallow fields.

Year-round Buffer
An area set between the outer edge of the nesting colony and the inner perimeter of the seasonal buffer. Within this area most land use activities are not recommended at any time of the year.

Cavity Nesting Ducks

Barrow's Goldeneye -*Bucephala islandica*
Common Goldeneye - *Bucephala clangula*
Hooded Merganser - *Lophodytes cucullatus*
Bufflehead - *Bucephala albeola*
Wood Duck - *Aix sponsa*

Last updated: 2000

Written by Jeffrey C. Lewis and Don Kraege

GENERAL RANGE AND WASHINGTON DISTRIBUTION

These five species of cavity-nesting ducks vary in distribution. The breeding and wintering ranges of the Barrow's goldeneye (*Bucephala islandica)* and the bufflehead *(Bucephala albeola*) extend from Alaska to California. The wood duck (*Aix sponsa*) and hooded merganser (*Lophodytes cucullatus*) winter south of Alaska and breed from British Columbia southward. The common goldeneye winters from Alaska to California and breeds in isolated areas of Washington northward to Alaska (Bellrose 1976).

Washington is one of a very few states where all 5 species are known to breed (Matt Monda, personal communication). The Barrow's goldeneye is widespread and breeds within the Cascades and in north-central Washington (see Figure 1). A unique population of Barrow's goldeneye nest in cavities within the talus slopes and basalt cliffs surrounding Lake Lenore and Alkali Lake in central Washington (Matt Monda, personal communication). Buffleheads are only known to breed south of Spokane on Turnbull National Wildlife Refuge and at Big Meadow Lake in Pend Oreille County (see Figure 2; Smith et al. 1997). The common goldeneye breeds in a few isolated areas in northeastern Washington (see Figure 3). Breeding areas for hooded mergansers and wood ducks are more widespread, primarily in the western part of the state, but they also breed in eastern Washington where adequate habitat occurs (see Figure 4; Smith et al. 1997). In addition, large concentrations of
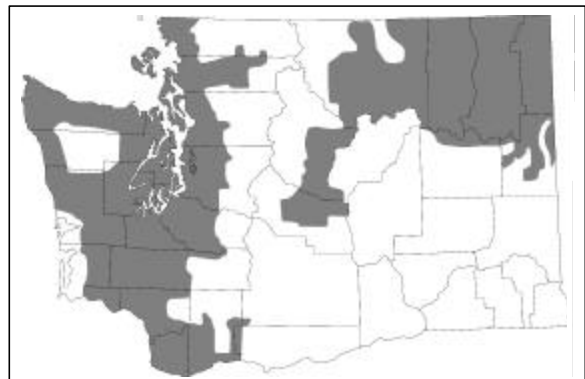

Figure 1. Breeding range of the Barrow's goldeneye (Bucephala islandica) in Washington. Map derived from GAP Analysis of Washington. Smith et al. 1997).

Figure 2. Breeding Distribution of the Bufflehead (Bucephala Clangula) in Washington. Map derived from GAP Analysis of Washington (Smith et al. 1997).

breeding wood ducks occur in the Yakima valley (see Figure 5; Matt Monda, personal communication).

All five species can be found in larger numbers during migration. Though wood ducks typically winter further south than Washington, significant wintering numbers can be found in the Yakima Valley and the Columbia River estuary. Goldeneyes and buffleheads winter in large numbers on Puget Sound and larger rivers. Hooded Mergansers are less common but winter in a wide variety of habitats (Matt Monda, personal communication).

RATIONALE

Cavity-nesting ducks provide recreation to hunters and bird watchers, and they are vulnerable to loss of nesting habitat. These species require nesting cavities within trees and snags, which are commonly lost through commercial forestry, firewood cutting, and shoreline development. All but the wood duck exhibit low productivity and low population sizes, breed for the first time at an older age, and are poor pioneers of unoccupied habitats (Goudie et al. 1994). Common goldeneye and bufflehead are the least common breeding ducks in the state. Loss of suitable nesting sites will eliminate use of an area by breeding birds.

HABITAT REQUIREMENTS

In Washington, cavity-nesting ducks nest primarily in late-successional forests and riparian areas adjacent to low gradient rivers, sloughs, lakes, and beaver ponds (Thomas 1979, Brown 1985, Parker 1990). Animal matter can comprise over 75% of the diets of the hooded merganser, bufflehead, common goldeneye and Barrow's goldeneye. These species feed primarily on aquatic insects, mollusks, crustaceans, and small fish (Gauthier 1993, Dugger et al. 1994, Fitzner and Gray 1994, Eadie et al. 1995, Hepp and Bellrose 1995). Wood ducks up to 6 weeks old depend on animal matter, while older ducklings and adult wood ducks feed on aquatic and emergent plants, acorns, grain, and other seeds (Bellrose and Holm 1994).

Nest Site Characteristics

These 5 species of ducks nest almost exclusively in tree cavities, which offer protection from weather and predators. They are secondary cavity nesters, using cavities created by large woodpeckers or by decay or damage to the tree. Cavity use is dependent on the proximity of suitable brood habitat, predator levels, and competition (and perhaps brood parasitism) from the other cavity-nesting species (Peterson and Gauthier 1985, Dugger et al. 1994, Eadie et al. 1995, Robb and Bookhout 1995). Nest site fidelity is common,
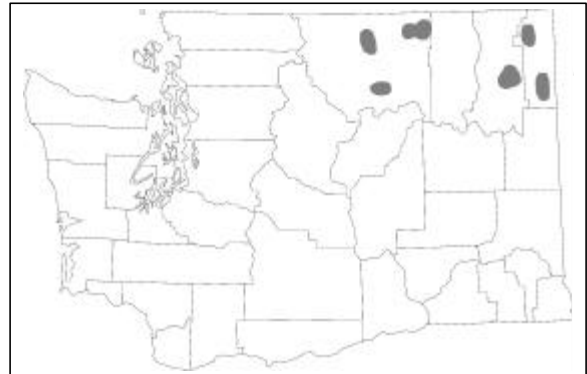
Figure 3. Breeding distribution of the common goldeneye in Washington. Map derived from GAP Anaylsis of Washington (Smith et al. 1997).

Figure 4. Breeding distribution of the hooded merganser (Lophodytes cucullatus) in Washington. Map derived from GAP Analysis of Washington (Smith et al. 1997).

Figure 5. Breeding range of the wood duck (Aix sponsa) in Washington. Map derived from GAP Analysis of Washington (Smith et al. 1997).

especially at successful nests (Dow and Fredga 1984, Hepp and Kennamer 1992, Gauthier 1993, Dugger et al. 1994). Population levels of cavity-nesting ducks can be related to the availability of nesting sites (Dow and Fredga 1984, Gauthier 1993, Dugger et al. 1994, Eadie et al. 1995, Hepp and Bellrose 1995).

In general, minimum cavity dimensions that will accommodate all 5 species include an entrance hole at least 9 cm (3.5 in) in diameter, with the internal cavity 25 cm (10 in) deep and 19 cm (7.5 in) in diameter (Gauthier 1993, Dugger et al. 1994, Eadie et al. 1995, Robb and Bookhout 1995). The bufflehead, however, appears to prefer smaller cavity entrances (6.5 cm diameter [2.5 in]; flicker nests are ideal) which may reduce nest-site competition and brood parasitism from larger ducks (especially goldeneyes) (Gauthier 1993). Hooded mergansers have less specific nest-cavity preferences, but they prefer nest sites that are within or very near brood habitat (Dugger et al. 1994). Nest trees should have a diameter at breast height (dbh) of 30 cm (12 in) (Soulliere 1988), but all 5 species typically use nest trees >60 cm (24 in) dbh. These ducks will use tree cavities that occur above 20 m (66 ft), but they generally use cavities 2-15 m (6-49 ft) above the ground or water. The canopy around a cavity is generally open and does not overhang the entrance (Bellrose 1976). Optimal density of potential nest trees is 12.5/ha (5/ac) (Sousa and Farmer 1983).

Brood Habitat

Shallow wetlands within 0.8 km (0.5 mi) of cavities provide optimal brood habitat for all cavity-nesting ducks. Wood ducks typically use habitats with 50-75% overhanging woody vegetation and/or emergent vegetation for brood escape cover (Sousa and Farmer 1983); all 5 species use downed logs or low islands for loafing (Webster and McGilvrey 1966, Gauthier 1993, Dugger et al. 1994, Eadie et al. 1995, Hepp and Bellrose 1995). Both goldeneye species and the bufflehead typically use more open water with less emergent vegetation as brood habitat (Gauthier 1993, Dugger et al. 1994, Eadie et al. 1995). Common goldeneyes prefer acidic and fishless waters where there is little or no competition from fish for aquatic insects (Gauthier 1993, Poysa and Virtanen 1994, Eadie et al. 1995).

LIMITING FACTORS

Population levels of cavity-nesting ducks can be limited by the availability of suitable nesting sites, adequate brood escape cover, foraging areas, nest predation, and nest parasitism (Dow and Fredga 1984, Gauthier 1993, Bellrose and Holm 1994, Dugger et al. 1994, Eadie et al. 1995, Hepp and Bellrose 1995). Human disturbance of nesting ducks may affect productivity. Destruction of cavity trees can eliminate these species from an area (Matt Monda, personal communication).

The use of herbicides or pesticides near wetlands may affect cavity-nesting ducks by lowering the numbers of invertebrates, and by adversely affecting aquatic and emergent vegetation. All of these ducks are known to accumulate toxins in their tissues, especially in areas where toxins are elevated, such as downstream from mines, pulp and paper mills (Blus et al. 1993, Swift et al. 1993, Vermeer et al. 1993, Champoux 1996).

MANAGEMENT RECOMMENDATIONS

An adequate supply of nest cavities is the key to supporting populations of cavity-nesting ducks in Washington. Land management activities designed to promote healthy populations of these 5 duck species should ensure a continuous supply of available nest cavities.

Snags and cavity trees near suitable wetlands should be preserved and created to achieve a minimum density of 12.5 potential nest cavities/ha (5/ac) (McGilvrey 1968). Snags and cavity trees should have a minimum diameter of 30 cm (12 in), although a diameter of 60 cm (24 in) is preferred (McGilvrey 1968).

In general, the following nest cavity characteristics will accommodate all five species and should be considered when evaluating potential nest sites:

- an elliptical entrance hole at least 9 cm (3.5 in) in diameter (buffleheads may prefer smaller cavity entrances that are 6.5 cm diameter [2.5 in])
- an internal cavity 25 cm (10 in) deep and 19 cm (7.5 in) in diameter (Gauthier 1993, Dugger et al. 1994, Eadie et al. 1995, Robb and Bookhout 1995)
- cavities 2-15 m (6-49 ft) above the ground or water are generally preferred, although cavities above 20 m (66 ft) in trees will be used
- the canopy around a cavity should be open and not overhang the entrance (Bellrose 1976)

Large woody debris and downed logs should be present, as well as low islands for breeding and brood use (McGilvrey 1968). Flooded timber should not be logged, and woody vegetation along the shores of nesting and brood areas should be retained. In some situations, flooding standing or downed timber may be used to create snags and brood habitat (McGilvrey 1968).

Predator-proof nest boxes for cavity nesting ducks can be used in areas where natural cavity sites are limited but other habitat requirements are met (Bellrose 1976). However, it is unknown how nest boxes affect natural selection or species fitness over time. In some situations, it may not be suitable to consider nest boxes as permanent substitutes for natural cavities. The decision to provide nest boxes to supplement existing cavities or nest boxes should consider occupancy rates of existing suitable nest sites.

Wood duck boxes should be designed and placed following the recommendations of Bellrose and Holm (1994). Boxes for the other four species should follow the guidelines provided by Lumsden et al. (1980) and Gauthier (1993). Nest boxes for cavity nesting ducks are commonly made out of rough-cut lumber. Other materials that can be used include sheet metal and slab wood (Bellrose and Holm 1994).

To minimize the impacts of brood parasitism, predation, and starling use, nest boxes for wood ducks should be placed far enough apart so that one is not visible from the other. (Bellrose and Holm 1994, Semel and Sherman 1995). Bellrose and Holm (1994) recommend a minimum of 46 m (150 ft) between nest box structures. Nest box placement can affect clutch size, rates of brood parasitism, and hatching success in wood ducks. Traditionally placed nest boxes that are grouped together with highly visible entrances often suffer from higher rates of brood parasitism and produce less ducklings over time than nest boxes placed in trees out of sight of each other (Bellrose 1976, Semel and Sherman 1995).

In areas supporting wood ducks, mast-producing (nut producing) trees and shrubs, such as oaks (*Quercus garryana*) and hazelnuts (*Corylus cornuta*), should be maintained.

The use of pesticides or herbicides may negatively affect these species. If pesticide or herbicide use is planned for areas where cavity-nesting ducks occur, refer to Appendix A for useful contacts to help assess the use of pesticides, herbicides, and their alternatives.

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PERSONAL COMMUNICATION

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KEY POINTS

Habitat Requirements

- Cavity-nesting ducks use natural cavities with minimum entrance size of 9 cm (3.5 in) in diameter and minimum internal dimensions of 25 cm (10 in) deep and 19 cm (7.5 in) diameter. Smaller entrances (~6.5 cm [2.5 in]) are preferred by buffleheads.
- Nest trees usually have a minimum dbh of 30 cm (12 in), although 60 cm (24 in) is preferred.
- Natural cavities 2-15 m (6-49 ft) above ground or water are typically used by all 5 species; however, use of cavities over 20 m (66 ft) is not unusual.
- Optimal density of potential nest cavities is 12.5/ha (5/ac), within 0.8 km (0.5 mi) of suitable brood habitat.
- Ideal wood duck brood habitat consists of shallow wetlands with 50-75% cover and abundant downed logs or low islands. Goldeneyes, buffleheads, and to some extent hooded mergansers do not require the amount of emergent vegetation typical of wood duck brood habitat.

Management Recommendations

- Predator-proof nest boxes for cavity nesting ducks can be used in areas where natural cavity sites are limited but other habitat requirements are met. However, in some situations, it may not be suitable to consider nest boxes as permanent substitutes for natural cavities. The decision to provide nest boxes to supplement existing cavities or nest boxes should consider occupancy rates of existing suitable nest sites.
- Wood duck boxes should be designed and placed following the recommendations of Bellrose and Holm (1994). Boxes for the other four species should follow the guidelines provided by Lumsden et al. (1980) and Gauthier (1993).
- To minimize the impacts of brood parasitism, predation, and starling use, nest boxes for wood ducks should be placed far enough apart so that one is not visible from the other. Bellrose and Holm (1994) recommend a minimum of 46 m (50 yd) between nest box structures.
- Snags and cavity trees 30 cm (12 in) (60 cm [24 in] preferred) near suitable wetlands should be maintained to achieve a minimum density of 12.5 potential nest cavities/ha (5/ac).
- Mast-producing trees and shrubs (e.g., oaks, hazelnuts) should be maintained.
- Large woody debris and downed logs should be present, as well as low islands for breeding and brood use.
- Avoid logging flooded timber and leave woody vegetation along the shores of nesting and brood areas. In some situations, flooding standing or downed timber may be used to create snags and brood habitat.
- The use of pesticides or herbicides may negatively affect these species. If pesticide or herbicide use is planned for areas where cavity-nesting ducks occur, refer to Appendix A for contacts useful for assessing pesticides, herbicides and their alternatives.

Harlequin Duck
Histrionicus histrionicus

Last updated: 1999

Written by Jeffrey C. Lewis and Don Kraege

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Harlequin ducks winter along the Pacific Coast from the Aleutian Islands to northern California and along the Atlantic Coast. Their breeding and summer range extends from the coastal mountains of Alaska to California, along the northern Rocky Mountains to northwestern Wyoming, and along the north Atlantic Coast, southern Greenland, and Iceland (Bellrose 1980).

In Washington, harlequins historically breed in the Olympic Mountains, the Cascades, and the Blue and Selkirk Mountains (see Figure 1; Jewett et al. 1953, Schirato 1994); however, their presence in the Blue Mountains is now in question (Schirato 1994). Wintering areas include northern Puget Sound, northern Hood Canal, the Strait of Juan de Fuca, San Juan Islands, and the outer coast. Significant numbers of harlequins that breed in Washington molt and winter in the Strait of Georgia, British Columbia (I. Goudie, personal communication). Also, some harlequins that molt and winter in Washington breed in interior British Columbia, Alberta, Idaho, Wyoming, and Montana.
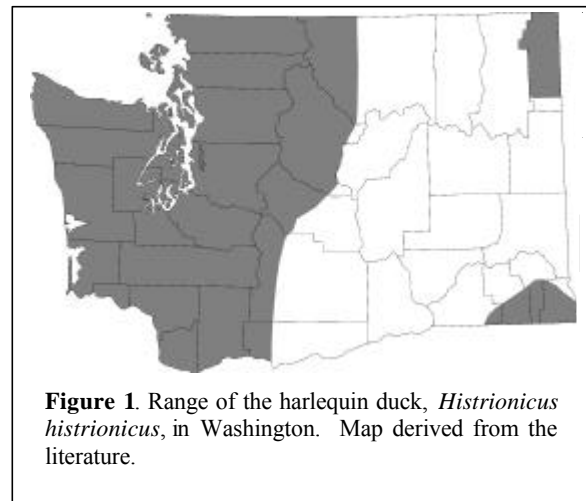

Figure 1. Range of the harlequin duck, *Histrionicus histrionicus*, in Washington. Map derived from the literature.

RATIONALE

The harlequin duck is a Washington State Game species that provides year-round recreation for consumptive and non-consumptive users. This species is limited by low productivity, older age at sexual maturity, and low intrinsic rate of population growth (Goudie et al. 1994). They are also sensitive to human disturbance (Cassirer and Groves 1994), which is likely to decrease their productivity.

HABITAT REQUIREMENTS

During the nesting season (April-June), adult harlequin ducks require fast-flowing water with loafing sites nearby. Streams usually have substrate that ranges from cobble to boulder, with adjacent vegetated banks. They have been found more often at distances >50 m (164 ft) from roads or trails, and in stream reaches with mature and old growth forest cover (Cassirer and Groves 1994). Whereas harlequins generally appear to avoid certain types of human disturbances, some anecdotal evidence has shown that individuals may use and even nest in areas that are regularly

visited by humans (Cassirer et al. 1993). Harlequins often nest on the ground (Bengtson 1972), however, cavities in trees and cliff faces also serve as nest sites (Cassirer et al. 1993). Midstream loafing sites are an important part of suitable habitat (Cassirer and Groves 1994). Since adult females show fidelity to nest sites, it is unlikely that they will relocate to new nesting areas once they are disturbed (Wallen and Groves 1989). However, radio-tagged harlequins have used new nest sites after a nest failure the previous year (Cassirer et al. 1993).

Broods remain near nesting areas for the first few weeks after hatching, then move downstream during the summer (Kuchel 1977, Wallen 1987, Cassirer and Groves 1989). Broods prefer low-gradient streams with adequate macroinvertebrate fauna (Bengtson and Ulfstrand 1971). Preferred prey include crustaceans, molluscs, and aquatic insects (Cottam 1939). Aquatic insect larvae appear to make up the bulk of the diet for juveniles and for adults during the breeding season (Cassirer and Groves 1994).

During winter, harlequins forage and loaf along boulder-strewn shores, points, gravel substrates, and kelp beds. Prey species occur chiefly on rock substrate (70%) and gravel substrate (22%) (Vermeer 1983). Most wintering harlequins occur within 50 m (164 ft) of shore in saltwater areas (Gaines and Fitzner 1987).

LIMITING FACTORS

Low benthic macroinvertebrate abundance may limit the productivity of harlequin ducks (Bengtson annd Ulfstrand 1971). Human disturbance discourages nesting at traditional sites and thereby decreases productivity. A high tendency for individuals to breed at the same location year after year may result in a separation of populations with little chance to replenish stable or declining populations. Populations are highly sensitive to additional mortality from such causes as hunting, oil pollution, or food contamination. Additional mortality sources exceeding 5% appear to be unsustainable (Goudie et al. 1994).

MANAGEMENT RECOMMENDATIONS

Maintain woody debris and riparian vegetation in and adjacent to streams. A 50 m (164 ft) buffer along nesting streams is necessary to recruit suitable large organic debris for loafing sites and to ensure cover for nesting females and protective cover from predators (Murphy and Koski 1989). A larger buffer may be necessary on second growth stands. Logging activity in the riparian corridor should be avoided (Cassirer and Groves 1989, 1994).

Stream alterations that would cause greater surface runoff, changing water levels, or lower macroinvertebrate levels should be avoided (Kuchel 1977).

Human disturbance should be managed during the breeding and brood-rearing season (April-August). To limit disturbance, trails or roads should be farther than 50 m (164 feet) from streams used by harlequin ducks and should not be visible from the stream (Cassirer and Groves 1989). Fishing, rafting, and canoeing activities should be limited on streams used by nesting harlequins (Wallen 1987), especially in streams <20 m (66 ft) in width. The April through August nesting and brood-rearing period are the critical months to reduce disturbance.

Rocky shoreline areas used during winter should be protected. Disturbances at traditional coastal molting sites should be limited.

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PERSONAL COMMUNICATIONS

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KEY POINTS

Habitat Requirements

- In the summer, adult harlequin ducks require fast-flowing streams with clear water, loafing sites, and dense bank vegetation.
- Broods require low gradient streams with an adequate macroinvertebrate food supply.
- During the nesting season, harlequin ducks require areas with little or no human disturbance.
- Harlequin ducks winter along rocky marine shorelines, frequently using kelp beds.

Management Recommendations

- Manage human disturbance during the breeding and brood-rearing season (April-August).
- Protect rocky shoreline areas used during winter. Limit potential disturbance at traditional coastal molting sites.
- Maintain woody debris and riparian vegetation in and adjacent to streams.
- A 50 m (164 ft) buffer along nesting streams is necessary to recruit suitable large organic debris for loafing sites. A larger buffer may be necessary on second growth stands. Provide nesting and hiding cover within this buffer.
- Logging activity in the riparian corridor should be avoided.
- Stream alterations that would cause greater surface runoff, change water levels, affect water quality, or lower macroinvertebrate levels should be avoided.
- To limit disturbance, trails or roads should be farther than 50 m (164 ft) from streams used by harlequin ducks, and should not be visible from the stream. Also fishing, rafting, and canoeing activity should be limited on streams used by nesting harlequins, especially if such streams are <20 m (66 ft) wide.
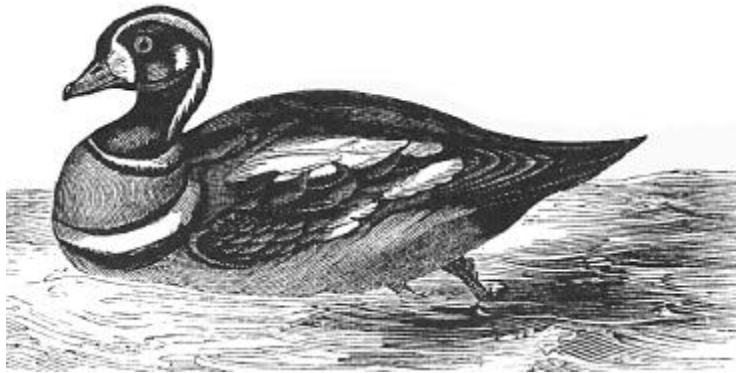
Northern Goshawk
Accipiter gentilis

Last revised: 2003

Written by Steven M. Desimone and David W. Hays

GENERAL RANGE AND WASHINGTON DISTRIBUTION

The northern goshawk (*Accipiter gentilis)* is holarctic in distribution, occupying a wide variety of boreal and montane forest habitats throughout Eurasia and North America (Palmer 1988, Johnsgard 1990). Three subspecies of the goshawk are recognized in North America (Johnsgard 1990, James and Palmer 1997), but only the northern goshawk (*A.g. atricapillus*) is known in Washington.

Northern goshawks can occur in all forested regions of Washington (see Figure 1). As of 2003, there were 338 documented breeding territories in the state (Washington Department of Fish and Wildlife [WDFW], unpublished data). The exact number is not known, because monitoring is not currently being

Figure 1. Shaded areas contain the general forest conditions that could provide potential suitable habitat for the northern goshawk (*Accipiter gentilis)* in Washington.

conducted. The number of historical breeding sites lost due to habitat alteration and the number of new territories in suitable habitat are also unknown. About 50% of the documented breeding territories occur in the eastern Cascades, 27% in the western Cascades, 12% in other forested areas of northeast and southeast Washington, and 10% in the Olympic Peninsula (WDFW, unpublished data). Breeding birds formerly occurred in the Puget trough (Jewett et al. 1953). Less than one percent of recent breeding records have been recorded from this area and southwest Washington (south of the Puget Sound and west to the coast). Wintering goshawk populations in Washington include resident birds (Bloxton 2002; WDFW, unpublished data) and migrants that move into the state during winters when food shortages occur in their territories (Squires and Reynolds 1997). Overall, densities of territorial pairs in Washington appear to be lower than elsewhere in the western United States (Table 1) but this is partly dependent on habitat quality.
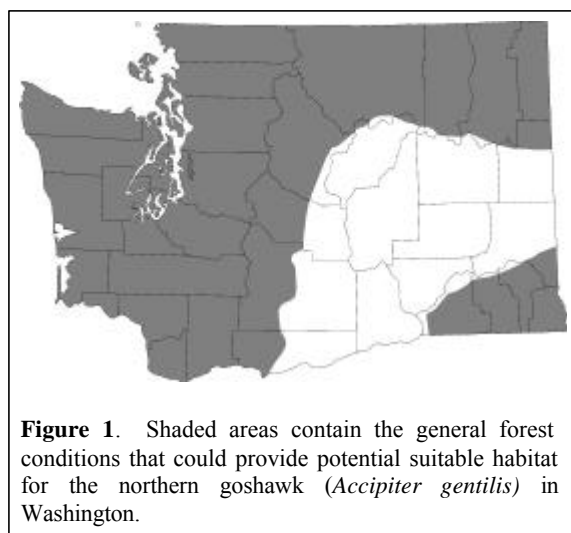
Table 1. Density estimates of northern goshawk territories in the western United States. Forest management in the study areas ranged from intensive to minimal timber harvest.

Study	Number of pairs	Mean distance (km) to nearest-neighbor	Density (territories/ 1000 ha)	Spacing (ha/pair)	Reference
Western Washington industrial forest	3	-	0.04-0.13	-	Bosakowski et al. 1999
Upper Yakima River, Washington	1 4 5	- - -	0.1 [a, b] 0.5 [a, c] 0.5 [a, d]	9091 2083 1852	Wagenknecht et al. 1998
Eastern Oregon National Forests	20	4.4	0.7	1538	DeStefano et al. 1994
Eastern Oregon	4	5.6	-	2750	Reynolds and Wight 1978
Klamath National Forest, California	21	3.3	0.6 - 1.1	1750 - 935	Woodbridge and Detrich 1994
North Kaibab NF, Arizona	100	2.5	2.0	491	Reynolds 1997, Reynolds and Joy 1998

[a] Estimate calculated with one year of survey data in each forest type; [b] Open Douglas-fir/ponderosa pine; [c] mixed conifer-lodgepole pine; [d] mixed Douglas-fir, grand fir, western hemlock

RATIONALE

The northern goshawk is a Federal Species of Concern and State Candidate species in Washington because of concerns about its population status. Although a decline in populations of northern goshawks has been suggested based on reduced nesting in areas of extensive harvest of mature forest (Crocker-Bedford 1990, 1995; Ward et al. 1992), Kennedy (1997) found no evidence to support the contention that goshawk populations in the western United States were declining, increasing, or stable. Kennedy (1997) acknowledged, however, that population declines might not be apparent due to insufficient sampling techniques. In Washington, goshawks appear to have been largely extirpated from urbanized landscapes and from some areas that are moderately developed or intensively managed for timber on short rotations (WDFW, unpublished data). There are no studies evaluating the population status of the goshawk in the Pacific Northwest. Because goshawks build multiple nests within nesting territories that are often used by other raptor species (Moore and Henny 1983, Buchanan et al. 1993; S. Desimone, unpublished data), the loss of goshawks might indirectly affect other forest species.

HABITAT REQUIREMENTS

Research in western North America suggested that the home range of breeding goshawks can be split into three functional divisions: the nest area or areas, the post-fledging family area (PFA), and the foraging area; the sum of these areas compose a northern goshawk's home range (Reynolds et al. 1992) (Figure 2). Habitat information relevant to each of these scales is provided below.

Nest Area

The nest area (in some studies referred to as the *nest stand*) is composed of one to several forest stands that contain the active and alternate nest structures (Figure 2). Usually occupied by breeding goshawks from March until

September, nest area boundaries are determined by the movement and behavior of the adults and newly fledged young, and by the locations of prey plucking areas and roosts that are usually within the nest area. (Reynolds et al. 1982). The term "occupied" is defined by the presence of at least one adult goshawk in the area or territory during a breeding season surveys (Desimone 1997; Finn et al. 2002a, b). The size of nest areas ranged between 8-12 ha (20-30 ac) (Reynolds 1983, Crocker-Bedford and Chaney 1988, Reynolds et al. 1992), but other studies suggest that nest areas can be larger (39 ha [96 ac; Finn et al. 2002a] up to 115 ha [284; Woodbridge and Detrich 1994]).

Within the nest area, the nest site is defined for this document as the immediate vicinity surrounding the nest tree, usually = 1.0 ha (2.5 ac; see McGrath et al. 2003). Goshawks in Washington nest almost exclusively in coniferous forest, although a few nests have been found in smaller aspen (*Populus* spp.) groves within the larger coniferous forest landscape in Okanogan County, Washington (WDFW, unpublished data; S. Desimone, personal observation).

Stand age. Studies in North America indicate that goshawks typically select mature or old forest habitat for nesting (Reynolds et al. 1982, Moore and Henny 1983, Fleming 1987, Crocker-Bedford and Chaney 1988, McGrath 1997, Daw and DeStefano 2001; Finn et al. 2002a, b). Research in Washington and Oregon has shown links between nest stand occupancy and forest stand age. Finn et al. (2002a) found late-seral forest consistently averaged 64-75% of the nest areas (39 ha [96 ac]), PFA (177 ha [437 ac]) and home ranges (1886 ha [4660 ac]) of occupied goshawk territories on the Olympic Peninsula, and the average age of trees at occupied nest stands in managed and unmanaged forest were 147 years (95% CI 97-198) (Finn et al. 2002b). These forests are generally characterized by large sawtimber, >50% canopy closure, two or more canopy layers, gaps in the canopy, abundance of large diameter crowns, and the presence of shade tolerant trees. Most goshawk nests in eastern Washington (Finn 1994, McGrath 1997; J. Buchanan, unpublished data) and Oregon (Reynolds et al. 1982, Desimone 1997, Daw and DeStefano 2001, McGrath et al. 2003) were in mature or older forest. In eastern Oregon, Daw and DeStefano (2001) showed that goshawk nest stands were negatively associated with regenerating and young (average diameter at breast height [dbh]: 12-22 cm [5-9 in]) forest at the

Figure 2. An idealized diagram (not to scale) for management of the breeding home range of the northern goshawk. Filled circles represent a possible nest site (i.e., tree where nest is located); open circles are nest sites within replacement nest areas (suitable or developing stands). Scale sizes represent averages. The Foraging Area of 2200 ha does not include the PFA and Nest Areas (i.e., 2200+170+72 = 2442 ha = total Home Range).

nest stand scale (10 ha [25 ac]). In east-central Washington and eastern Oregon, McGrath (1997) determined that increasing the amount of early-seral forest by 1% within specified areas surrounding the nest tree would decrease the odds of the site being suitable for nesting by 10%.
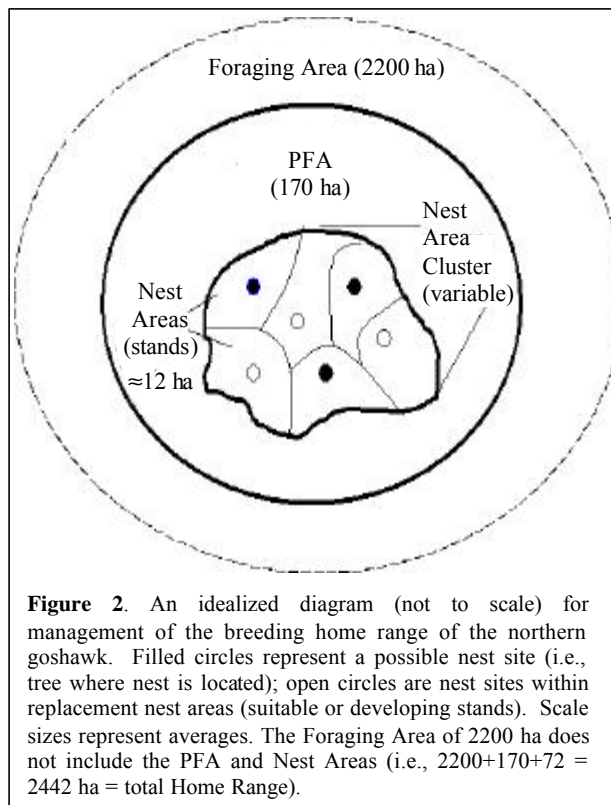
Finn (unpublished data) studied landscape patterns and habitat patch features around 25 goshawk nests in the upper Yakima River basin from 1992-1996. They found that the landscape surrounding nests was more homogeneous and contained less seedling/sapling and forest edge than what was available at the combined nest areas scale (32 ha [79 ac]) and at the post-fledging family area scale (210 ha [519 ac]). At the foraging range scale (3,566 ha [8,812 ac]), no differences were found between areas used by goshawks versus other areas in the landscape.

Tree density. Goshawk nest areas generally have a high density of large trees. On the Olympic Peninsula, the average diameter of trees within occupied nest areas was 59 cm (23 in; 95% CI 51 - 67cm) (Finn et al. 2002b). These stands had more large-diameter (≥63cm [25.7 in; 95% CI 22-59 cm]) trees than unoccupied historic nest areas. In the Olympic Peninsula and western Cascades, dominant and co-dominant trees in nesting stands averaged 43-48 cm (17-19 in) dbh and generally exceeded 27 m (89 ft) in height (Fleming 1987). On average, there were 482 trees/ha (195 trees/acre) >6 cm dbh (2.4 in) within nest stands in eastern Oregon (Reynolds et al. 1982). Finn (1994)

found that goshawk nest stands contained more snags and down woody material, had greater basal area, and an increased number of tree species than random plots in Okanogan County, Washington.

Canopy attributes. Researchers have used various methods to measure forest canopy and this may influence the ability to compare different data sets. Despite this, the overwhelming majority of stands used by nesting goshawks have relatively closed canopies (i.e., >50%) and are often characterized by multiple canopy layers. In western Washington, Fleming (1987) found goshawk nests in stands with an average canopy closure of about 60-65%. Additionally, nest stands had one to three canopy layers with generally poor development of understory vegetation. Similarly, Finn et al. (2002b) found that canopy closure in occupied nest areas averaged 78% in the Olympic Peninsula. Occupied nest areas had relatively greater canopy depth (i.e., the difference between the average maximum and minimum overstory height; Finn et al. 2002a) as compared to unoccupied historic nest areas. The odds of occupancy at historical nest areas increased with increasing overstory canopy depth (Finn et al. 2002a). Greater canopy depth coupled with low shrub density best discriminated occupied nest areas versus unoccupied historic nest areas (Finn et al. 2002a). This research also showed that occupancy of a stand by goshawks decreased by 47% with each 10% increase in understory shrub cover. Overall, increasing early-seral forest cover was associated with decreasing goshawk occupancy at historical nest stands on the Olympic Peninsula (Finn et al. 2002a).

Canopy attributes east of the Cascades are relatively similar to the previously discussed west-side attributes. Goshawk nest stands in eastern Oregon typically had multi-layered canopies with green foliage occurring a few meters to over 40 m (131 ft) above the ground, and the tops of understory trees overlapped with the lower crowns of overstory trees (Reynolds et al. 1982). In Okanogan County, average overstory canopy closure in nest stands was 75% (Finn 1994), and canopy closure in the eastern Cascades averaged 74% in stands where spotted owls exploited goshawk nests for breeding (J. Buchanan, personal communication). In east-central Washington, canopy closure averaged 73% (McGrath 1997). In eastern Oregon, mean canopy closure was 60% (Reynolds et al. 1982) and 88% (Moore and Henny 1983) within nest stands.

Size. The sizes of goshawk nest areas in the Pacific Northwest are variable. On the Olympic Peninsula, occupied goshawk nest areas averaged 33 ha (82 ac) (range: 12-69 ha [30-170 ac]) (Finn et al. 2002b). The conclusions of Finn et al. (2002a) indicated that the composition of nest areas was largely (about 67%) late-seral forest.

In eastern Oregon, Reynolds and Wight (1978) found that the size of nest areas or stands varied with topography and the availability of large trees in dense patches of at least 10 ha (25 ac). Woodbridge and Detrich (1994) found that goshawk territories in northern California contained one to five different forested nesting stands (average = 2). These nest stands were homogeneous in composition, age, and structure relative to the surrounding forest (Woodbridge and Detrich 1994). Stands <10 ha (25 ac) typically contained one or two nests that were occasionally occupied by goshawks, whereas stands >20 ha (49 ac) often contained several nests that were frequently occupied (Woodbridge and Detrich 1994).

Spacing and number of nests. Established pairs of goshawks have multiple nest areas that are often structurally similar within a home range (Reynolds et al. 1992). Goshawks may build =10 nest structures within a territory that can be occupied over multiple generations (Crocker-Bedford 1990; S. Joy and T. Fleming, personal communications). In western Washington, the distance between alternate nests of the same territory averaged 536 m (1759 ft) (S. Finn, unpublished data). In more arid forested habitats such as pine and mixed conifer, the average distance between alternate nests within a territory ranged between 245 and 273 m (804-896 ft) (Reynolds et al. 1994, Woodbridge and Detrich 1994, Desimone 1997).

Nest tree and nest site. Nest structures in western Washington are often in Douglas-fir (*Pseudotsuga menziesii*), with western hemlock (*Tsuga heterophylla*) used to a lesser extent (Fleming 1987, Finn 2000). Nests in deciduous trees are uncommon (Fleming 1987; S. Finn and T. Bloxton, unpublished data). Deciduous trees used for nesting west of the Cascade mountain crest (e.g., red alder [*Alnus rubra*]) were generally found in the sub-canopy and isolated in coniferous forest stands comprised of less than 2% deciduous species (Finn et al. 2002b). Goshawks in eastern Washington and Oregon nest in Douglas-fir, ponderosa pine (*Pinus ponderosa*), western larch (*Larix occidentalis*), lodgepole pine (*Pinus contorta*), grand fir (*Abies grandis*) and occasionally aspen (Finn 1994,

McGrath 1997; WDFW, unpublished data). In areas of heavy mistletoe infection, goshawks will use mistletoe "brooms" as a nesting substrate (Moore and Henny 1983, Buchanan et al. 1993, Finn 1994). They may also occasionally nest in dead trees (Moore and Henny 1983; S. Desimone, unpublished data). Average nest tree size in the Pacific Northwest is >53 cm (21 in) dbh (range: 25-172 cm [10-68 in]) (Moore and Henny 1983, Fleming 1987, Bull and Hohmann 1994, McGrath et al. 2003; S. Finn, unpublished data). Goshawks build fairly large, bulky stick nests (about 0.6-0.9 m [2-3 ft] outside diameter), and nest placement is usually in the lower third of the forest canopy and relatively close to the tree trunk (Reynolds et al. 1982, McGrath 1997, Finn 2000).

Basal area at the nest site is usually higher than that of the surrounding stand. McGrath (1997) measured vegetation attributes around 82 active goshawk nests in eastern Oregon and central Washington east of the Cascade crest. At the nest site scale (1 ha [2.5 ac]), higher basal area best discriminated nest sites from random sites. Nest sites had higher average basal area/tree, and greater live stem density compared to random sites (McGrath 1997). In Montana and northern Idaho, 0.04 ha (0.1 ac) plots around nest sites (n=17) had an average of about 6 trees/plot that were >30 cm dbh (64 trees/ac >12 in) (Hayward and Escano 1989). In northeastern Oregon, Moore and Henny (1983) reported an average of 208 trees/ha >32 cm dbh (84 trees/ac >13 in) surrounding 34 nests.

Goshawks pluck the hair or feathers of their prey before consuming or bringing it to the nest for incubating/brooding females or young. Consequently, established 'plucking posts' (i.e., perches used to pluck captured prey) may be present within the nest area and are typically within 100 m (328 ft) of an active nest (S. Desimone, unpublished data).

Water and topography. It is unclear whether goshawks prefer to nest close to water, but close proximity to water may improve nesting conditions in drier forest types based on the results of several studies (see Reynolds et al. 1982, Hargis et al. 1994, Squires and Reynolds 1997). Bathing by a brooding goshawk in hot dry climates may help to maintain proper humidity in the nest during incubation, and may aid in thermoregulation (Hennessy 1978). However, Crocker-Bedford and Chaney (1988) found no association with water in Arizona where actual breeding density was high. Overall, goshawk nests in western Washington generally averaged >200 meters (654 ft) from perennial water (WDFW, unpublished data). On the Olympic Peninsula, water bodies were an average of 232 m (761 ft) from nest sites (S. Finn, unpublished data). Other studies found that goshawk nests were generally within 200-300 m (656-984 ft) of permanent water sources in Idaho (Hayward and Escano 1989), northeastern Oregon (Bull 1992), and in the eastern Cascades of Washington (McGrath 1997). However, McGrath (1997) found that eastern Oregon nest sites averaged =335 m (1099 ft) from water. Goshawk nests in east-central Washington and Oregon were generally associated with low topographic position (i.e., lower 1/3 or bottom of drainage; McGrath et al. 2003; J. Buchanan, personal communication), most likely because the larger trees at lower elevations provided a more favorable microclimate. McGrath et al. (2003) found only a single nest near a ridge top east of the Cascades, and Bull (1992) found no goshawk nests near ridge tops in eastern Oregon.

Nest area cluster. Woodbridge and Detrich (1994) suggested that the aggregate of all nest stands and alternate nests within a goshawk pair's territory form a "cluster" of nest stands (i.e, "nest stand cluster"; see Figure 2). For this document, the aggregate of nest areas will be referred to as the "Nest Area Cluster" (NAC). A pair's NAC generally does not overlap with NACs of neighboring territories. NACs are variable in size and their size is believed to be less than that of the PFA (Woodbridge and Detrich 1994). It is possible the NAC coincides with PFAs, but this has not been verified. The occupancy of nesting stands (or nesting areas) by marked territorial adults was used as a basis for the NAC concept (Woodbridge and Detrich 1994).

On the Klamath National Forest in California, NACs ranged between 11 and 114 ha (26-282 ac) (Woodbridge and Detrich 1994). Occupancy rates of clusters <20 ha (49 ac) were typically less than 50%. However, occupancy at clusters that were 40 ha (99 ac) and 41-61 ha (100-151 ac) were 75-80% and about 90%, respectively, and nearly 100% of clusters >61 ha (151 ac) were occupied. Overall, long-term territory occupancy was positively correlated with the size of clusters and with larger proportions of mature forest (Woodbridge and Detrich 1994). This larger percent of area in older forest appears to provide more opportunities to maximize a pair's chance of maintaining occupancy.

Mid- and late-successional habitat is strongly associated with goshawk sites at the NAC scale. In eastern Oregon, Desimone (1997) found that substantial amounts of mid- (average dbh of 23-53 cm [9-21 in]) and late-successional

(average dbh >53 cm [21 in]) forest at the NAC scale (52 ha [128 ac]) were important to the persistence of goshawks in historic territories. Occupied areas during that study had more forest area with these characteristics than historic territories without goshawks. Within the 52 ha (128 ac) surrounding historic nests, habitat around recently occupied sites was not significantly different from occupied historic sites at the time they were last known to be active. The historic sites where no goshawks were located had significantly lower amounts of combined mid-age and late-successional forest within the NAC. It was concluded that recent site conditions within the NAC that most resembled the historic conditions contributed to the persistence of goshawks in a territory over time (Desimone 1997).

Post-fledging Family Area

The Post-fledging Family Area (PFA) contains the nest area(s) and is an area of concentrated use by adult females and developing juveniles after fledging and prior to natal dispersal (Reynolds et al. 1992, Kennedy et al. 1994). The PFA surrounds and includes nest area habitat (Kennedy et al. 1994), and provides foraging opportunities for adult females and fledgling goshawks, as well as hiding cover for fledglings (Reynolds et al. 1992). The parameters used to calculate the PFA included the average core area used by nesting females as well as the average distance juveniles dispersed from the nest tree over a specified time period (Kennedy et al. 1994). PFAs in New Mexico were high-use core areas used by breeding females that averaged 168 ha (415 ac; Kennedy et al. 1994), and may have corresponded to the defended areas of goshawk pairs (Reynolds et al. 1992). Similarly, high-use areas of adult breeding females (post-hatching) in western Washington averaged about 143 ha (353 ac) (S. Finn, unpublished data). These values are similar to the average of 168 ha (415 ac) reported by Kennedy et al. (1994) for core-use areas of breeding females.

Studies on the use of habitats by northern goshawks in the PFA indicate the importance of structurally complex forests. McGrath (1997) measured structural stages on the eastern Cascades within 83 and 170 ha (205 and 420 ac) areas around recently active nests. He found that "stand initiation phase" (clearcut/sapling stage) accounted for 7% (range 0-23%) of the 83 ha (205) plot and 10% of the 170 ha (420) plot; both values were significantly smaller than random sites. In the southwestern United States, the PFA contained 40% (by area) mature and old forest with >40% canopy closure (Reynolds et al. 1992). In eastern Oregon (with forest types similar to the southwestern U.S.) PFAs consisted of an average of 22% (Desimone 1997) and 29% (Daw and DeStefano 2001) dense canopy, late-seral (>50% canopy closure and =20 trees/ha >53cm) forest. In western Washington, PFAs contained an average of 72% (95% CI = 59-84) mature (>10% of trees >53 cm [21 in] dbh) coniferous forest (Finn et al. 2002a). PFAs consisted of forests with a dense cover of trees and an abundant number of snags and down logs (Reynolds et al. 1992).

Foraging Areas (breeding season) and Home Range

Foraging areas are the various habitats where goshawks secure prey. Foraging areas also define the goshawk's home range during the breeding season. Home range (HR) size estimates for goshawk pairs in western states (other than Washington) ranged between 569-3774 ha (1400-9321 ac) (Austin 1993, Bright-Smith and Mannan 1994, Hargis et al. 1994, Kennedy et al. 1994). The average HR size on managed forest landscapes in western Washington was 3710 ha (9164 ac) (range 844 to 10,730 ha [2084-26500 ac]) (Bloxton 2002). Males generally had larger HRs than females, while HRs of non-breeders tended to be larger than that of breeders. Two years of unusually wet conditions was thought to partly explain variability in foraging distances from nests of male goshawks (Bloxton 2002).

Goshawks forage in a variety of forest types. Limited information describing goshawk foraging habitat is available for Washington. Bloxton (2002) found that goshawks tended to hunt in stands with larger diameter (= 50 cm [20 in]) trees, and they avoided stands in the sapling and pole stages. Kill sites had greater basal area (average = 52 m^2/ha), snag density (average = 77 snags/ha = 13 cm dbh [31 snags/ac =5 in]), large tree density (average = 62 trees/ha >50 cm dbh [25 snags/ac = 20 in]) and higher average dbh (32 cm [13 in]) than random sites. Bloxton (2002) reported that a disproportionately high number of goshawk kill sites were in forests with a 25-36 cm (10-14 in) quadratic mean dbh (Qdbh; i.e., the dbh of a tree with average basal area in a stand) as well as in mature (35-51 cm [14-20 in] Qdbh) and old-growth (>51 cm [20 in] Qdbh) structural classes. Also, 96% of kill sites had canopy closures = 60% (average = 77%). Bloxton (2002) noted that young (< 30 years) forests generally did not provide

appropriate conditions (i.e., large trees with well developed canopies, adequate flight space beneath the canopy) for goshawk hunting.

In ponderosa pine forests of northern Arizona, breeding male goshawks preferred to forage in mature forests with higher basal areas and higher densities of trees >41 cm (16 in) dbh (Beier and Drennan 1997). In winter, foraging sites used by the same birds had higher canopy closure and more trees between 20-40 cm (8-16 in) dbh as compared to random sites (Drennan and Beier 2003). Based on these findings, one could conclude that in landscapes where the coverage of older forest has decreased, foraging areas and home ranges would become larger and territories more widely spaced (see Crocker-Bedford 1998).

Goshawks in the Cascade Range of northern California selected closed canopy mature and old-growth stands for foraging (>51 cm [21 in] average dbh and >40% canopy closure) (Austin 1993). Greater basal area, more large trees (>46 cm [18 in] dbh), and higher canopy closure characterized areas of goshawk use in eastern California as compared to random sites (Hargis et al. 1994).

Studies in the western United States (Austin 1993, Bright-Smith and Mannan 1994, Hargis et al. 1994, Desimone 1997, Patla 1997, Daw and DeStefano 2001; Finn et al. 2002a, b) indicate that mid- to late-successional forested habitats comprise a significant proportion of the total home range area. Average habitat composition of the HR (1886 ha [4660]) was 64% (95% CI 54-78) "late-seral" forest on the Olympic Peninsula (Finn et al. 2002a). Historical goshawk sites were more likely to be occupied in landscapes (i.e., home ranges) dominated by large uniform patches in late-seral stages.

Diet

Goshawks are considered opportunistic foragers (Beebe 1974), as exhibited by the wide range of prey taken in the United States (Squires and Reynolds 1997). Douglas' squirrel (*Tamiasciurus douglasii*), grouse, and snowshoe hare (*Lepus americanus*) were the most frequently represented prey species (representing 54% of all prey in the eastern slope of the Cascade range and Okanogan county and 41% in the Olympic peninsula and west slope of Cascade range) (Watson et al. 1998). Chipmunks (*Tamias* spp.), northern flying squirrel (*Glaucomys sabrinus*), Steller's jay (*Cyanocitta stelleri*), northern flicker (*Colaptes auratus*) and small woodpeckers (Picidae) each constituted >3% of the goshawks diet by frequency. Passerine bird species (e.g., American robin [*Turdus migratorius*]) accounted for 28% of west-side and 18% of the east-side prey by frequency (Watson et al. 1998). Goshawks in the northeastern Cascades took the highest proportions of grouse, while those in the Olympics took the fewest. Combined grouse and snowshoe hare accounted for the majority of all prey biomass consumed. Similar prey species and ratios were documented in eastern Oregon (Reynolds and Meslow 1984, Bull and Hohman 1994, Cutler et al. 1996).

In northeastern Washington and the Blue Mountains, the red squirrel (*T. hudsonicus*) replaces the Douglas' squirrel as an important food item (Hayward and Escano 1989, Patla 1997; D. Base and S. Fitkin, personal communications). In Klickitat County, a western gray squirrel (*Sciurus griseus*) was observed being taken by an immature goshawk in ponderosa pine/Garry oak (*Quercus garryana*) habitat (M. Linders, personal communication).

Bloxton (2002) studied goshawk foraging behavior and prey use among 15 territories in an intensively managed forest landscape in western Washington. He found that grouse (ruffed and blue combined) and band-tailed pigeon (*Columba fasciata*) were the predominant prey by frequency, followed by Steller's jay, snowshoe hare, thrushes (Turdidae), woodpeckers, Douglas' squirrel, northern flying squirrel, other rodents, and birds. Grouse and hares probably represented the majority of biomass consumed.

Given the importance of snowshoe hare in Washington goshawk diets, it is possible that goshawk territory occupancy could fluctuate in response to cyclical changes in snowshoe hare abundance (e.g., see Doyle and Smith 1994). However, the variety of prey species identified suggests that Washington's goshawks are not dependent on hare and grouse abundance because of opportunistic feeding on other prey species (Watson et al. 1998).

Dispersal

Dispersal data for adult goshawks in the western U.S. is limited. The cycling population patterns of snowshoe hare and grouse are believed to influence periodic southward movement of goshawks from northern Canada (Squires and Reynolds 1997). Although some goshawks appear to disperse short distances during the non-breeding season, most populations are believed to be non-migratory (Johnsgard 1990, Squires and Reynolds 1997, Bloxton 2002, Drennan and Beier 2003). These short-distance movements are likely a response to prey availability during winter (Keane and Morrison 1994, Reynolds et al. 1994, Squires and Ruggiero 1995, Drennan and Beier 2003; T. Bloxton, personal communication). In western Washington, female goshawks had higher winter site fidelity to their breeding areas compared to their mates (Bloxton 2002). Adult northern goshawks are not believed to make significant movements to seek new breeding sites (Detrich and Woodbridge 1994, Doyle and Smith 1994, Reynolds and Joy 1998).

Limited information is available about dispersal patterns in Washington. In one unpublished study, four immature goshawks were captured, marked, and released near Chelan, Washington, in autumn; they occupied transitional areas between coniferous forest and either subalpine parkland or lower elevation shrub-steppe savannah. Monitored until their deaths (average survival time: 13 weeks), they remained within 150 km of their banding site (J. Smith, personal communication).

LIMITING FACTORS

Generally, the two most significant limiting factors to the long-term productivity and survival of raptors are the availability of suitable prey and nesting habitat (Newton 1979). Although the effects of timber harvesting on goshawks in the United States are not fully understood, there is evidence to suggest that harvest impacts nest site selection (Reynolds 1989, Crocker-Bedford 1990, Ward et al. 1992, Woodbridge and Detrich 1994, Desimone 1997; Finn 2002a, b), and potentially, nesting rates (Crocker-Bedford 1990, 1995). In addition, nesting goshawks appear to be largely absent from some extensive forested landscapes in western Washington that have been intensively managed on rotations =50 years (WDFW, unpublished data). Fragmentation of suitable habitat potentially increases interaction with competing raptors (e.g., red-tailed hawks [*Buteo jamaicensis*], great horned owls [*Bubo virginianus*]) (Moore and Henny 1983, Crocker-Bedford and Chaney 1988, Crocker-Bedford 1990, Kenward 1996). The impact of regulated falconry on wild raptor populations is thought to be minimal (Conway et al. 1995, Kenward 1997, Mosher 1997), but is largely unknown for goshawks (Squires and Reynolds 1997).

MANAGEMENT RECOMMENDATIONS

Management recommendations for goshawks in Washington before the publication of this volume largely relied on the Northern Goshawk Scientific Committee's (GSC) recommendations developed for forests in the southwestern United States (Reynolds et al. 1992). The GSC recommendations were prescriptions that reflected a balance of different forest age classes to provide "desired forest conditions" needed to sustain goshawk populations and an adequate prey population in the U.S. Forest Service's (USFS) Southwestern Region (Reynolds et al. 1992). Many of the following recommendations for Washington are still based, at least in part, on the GSC guidelines because there is currently limited information for northern goshawks in the Pacific Northwest. However, where appropriate, some of the following prescriptions are based on recent research in western Washington.

Certain general forest types listed in the GSC guidelines may be similar to some forest types in eastern Washington (e.g., ponderosa pine and higher elevation mixed conifer) and the guidelines may be more applicable to these forest types east of the Cascade crest (S. Desimone, personal observation; R. Anthony and R. Reynolds, personal communications). Although eastern Washington vegetation data have not been fully evaluated in goshawk studies, some information exists that can be used to make limited comparisons (see Finn 1994, McGrath 1997). However, the GSC guidelines have not been assessed in Washington, particularly for moist forest types west of the Cascade crest (e.g., western hemlock/Douglas-fir and Sitka spruce zones). Also, eastern Washington lodgepole pine, moist Douglas-fir/grand fir/western larch, and true fir/Engelmann spruce (*Picea engelmannii*) forest stands have not been

assessed. Overall, the GSC does not recommend applying specific management prescriptions outside of the southwestern United States. Rather, they recommend the application of general GSC model concepts elsewhere (R. Reynolds, personal communication). In addition, Anthony and Holthausen (1997) caution that the appropriateness of the PFA and foraging area estimates need to be tested for applicability to the Pacific Northwest.

Nest Areas

Nest areas should be approximately 12 ha (30 ac) in size (Reynolds et al. 1992). At least three suitable nest areas should be protected per home range (Reynolds et al. 1992). In addition, at least three replacement areas should be present per home range, for a total of 72 ha (180 ac) (Table 2). If only one nest area is known, additional stands and replacement areas within the PFA management areas should be identified and protected. Alternate nest areas selected by managers should be structurally similar to known nest areas (Reynolds et al. 1992). Replacement nest areas are needed because goshawk nest areas are subject to disturbances such as fire and windthrow. Selection of nest areas should prioritize active or most recent nest areas over historical areas. Nest areas should be delineated using known nests and plucking posts where possible. In mixed conifer and ponderosa pine forests of eastern Washington, data from Table 2 can be evaluated with stand-specific and area data to estimate local habitat needs. All nest areas should be located within approximately 0.8 km (0.5 mi) of the goshawk pair's adjacent nest areas (Reynolds et al. 1992).

Table 2. Size recommendations for areas within goshawk home range as reported by the Goshawk Scientific Committee (Reynolds et al. 1992).

Attribute	Home Range Components		
	Nest Area	**PFA**	**Foraging Area** [a]
Total areas	6	1	1
Suitable nest areas	3	N/A	N/A
Replacement nest areas	3	N/A	N/A
Size in hectares (acres)	12 (30) each	170 (420)	2,185 (5,400)
Management season	Oct - Feb	Oct - Feb	Oct - Feb

[a] Foraging area figures do not include the nest areas and PFA.

Human presence should be minimized in active nest areas during the nesting season (1 March - 30 September) (Reynolds et al. 1992). Broadcasting calls for survey purposes should not be implemented until June 1 (for recommended survey protocol guidelines and information, contact WDFW's goshawk specialist in Olympia). Data on human disturbances are lacking; however, in the absence of such data, the disturbance guidelines established for other raptors should be observed: activities such as road building, logging, site preparation and herbicide and pesticide application should not occur within 0.8 km (0.5 mi) of active nests during the nesting season (e.g., Washington Forest Practices Board 2001). On known occupied territories, if the active nest is not located during the year of management activity, then a 0.8 km (0.5 mi) radius from the geographic center of previous known nest sites should be protected. Road densities should be minimized in the vicinity of nest areas and should be managed within the context of adaptive management (a systematic process for continually improving management practices by learning from the outcomes of earlier practices) (Reynolds et al. 1992).

An average canopy closure of 70-80% for both western and eastern Washington nest areas should be retained (McGrath 1997, Finn et al. 2002b). Activities conducted within suitable and replacement nest areas should be limited to those designed to enhance stand development and maintain habitat structure (Reynolds et al. 1992). Selective overstory removal, patch harvests, or clearcut harvests resulting in complete removal of trees or the reduction of large stem density and canopy volume over a landscape compromises goshawk nesting habitat (Ward et al. 1992, Crocker-Bedford 1995, Desimone 1997; Finn et al. 2002a, b). Activities in nest areas that are detrimental to desired nesting structure for goshawks should not occur at any time in areas managed for goshawks (Reynolds et al. 1992). All intact forest patches in late stages of forest development within the nest area should be retained (Daw

and DeStefano 2001, Henjum et al. 1996). Fidelity of some goshawks to nest areas in winter (T. Bloxton, personal communication) underscores the importance of protecting mature and old forested habitat in nest areas to sustain resident prey populations.

No overstory or regeneration harvest should take place within the NAC at any time (Woodbridge and Detrich 1994, Desimone 1997, Daw and DeStefano 2001). For the Olympic Peninsula, controlled understory thinning to enhance development of stands for desirable nest characteristics should be carefully monitored so that dominant overstory trees are not removed and deep overstory canopy attributes are maintained (see Finn et al. 2002b); average canopy closure should remain =70%. Thinning may help younger stands develop characteristics conducive to nest habitat sooner than if left unmanaged. However, their potential for use by goshawks will be negated if the newly enhanced stands are not allowed to exist over an extended time period (e.g., 20-70 years) beyond a harvest rotation age (depending on stand age and site conditions). Thinning and stand enhancements for nest areas should be done within the context of local forest conditions and within an adaptive management framework.

Post-fledging Family Area (PFA)

The size of the PFA should be approximately 170 ha (420 ac) in addition to the identified suitable and replacement nest areas (Reynolds et al. 1992). This area should be delineated and centered on active and alternate nest areas (i.e., the nest area cluster [Woodbridge and Detrich 1994]), and include as much mature and old forest as possible (Desimone 1997, Daw and DeStefano 2001).

In western Washington and moist forests east of the Cascade crests, canopy closure in the PFA should average ≥70% (Finn et al. 2002a, b), and ≥60% in the drier pine-dominated forests east of the Cascades (Finn 1994, McGrath 1997, Wagenknecht et al. 1998). Preference should be given to stands that are similar in structure to the nest area (Reynolds et al. 1992, Daw and DeStefano 2001). Forest management should emphasize the retention and enhancement of complex forest structure and desirable canopy closure (Finn et al. 2002a, b). PFA attribute information for eastern Washington forests is virtually unknown; therefore, forest management should avoid reducing or further fragmenting existing late-seral forest in PFAs (Beier and Drennan 1997, Daw and DeStefano 2001) until more data are collected. If possible, the PFA should not contain >10% seedling/sapling or early forest cover (Finn et al. 2002a). Retaining snags and down logs will likely enhance goshawk prey abundance (Reynolds et al. 1992).

Foraging Area (Home Range)

The GSC recommends that 60% of the foraging habitat be equally divided between mid-aged (20%), mature (20%), and old (20%) successional classes of forest by area based on work in the southwestern United States (Reynolds et al. 1992). These percentages might not be adequate in western Washington, because the average proportion of late-seral forest in foraging areas was at least 1.5 times that of the southwest in certain forest types (Finn et al. 2002a). In addition, goshawks made most kills in mature and older closed-canopy forest in western Washington (Bloxton 2002). Goshawks also occupied landscapes where ≥54% of the foraging area (i.e., home range) was comprised of late-seral forest, and averaged no more than 11% seedling/sapling or early forest stages (Finn et al. 2002a). Based on these findings, it is recommended at least 60% of the foraging area be retained in mature and old forest. This is in addition to the mature and old forest area that should be retained in nest areas and PFAs.

Snags are important resources for sheltering birds and mammals that are goshawk prey. Large-diameter snags and logs should be retained within managed goshawk foraging areas to provide cover for important prey species. While no information exists for goshawk foraging areas in ponderosa pine forests in eastern Washington, we recommend the retention of at least 5 large ($\geq$ 46 cm dbh [18 in], $\geq$ 9.1 m [30 ft] in height) snags/ha (2 large snags/ac), and at least 7 large ($\geq$ 30 cm [12 in] diameter, $\geq$ 2 m [7 ft] in length) downed logs/ha (3 logs/ac) based on the guidelines of Reynolds et al. (1992). At least 7 large snags/ha (3/ac) with at least 12 large downed logs/ha (5/ac) should be retained in interior-fir forests (Reynolds et al. 1992). These criteria are recommended until more local information is obtained for eastern Washington.

Few studies have documented snag abundance within goshawk home range habitat in western Washington. Foraging habitat patches should be structurally similar to mimic suitable nesting habitat as well as the habitat of

preferred prey. Based on Bloxton (2002), average snag density in intensively managed habitats should average 14 snags/ha >30 cm (6 snags/ac >12 in); however, additional research is needed.

Landscape Management

Planning in Pacific Northwest forests should occur at the landscape scale because site-by-site management will not maintain viable populations (Kennedy 1991, Bright-Smith and Mannan 1994, Hargis et al. 1994). Conservation and management strategies should consider multiple spatial scales (e.g., watershed, forest-wide, territory, etc.) and potential overlap between adjacent territories. Emphasis should be placed on retaining vegetative diversity and sufficient amounts of mature forested habitat for goshawk nesting and foraging (Crocker-Bedford 1990, Reynolds et al. 1992, Bright-Smith and Mannan 1994, Hargis et al. 1994, Beier and Drennan 1997, Crocker-Bedford 1998, Finn et al. 2002a, Drennan and Beier 2003).

Because of limited information on the habitat requirements of goshawks (especially in eastern Washington), it is recommended that habitat manipulations occur using adaptive management techniques. More direct observational data of goshawk habitat use will be required to develop management plans, predict the species distribution, and aid in the assessment of habitat for goshawks on a landscape-level in eastern Washington (Dewhurst et al. 1995, Braun et al. 1996).

Forest Management

Although largely untested, recommendations for silvicultural manipulations within goshawk home ranges have been proposed. The GSC recommended forest manipulations to benefit goshawk prey (Reynolds et al. 1992). Merrill (1989) and Lilieholm et al. (1993, 1994) recommended the use of a stand density index to manage goshawk habitat in Utah and Idaho. They provided recommendations on desirable stand conditions as well as some specific examples of stand management.

Forest stands in lower elevations of western Washington begin to develop suitable nesting habitat characteristics at about 50 years (Bosakowski et al. 1999, Finn et al. 2002b). However, current timber rotations on industrial lands are approximately 35-50 years (Finn et al. 2002b; F. Silvernail, personal communication). The net result may be the sustained loss of suitable nesting and foraging habitat in intensively managed forests in Washington. We concur with researchers (e.g., Merrill 1989; Lilieholm et al. 1993, 1994; Bloxton 2002, Finn et al. 2002a) who recommend that portions of intensively managed forested landscapes surrounding existing late-seral forest patches be allowed to mature beyond industrial rotational ages (e.g., 70-120 years on the Olympic peninsula and lowland western Washington) to benefit goshawks. Such practices would ensure that some suitable nesting and foraging habitat is available across the managed landscape. Existing occupied marbled murrelet (*Brachyramphus marmoratus*) habitat, which is composed primarily of late forest structure (Ralph et al. 1995), may potentially provide some interim goshawk nest sites (WDFW, unpublished data). However, the potential of these patches to provide adequate PFA and foraging habitat to sustain potential goshawk nest areas is limited to the size and adjacency of mature forests that are within the range of the murrelet in western Washington (i.e., generally within 80 km [50 mi] of marine waters).

To promote the development of nest habitat in western Washington, managers should thin young (30-35 years) conifer stands by removing the understory trees to a density of 345-445 trees/ha (140-180 trees/ac) (Finn et al. 2002a). This forest practice will accelerate tree growth and should eventually result in a deep overstory canopy and a low density of shrub cover if the stand is allowed to mature beyond 50-70 years.

Because goshawks have a strong fidelity to high quality nest areas, there can be a temporal lag before birds respond to habitat changes (T. Bloxton, unpublished data; S. Desimone, personal observation). Abandonment of a nest area following timber management depends on the proximity, timing, and extent of the habitat removal. Habitat assessment models and change detection (e.g., McGrath 1997, Desimone 1997) can evaluate the effects of management on site suitability. However, these processes sometimes lead to an overestimation of suitable habitat if the assumptions of the model are not explicitly addressed (McGrath 1997). A landscape-scale habitat model is currently being developed for predicting nesting habitat for goshawks in Washington (S. Finn, personal communication).

Falconry

The impact of removing wild goshawks for falconry is thought to be negligible (Squires and Reynolds 1997). Of the various hawk species captured, Kenward (1997) estimated that 50-93% are eventually lost or released back into the wild. In Washington, falconry permit holders reported 64 northern goshawks taken from the wild between 1990 and 2002; one immature escaped and one adult died in captivity between 1998 and 2002 (WDFW, unpublished data). As the data are relatively sparse for Washington birds, the removal of northern goshawks from the wild for falconry should continue to be closely monitored.

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KEY POINTS

Habitat Requirements

- Home ranges for breeding goshawks can be split into three functional divisions: the nest area or areas, post-fledgling family area (PFA), and foraging area.
- Nest areas are composed of one or several forest stands that contain active or alternate nest structures that are usually occupied by goshawks between March and September.
- Nest areas are typically located in mature or old coniferous forest with a high density of large trees. Additionally, nest areas primarily are composed of stands with a closed canopy and multiple canopy layers.
- Nests are often found in Douglas-fir in western Washington and in Douglas-fir, ponderosa pine, western larch, lodgepole pine, and grand fir east of the Cascades.
- Nest areas typically have a higher basal area than that of surrounding forest east of the Cascade crest.
- Plucking posts are usually found within 100 m (328 ft) of active nests.
- Goshawks apparently prefer to nest close to water and at low topographic positions.
- All nests and alternate nests of a pair form a cluster that generally does not overlap with clusters of neighboring territories.
- The PFA is an area of concentrated use by adult females and developing juvenile goshawks.
- PFAs are typically comprised of complex forest structure and typically contain mature and old forest
- Foraging areas are where goshawks secure prey and it defines their home range during the breeding season. Goshawks forage in a variety of forest types.
- Goshawks are considered opportunistic foragers, as exhibited by the wide range of prey taken.

- Goshawks are believed to be non-migratory

Management Recommendations

- Protect at least three nest areas and three alternate nest areas per home range. Each nest area should be at least 12 ha (30 ac) in size, and selected nest areas should be structurally similar to known nest areas.
- Minimize human disturbance in active nest areas between March 1st – September 30th.
- Retain an average canopy closure of 70-80% and maintain forest in late stages of forest development.
- Limit all overstory or regeneration harvest and increase harvest rotation length in nest area clusters.
- Delineate and center areas to managed as PFAs on active and alternate nests. PFAs should be approximately 170 ha (420 ac) and include as much old and mature forest as possible.
- Manage PFAs for ≥ 70% canopy closure in western Washington and for moist forests east of the Cascade crest. Drier forests east of the Cascade crest should have ≥ 60 canopy closure.
- Avoid removing late-seral forest in PFAs, and retain snags and downed logs.
- Retain at least 60% of foraging habitat in mid-aged (20%), mature (20%), and old (20%) forest successional classes.
- Large diameter snags and logs should be retained in goshawk foraging areas.
- Retain at least 5 large (≥ 46 cm dbh [18 in], ≥ 9.1 m [30 ft] in height) snags/ha (2 large snags/ac), and at least 7 large (≥ 30 cm [12 in] diameter, ≥ 2 m [7 ft] in length) downed logs/ha (3/ac) in foraging areas comprised of ponderosa pine forest in eastern Washington. At least 7 large snags/ha (3/ac) with at least 12 large downed logs/ha (5/ac) should be retained in interior-fir forests.
- Conservation of goshawk habitat should be managed on a landscape-scale and multiple spatial scales (e.g., watershed, forest-wide, territory, etc.)
- Forest management should consider increasing timber harvest rotations (e.g., 70-120 years in western Washington lowlands and Olympic peninsula) because intensively managed forest appear to negatively impact goshawks.
- Thin young (30-35 years) conifer stands to a density of 345-445 trees/ha (140-180/ac) to promote the development of nesting habitat in western Washington. If allowed to mature beyond 50-70 years, this practice should result in preferred forest conditions.
- Closely monitor the impact of the removal of northern goshawks from the wild for falconry purposes.
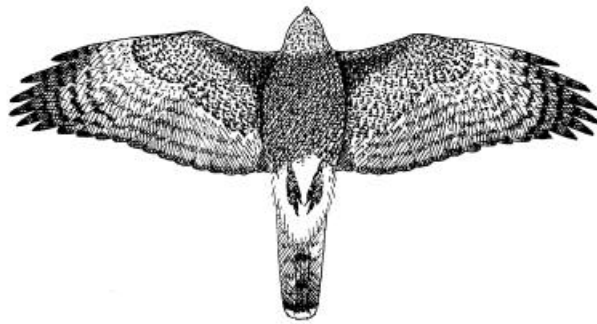
Illustration by Frank L. Beebe; used with permission of Royal British Columbia Museum; http://royalbcmuseum.bc.ca/

Ferruginous Hawk
Buteo regalis

Last updated: 1999

Written by Scott Richardson, Morie Whalen, Dinah Demers, and Ruth Milner

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Ferruginous hawks inhabit the arid, open country of 17 western states and 3 Canadian provinces during the breeding season. They winter primarily in Mexico and the southwestern and southcentral United States (American Ornithologists' Union 1983, Olendorff 1993).

Ferruginous hawks breed in the Lower Columbia Basin and surrounding arid lands of southeast Washington (see Figure 1). The Washington breeding range includes Adams, Benton, Columbia, Douglas, Franklin, Garfield, Grant, Kittitas, Lincoln, Walla Walla, Whitman, and Yakima counties.
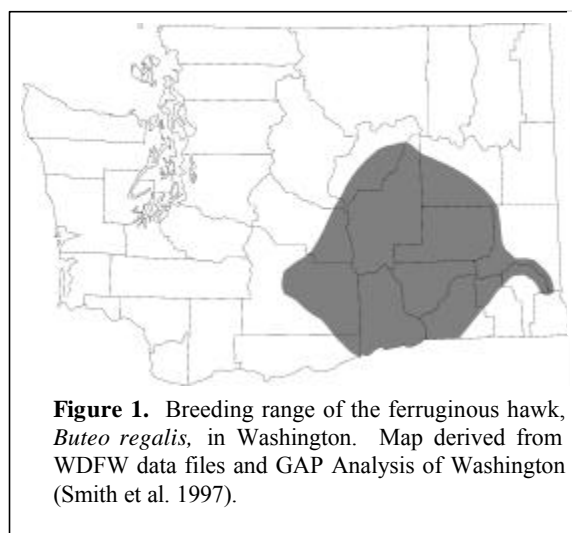

Figure 1. Breeding range of the ferruginous hawk, *Buteo regalis,* in Washington. Map derived from WDFW data files and GAP Analysis of Washington (Smith et al. 1997).

RATIONALE

The ferruginous hawk, a State Threatened species, is an uncommon breeding species and rare winter visitor east of the Washington Cascades (Washington Department of Fish and Wildlife 1996). Uncultivated land is a major component of ferruginous hawk habitat (Lokemoen and Duebbert 1976; Schmutz 1984, 1987; Olendorff 1993). Loss of uncultivated land and the prey base it supports (Howard and Wolfe 1976, Woffinden and Murphy 1977) may limit the frequency and success of ferruginous hawk nesting efforts. This species is also sensitive to human disturbance, particularly early in the breeding cycle (Smith and Murphy 1978, Schmutz 1984, White and Thurow 1985, Olendorff 1993). The amount of undisturbed natural habitat within the ferruginous hawk's Washington range has been reduced, which may make the population vulnerable.

HABITAT REQUIREMENTS

Ferruginous hawks are obligate grassland or desert-shrub nesters (Woffinden and Murphy 1989). In Washington, they frequent shrub-steppe in the channeled scablands, as well as juniper-savannah areas of the Columbia Basin.

Nesting

Landscapes comprised primarily of shrub-steppe, native prairie, haylands, and pasture are favored for nesting, while cropland is avoided (Howard 1975, Gilmer and Stewart 1983, Schmutz 1984, Roth and Marzluff 1989). Most nests are found in areas with a high proportion of grassland, shrubland, and juniper forest and a low proportion of wheatland, although nests can be found in areas with 50% to 100% wheatland within 3 km (1.9 mi) (Bechard et al. 1990). Ferruginous hawk populations decline consistently once cultivated land exceeds 30% of the area (Schmutz 1987, 1989). This species' nesting requirements may not be adequately accommodated in areas where native grasses are replaced by dense and tall cultivated crops (Schmutz 1987).

In Washington, ferruginous hawks nest on rock outcrops, steep low cliffs, ledges on hills, in some canyons, in isolated trees [juniper (*Juniperus* spp.), black locust (*Robinia pseudoacacia*) and others], and on powerline towers or other artificial structures (Washington Department of Fish and Wildlife 1996).

Ferruginous hawks are sensitive to disturbance; pairs may abandon nests even when mildly disturbed during nest building or incubation (1 March through 31 May) (Smith and Murphy 1978, White and Thurow 1985, Olendorff 1993, Washington Department of Fish and Wildlife 1996). Furthermore, disturbed nests fledge fewer young, and they often are not reoccupied the year following disturbances (White and Thurow 1985). Rather than becoming acclimated to repeated disturbance, ferruginous hawks become sensitized and flush at greater distances (White and Thurow 1985), which may result in increased clutch or brood mortality due to exposure, predation, starvation, or nest desertion.

Ferruginous hawks typically nest farther from human habitations than closely related raptor species (Schmutz 1984, Gaines 1985). In South Dakota, occupied nest sites were significantly farther from human activity as opposed to sites selected at random (Lokemoen and Duebbert 1976). Nests located in physically remote areas or on posted land tend to fledge more young than nests in areas where human access is not limited (Olendorff and Stoddart 1974).

Food

The diet of ferruginous hawks consists primarily of small- to medium-size mammals and, to a lesser extent, snakes, birds, and insects (Olendorff 1993). Northern pocket gophers appear to dominate the diet of Washington ferruginous hawks. Other rodents, snakes, and insects are also common prey (Washington Department of Fish and Wildlife 1996).

Density of major prey species may influence productivity and limit ferruginous hawk populations (Howard and Wolfe 1976). In years of food scarcity, many nesting territories may be left vacant, territorial pairs may fail to nest, clutch sizes may be reduced, or productivity may decline (Woffinden and Murphy 1977, Smith et al. 1981).

Home Range

The average home range for ferruginous hawks in the western states is 7.0 km^2 (2.7 mi^2), but size varies with habitat conditions and prey availability (Olendorff 1993). Some home ranges in Washington are considerably larger (i.e., mean = 79 km^2 [49 mi^2] for 7 males), mainly due to long-distance foraging flights (Leary 1996).

LIMITING FACTORS

Ferruginous hawks may be limited by availability of suitable nesting sites in undisturbed habitats supporting adequate prey populations (Olendorff and Stoddart 1974, Lokemoen and Duebbert 1976, Smith and Murphy 1978, Schmutz 1984, Schmutz et al. 1984, Schmutz 1987).

MANAGEMENT RECOMMENDATIONS

Habitat Protection

Landowners should protect at least half of the native shrub-steppe within ferruginous hawk home ranges (Gilmer and Stewart 1983, Schmutz 1984).

Disturbance

Brief human access and intermittent ground-based activities should be avoided within a distance of 250 m (820 ft) of nests during the hawks' most sensitive period (1 March to 31 May) (White and Thurow 1985). Prolonged activities (0.5 hr to several days) should be avoided, and noisy, prolonged activities should not occur, within 1 km (0.6 mi) of nests during the breeding season (1 March to 15 August) (Suter and Joness 1981). Construction or other developments near occupied nests should be delayed until after the young have dispersed (Konrad and Gilmer 1986), which generally occurs about a month after fledging (Olendorff 1993; A. Jerman, unpubl. data).

Spatial and temporal buffers should be tailored to the individual hawks involved (Knight and Skagen 1988), based on factors such as line-of-sight distance between nest and disturbance, nest structure security, history of disturbance, observed responses, and nest elevation in relation to the disturbance.

Natural Nest Structures

Isolated trees should be protected from cattle rubbing by surrounding them with stick piles or fences. Old, unoccupied nest trees should not be cut for at least 10 years after they have been abandoned by ferruginous hawks. Junipers and black locusts may be planted to provide future nest sites.

In areas where natural nesting materials are in short supply, sagebrush stems and other large sticks may be provided in the vicinity of potential nest structures.

After the dispersal of young, the amount of material in nests may be reduced to avoid having nest-site competitors (e.g., great horned owls) usurp the nests prior to the hawks' return.

Artificial Nest Structures

Artificial nest structures are an effective tool for encouraging successful ferruginous hawk nesting (Tigner et al. 1996). Such structures can be especially valuable if prey populations are adequate, disturbances are minimal, and nest sites are thought to be limiting. However, they may also enhance populations or productivity under other conditions.

Commonly, artificial structures are platforms mounted on poles, trees, or cliffs. Poles should be buried at least 1 m (3.3 ft) deep and should be located away from watering holes, gates, and other areas where livestock congregate. Platforms should be approximately 1 m^2 (10.8 ft^2) to allow space for 3 or 4 nestlings to lie down during strong winds. The structure should allow adult hawks to anchor nest materials. Shade is not required. Specifications for cliff nest structures are available from the Spokane office of the Bureau of Land Management.

Although largely beneficial, artificial structures may attract undesirable or competitive species and are prone to increased disturbance due to their conspicuousness (Howard and Hilliard 1980, Suter and Joness 1981).

Prey

Ferruginous hawks will benefit from land-use practices that ensure an adequate prey base. Landowners should protect shrub-steppe and grassland habitats that harbor significant populations of small mammals and other prey. Habitat conversions, especially through chemical application, should be discouraged where ferruginous hawks occur. Developments (e.g., oil, gas, or geothermal exploration; pipeline and road construction; campgrounds;

interpretive facilities) should be kept at least 400 m (¼ mi) from important prey concentrations, such as ground squirrel colonies (Suter and Joness 1981). Pesticides and rodenticides should not be used within this 400 m area. Appendix A provides useful contacts to help assess the use of pesticides, herbicides, and their alternatives.

Range management activities such as chaining, disking, and brush burning may be detrimental to prey populations and should be avoided. In areas where chaining cannot be avoided, brush may be windrowed to provide nesting and cover for prey species. Reseeding of native plant species after chaining or burning promotes habitat stability and is beneficial to ferruginous hawk prey populations (Olendorff 1993).

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KEY POINTS

Habitat Requirements

- Sparse, short vegetation in steppe and shrub-steppe habitats is preferred by ferruginous hawks.
- Ferruginous hawks avoid nesting in heavily cultivated lands.
- Ferruginous hawks in Washington generally nest on rock outcrops, steep cliffs, isolated trees, or artificial platforms.
- Ferruginous hawks feed primarily upon a variety of small- to medium-size mammals.

Management Recommendations

- Encourage surrounding landowners to protect 50% or more of the shrub-steppe within ferruginous hawk home ranges.
- Avoid disturbance within 250 m (820 ft) of nests from 1 March through 31 May.
- Delay development near occupied nests until one month after young hawks fledge.

- Avoid construction within 1.6 km (1 mi) of nest sites.
- Install "No Trespassing" signs to prevent harassment.
- Fence isolated trees which show signs of abuse from livestock (e.g., rubbing, soil erosion).
- Retain trees and shrubs greater than 1 m (3.3 ft) in height and within 1.6 km (1 mi) of one another.
- Plant trees, especially junipers and black locusts, in isolated situations.
- Avoid cutting nest trees for at least 10 years after they are abandoned.
- Construct artificial nest structures where nest sites are limited.
- Remove some material from nests in the autumn to prevent nest loss to competitive species or weathering during the non-nesting season.
- Preserve remaining steppe and shrub-steppe habitat types that harbor significant populations of hares, rabbits, and small- and medium-size rodents.
- Maintain a "no disturbance" buffer of 400 m (¼ mi) around periphery of ground squirrel colonies and other prey concentrations.
- Avoid spray application of pesticides when possible. For spray application near ground squirrel colonies, add additional width to the 400 m (¼ mi) buffer to account for pesticide drift. Refer to Appendix A for contacts useful in assessing pesticides, herbicides, and their alternatives.
- Plant 5 m (16 ft) buffer of rye around edge of agricultural crops to protect against rodent damage.
- Avoid chaining, disking, and brush burning where prey species are concentrated or affected. Windrow brush where chaining or disking is necessary.

Illustration by Frank L. Beebe; used with permission of Royal British Columbia Museum; http://www.royalbcmuseum.bc.ca/

Golden Eagle
Aquila chrysaetos

Last updated: 2003

Written by Jim Watson and Morie Whalen

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Golden eagles are distributed throughout much of the northern hemisphere (Kochert et al. 2002). In Washington, golden eagles nest throughout much of the state, but are most common in the north-central highlands transitional area between montane and shrub-steppe habitats (see Figure 1). Scattered nest sites are found in more arid portions of eastern Washington and west of the Cascades where the species is uncommon (Larrison and Sonnenberg 1968). The migratory status of nesting golden eagles in Washington has not been studied; observations of golden eagles along the upper Columbia River suggest they remain at nest sites throughout the winter (Knight et al. 1979).
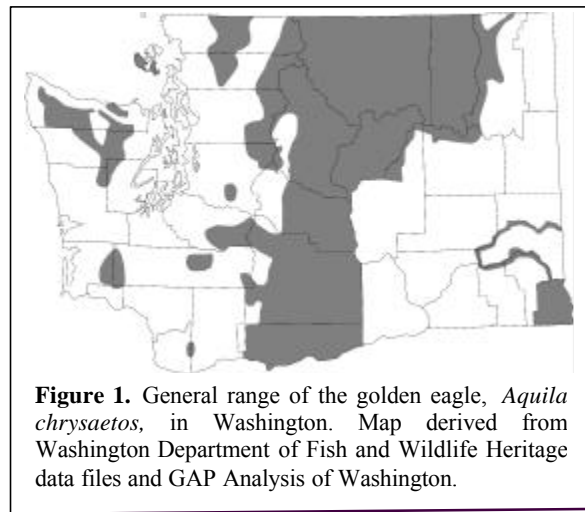

Figure 1. General range of the golden eagle, *Aquila chrysaetos,* in Washington. Map derived from Washington Department of Fish and Wildlife Heritage data files and GAP Analysis of Washington.

RATIONALE

The golden eagle is a State Candidate species. This species is vulnerable to population declines due to habitat loss and disturbance, loss of foraging areas, and through direct human-caused mortality (Franson et al. 1995, Kochert et al. 2002).

HABITAT REQUIREMENTS

Golden eagles are commonly associated with open, arid plateaus deeply cut by streams and canyons, western shrub-steppe and grassland communities and transition zones between shrub, grassland and forested habitat (De Smet 1987, Marzluff et al. 1997). Nests generally are located on cliffs and are occasionally located in trees (Anderson and Bruce 1980, Menkens and Anderson 1987, Kochert et al 2002). Golden eagles use the same territory annually but may use alternate nests in different years. This species uses an average of 2-3 alternate nests (range: 1-14 alternate nests) (Snow 1973). Individual eagles mature and may establish territories and breed during their fifth summer but are capable of breeding earlier in life (Kochert et al. 2002).

Although they are more common east of the Cascades, golden eagles are sometimes found in mature and old-growth forests near the edges of clearcuts in western Washington (Anderson and Bruce 1980). Golden eagle nesting was observed in the San Juan Island archipelago (<10 pairs) during the 1970s and 1980s (Washington State Wildlife Heritage Database). Bruce et al. (1982) found that golden eagle tree nests in western Washington were generally

smaller than bald eagle nests, were placed at or below canopy height, and were located no more than 500 m (1,600 ft) from large clearcuts (<10 years old) or open fields. In another study, bald eagle nests were located at or above the canopy on the interior of a stand and were closer to water than golden eagle nests (Anderson and Bruce 1980).

Shrub-steppe and native grassland communities provide important foraging habitat for the golden eagle (Marzluff et al. 1997, Kochert et al. 2002). Small to medium-sized mammals such as hares (*Lepus* spp.), ground squirrels (*Citellus* spp.), marmots (*Marmota* spp.), mountain beaver (*Aplodontia rufa*) and birds (e.g., pheasant, grouse) are important prey for golden eagles (McGahan 1967, Olendorff 1976, Bruce et al. 1982, Steenhof and Kochert 1988, Marzluff et al. 1997). Based on a survey of prey remains at 74 nests in eastern Washington, yellow-bellied marmots were the most important prey of nesting golden eagles, whereas carrion was regularly consumed in fall and winter (Marr and Knight 1983). Golden eagles nesting on large cliffs in the Columbia Basin commonly capture rock doves (*Columba livia*) that roost on canyon walls (J. Watson, personal observation). Jackrabbits and ground squirrels were historically more abundant in the Northwest (Richardson et al. 2001, Yensen and Sherman 2003) and likely were a more significant source of prey for the golden eagle. Extensive poisoning of ground squirrels in the 1980s, and possibly other factors (S. Zender, personal communication), significantly reduced Townsend's (*Citellus townsendi*) and Washington ground squirrel (*Citellus washingtoni*) populations in Washington (Washington State Wildlife Heritage Database) to the degree that they are being reviewed for status listing. Several researchers (Bates and Moretti 1994, Steenhof et al. 1997, McIntyre 2002) have found increased productivity in golden eagles in years with a higher abundance of hare. McIntyre (2002) and Steenhof et al. (1997) found that golden eagle reproduction was related to prey abundance, with more pairs producing eggs and increased numbers of young fledged when prey numbers were higher. Some eagles conserve energy by suspending their breeding activity when food supplies decrease (Steenhof et al. 1997, McIntyre 2002).

Densities of golden eagles in the western states range from one pair per 34 km^2 to 251 km^2 (13-96 mi^2) (Phillips et al. 1984). In Wyoming, prime golden eagle habitat as defined by high population densities consisted of a mixture of cliffs and trees suitable for nesting and open habitat with abundant and diverse prey (Phillips et al. 1984). Home range size, size of core areas, and travel distances can vary dramatically based on habitat composition, potential prey abundance and individual preferences (Marzluff et al. 1997).

LIMITING FACTORS

Golden eagle populations appear to be limited by habitat availability and disturbance, adequate prey populations (e.g., large rodents, rabbits and hares), and the availability of undisturbed nest sites (Olendorff and Stoddard 1974, Beecham and Kochert 1975, Kochert and Steenhof 2002). Direct mortality is increased by poisoning from lead and other contaminants, power line electrocutions, collision with wind turbines, and shooting (Phillips 1986, Harlow and Bloom 1989, Craig et al. 1990, Wingfield 1991, Leptich 1994, Avian Power Line Interaction Committee 1996, Hunt et al. 1997, Hoover 2002). Breeding success is limited by reduced habitat availability and decreased prey populations resulting from habitat conversion (Murphy 1977).

MANAGEMENT RECOMMENDATIONS

Factors affecting golden eagle habitat and populations have not been extensively studied in Washington, but studies have been conducted throughout western North America, and the following reflect the findings of these studies. These recommendations generally apply to conditions east of the Cascade Range because very few North American studies have been conducted in high rainfall zones.

In general, golden eagle habitat should be managed to improve native vegetation and maintain native prey populations (e.g., jackrabbits, ground squirrels) (Andersen 1991). Management of grassland habitats can influence prey density, diversity and availability (Andersen 1991). In general, certain prey species decrease with reduced herbaceous cover and foliage height diversity (Kochert 1989). Prey such as jackrabbits and ground squirrels, are believed to be moderately tolerant to grazing but they disappear where habitat is overgrazed (i.e., repeated grazing that exceeds the recovery capacity of the vegetation and creates or perpetuates a deteriorated plant community). Severely damaged native grassland can be restored by removing livestock, using controlled burning or chaining to

remove trees and invasive shrubs, and reseeding with native grasses (Kochert 1989). However, fire management should be conducted only after developing a professional fire management plan (see Washington State University Cooperative Extension Service in Appendix A), especially in low rainfall zones, where exotic vegetation (e.g., Cheatgrass [*bromus tectorum*]) often becomes dominant (Knick and Rotenberry 1995).

Burning and other techniques that reduce shrub stand density should be avoided in healthy shrub-steppe communities, such as those dominated by sagebrush, in order to maintain existing prey populations (Kochert et al. 1999, Kochert et al. 2002).

Few studies have documented the effects of habitat fragmentation on raptors. However, in several states, raptors survived only on large habitat patches (Robinson 1991). In arid regions, golden eagles require large expanses of undisturbed shrub habitat (Marzluff et al. 1997). Therefore, it is recommended that shrub stands be preserved within 3 km (1.9 mi) of golden eagle nests (Kochert et al. 1999). This distance accounted for 95% of eagle movements measured during the breeding season in western Idaho (Marzluff et al. 1997). Large-scale conversion of eagle foraging habitat should be avoided because it reduces prey abundance and availability. This is particularly important where prey are concentrated, such as at ground squirrel colonies. Many types of development that remove vegetation from localized areas, including oil, gas, and geothermal exploitation; power line, pipeline and road construction; and the development of campgrounds and other facilities may result in loss of habitat for certain prey species (Suter and Joness 1981).

Although empirical evidence is limited, recreation and other human activities near nests appear to cause breeding failure (Kochert et al. 2002). Rock climbing as well as development activities on or near cliffs containing nests should be avoided (De Smet 1987). Avoiding these activities is especially important during the nesting period of 15 February to 15 July (Beebe 1974; R. Friesz, personal communication). The establishment of buffer zones surrounding nests, wide enough to include 90-95% of flushing distances, is generally an accepted technique to reduce disturbance to nesting raptors (Olendorff and Stoddart 1974, Suter and Joness 1981, Mersmann and Fraser 1990). Buffer widths may be adjusted on a case by case basis (with the assistance of a professional wildlife biologist), depending on factors that may influence a pairs' response to a particular disturbance, such as influence of terrain on the "line of sight" distance, security of the nest, history of disturbance, and elevation of the disturbance relative to the nest (Suter and Joness 1981; K. Steenhof, personal communication).

Holmes et al. (1993) found that wintering golden eagles are more likely to flush when approached by a human on foot than by a vehicle. They suggested that a buffer zone of 300 m (980 ft) would prevent flushing by 90% of eagles.

Golden eagles often have wing spans that are greater than the distances between conductive materials on power poles, which increases their probability of electrocution (Harness and Wilson 2001). Power lines and poles in any nesting or feeding area should be constructed so birds cannot make simultaneous contact between any two items of conductive equipment. Once an electrocution problem is identified on any existing structures, utility managers should ensure these are quickly retrofitted or modified to eliminate bird loss (Avian Power Line Interaction Committee 1996, Harness and Wilson 2001). Because multiple-phase transformers are believed to be associated with a disproportionate number of eagle electrocutions (Harness and Wilson 2001), the construction of this form of transformer should be avoided.

Rabbits and ground squirrels are important prey for golden eagles and have been targeted in control efforts. Rodent control should not occur within eagle foraging areas because it reduces the prey base (Eaton 1976, Phillips 1986, Young 1989). Shooting and rodenticides should be replaced by wildlife repellents for use in agricultural damage control. Two very effective jackrabbit/hare repellents available are trinitrobenzene-aniline (TNB-A), and zinc tetramethyl thiuram disulfide (TMTD) (Besser and Welch 1959). Another effective jackrabbit/hare repellent for use in orchards consists of a rosin and ethyl alcohol mixture (Cardinell 1958).

Because ground squirrels are an important prey of golden eagles (Kochert et al. 2002), spray application of pesticides near squirrel colonies should be avoided. If pesticides are to be sprayed, an additional buffer area should be used to prevent drift into the protected area. Droplet size, volume of compound and meteorological conditions should be factored into the buffer width (Kingsbury 1975, Brown 1978, Payne et al. 1988). Payne et al. (1988) describes a method for estimating buffer zone widths for pesticide application. In addition, pesticide use should be avoided during the ground squirrel breeding season, from early March to late May, and during the critical foraging time before estivation (dormancy period), mid-August through September (Carlson et al. 1980).

Organochlorine, organophosphate, and carbamate insecticides can be highly toxic to raptors and mammals, and their use in areas inhabited by golden eagles should be avoided (McEwen et al. 1972; Balcom 1983; Grue et al. 1983, 1986; Smith 1987; Hooper et al. 1989). If insecticides must be used, synthetic pyrethroid compounds may be an alternative. For example, permethrin is low in toxicity to raptors and mammals and bio-degrades rapidly (Grue et al. 1983, Smith and Stratton 1986). Repellents can be used with pesticides to deter golden eagle prey species from treated areas (Blus et al. 1989). If insecticide or herbicide use is planned for areas where this species occurs, review Appendix A for contacts to assist in assessing the use of chemicals and their alternatives.

From collection and clinical analysis of dead or dying golden eagles, toxic lead poisoning has been recently identified as a potential source of adult golden eagle mortality in eastern Washington (J. Watson, personal observation). Craig et al. (1990) and Craig and Craig (1995) found elevated levels of lead in golden eagles in southern Idaho and believed this may be a more serious problem than previously thought. The source of contamination is under investigation. If bullet fragments and lead shot prove to be the source of contamination, hunter removal of carcasses and gut piles from the field, or conversion to the now widely available and ballistically comparable non-toxic ammunition (e.g., tungsten-alloy shot, solid copper bullets) might substantially reduce lead exposure (G. Hunt, personal communication).

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KEY POINTS

Habitat Requirements

- Commonly associated with open, arid plateaus deeply cut by streams and canyons, western shrub-steppe and grassland communities and transition zones between shrub, grassland and forested habitat. Nests usually located on cliffs and trees.
- Use the same territory annually, but have an average of 2-3 alternative nests used in different years.
- Although yellow-bellied marmots are the most important prey of nesting golden eagles, jackrabbits and ground squirrels were probably the most significant historical prey for eagles in the Northwest.
- Carrion is important prey during the fall and winter.
- Home range size, size of core areas, and travel distances can vary dramatically based on habitat composition, potential prey abundance, and individual preferences.

Management Recommendations

- Manage golden eagle habitat to improve native vegetation and maintain native prey populations
- Restore severely damaged grassland (e.g., non-shrub) habitat with controlled burning or chaining of trees and invasive shrubs, followed by reseeding with native grasses.
- Preserve shrub-dominated habitat (i.e., sagebrush) within 3 km (1.9 mi) of golden eagle nests and avoid practices that remove shrub cover (i.e., chaining or burning).
- Avoid new development and human activities near nest sites (especially between 15 February and 15 July).
- Designate spatial buffer areas to protect nests and juvenile eagles.
- Construct or modify power lines and poles so birds cannot make simultaneous contact between any two items of conductive equipment and avoid construction of multiple-phase transformers.
- Avoid rodent control within eagle foraging areas.
- Avoid using organochlorine, organophosphate, and carbamate insecticides in eagle habitat and prey concentration areas.

Bald Eagle

IMPORTANT MESSAGE

May 2011

The Washington Fish and Wildlife Commission amended the bald eagle protection rules (WAC 232-12-292), removing the requirement that landowners develop bald eagle management plans. This decision was mainly the result of the species' recovery and its downlisting to Sensitive status in Washington state. If at any point the bald eagle is listed as an endangered or threatened species (federally or by Washington state), the requirement to develop a management plan will be restored.

The Department removed the bald eagle chapter from this publication because it was specifically written to provide guidance on developing bald eagle management plans. Now that the state no longer requires a plan, the responsibility for bald eagle management has shifted from the Washington Department of Fish and Wildlife to the U.S. Fish and Wildlife Service (USFWS).

For information about federal requirements and guidelines, please go the USFWS Pacific Region's bald eagle website at http://www.fws.gov/pacific/eagle/.

Prairie Falcon

Falco mexicanus

Last updated: 1999

Illustration by Frank L. Beebe; used with permission of Royal British Columbia Museum; http://www.royalbcmuseum.bc.ca/

Written by David W. Hays and Frederick C. Dobler

GENERAL RANGE AND WASHINGTON DISTRIBUTION

The breeding range of the prairie falcon extends southward from central British Columbia through much of the western United States (Snow 1974), and reaches as far south as San Luis Potosi in northern Mexico (Lanning and Hitchcock 1991).

Prairie falcons winter throughout their breeding range, as far south as central Mexico and as far east as the Mississippi River (American Ornithologists' Union 1957).

In Washington, prairie falcons have been known to breed in all central and eastern counties except Pend Oreille County (see Figure 1; Parker 1972). Prairie falcons winter throughout their breeding range in Washington, but the largest wintering populations are found in the central Columbia Basin (Grant, Adams, Franklin, Walla Walla, and Benton counties). Reports of prairie falcons wintering in western Washington have also been reported (Decker and Bowles 1930, F. Dobler, unpublished data).
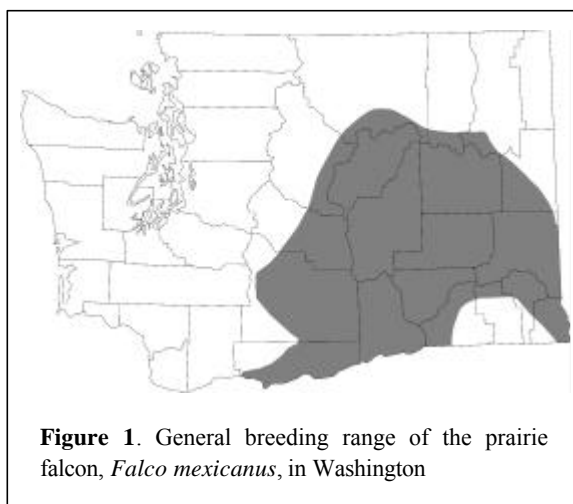

Figure 1. General breeding range of the prairie falcon, *Falco mexicanus*, in Washington

RATIONALE

Prairie falcons are of recreational importance in Washington, and are vulnerable to habitat loss and degradation. Prairie falcons nest on cliffs, and depend on steppe and shrub-steppe habitats that support abundant prey. There is a limited number of suitable cliffs in Washington, and steppe and shrub-steppe ecosystems in this state are rapidly being converted to agriculture. Human habitation close to cliffs limits their use by prairie falcons, as do agricultural practices that reduce available prey.

HABITAT REQUIREMENTS

Prairie falcons inhabit the arid environments of eastern Washington and nest on cliffs usually associated with native steppe and shrub-steppe habitat (Denton 1975). Often this habitat is intermixed with agricultural lands (Denton 1975). Typically, the landscape is treeless, but its edges include shrub-land that may contain a few conifers. Prairie falcon habitat in Washington does not differ markedly from other areas described in the literature (Fowler 1931, Skinner 1938, Enderson 1964, Denton 1975).

Prairie falcons use a wide variety of cliffs. Along the Columbia, Snake, and Yakima rivers, they commonly nest on basalt cliffs up to 122 m (400 ft) tall. They also use scant escarpments raised only 6 m (20 ft) above sloping canyon walls. In North Dakota, Allen (1987) found prairie falcons using cliffs ranging from 3-35 m (10-115 ft) tall, with a mean of 11 m (36 ft), and 5-500 m (16-1,649 ft) in length, with a mean of 103 m (338 ft). In Mexico, Lanning and Hitchcock (1991) found the range of cliff heights used by prairie falcons to be between 25 m and 130 m (92-427 ft) tall, with a mean of 65 m (213 ft). Runde and Anderson (1986), summarized data from 8 studies on prairie falcons, and reported a combined cliff height range of 2-154 m (6.5-505 ft), with a mean of 29 m (95 ft). They also summarized the aspect of the cliff lines, and reported that although prairie falcons may use cliffs facing any aspect, they tend to use cliffs with a southerly aspect.

Nest sites are often on a sheltered ledge or in a pothole in the cliff. Runde and Anderson (1986) found that 97% of their sites in Wyoming had overhead protection. Other studies (Enderson 1964, Leedy 1972, Platt 1974, Ogden and Hornocker 1977) generally found this same trend. Use of abandoned stick nests built by other raptors (particularly golden eagle [*Aquila chrysaetos*] or raven [*Corvus corvus*]) is well documented (Decker and Bowles 1930, Bent 1938, Williams 1942, Webster 1944, Enderson 1964, Brown and Amadon 1968, Hickman 1971). Use of artificial nests by prairie falcons has been documented in North Dakota, but long-term successful nesting was limited (Mayer and Licht 1995).

In Oregon, Denton (1975) found that most nest sites were located at elevations between 60 and 2530 m (200-8300 ft), in habitats typified by undulating topography and moderately xeric vegetation. This was comprised of juniper (*Juniperus* spp.), big sagebrush (*Artemisia tridentata*), and bunchgrass (*Agropyron spicatum* and *Festuca idahoensis*) associations, which were sometimes degraded where cheatgrass (*Bromus tectorum*) replaced native grasses. He also reported that of 63 nest sites, 76% were within 400 m (0.25 mi) of a water source, 32% bordered agricultural land, 62% were within 800 m (0.5 mi) of a road, but only 15% were within 800 m (0.5 mi) of human habitation.

Foraging territories surround prairie falcon nest sites, and studies have reported a wide variety of home range sizes during the breeding season. In Idaho, home range size varied between 26-142 km^2 (10-55 mi^2) (U. S. Bureau of Land Management 1979), in Southern California between 31-78 km^2 (12-30 mi^2) (Harmata et al. 1978), and in Northern California between 34-389 km^2 (13-150 mi^2) (Haak 1982). Squires et al. (1993) found that prairie falcons typically foraged within 10 km (6 mi) of nest sites during the breeding season, and that habitats closer to nesting sites were preferred. Males had the larger home ranges and traveled greater distances from their nests while hunting than did females.

Prairie falcons forage on a variety of prey, including birds and small mammals. Prey abundance largely determines diet composition. Some studies have found that prairie falcons foraged primarily on mammalian prey (Ogden and Hornocker 1977), whereas others found that avian prey predominated (Marti and Braun 1975, Becker 1979, Boyce 1985). In Wyoming, thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*) were found in 91% of pellets analyzed, western meadowlark (*Sturnella neglecta*) in 56%, and horned lark (*Eremophila alpestris*) in 23% (Squires et al. 1989). In Idaho, Townsend's ground squirrels (*S. townsendii*) were prey items in at least 98% of the aeries, with western meadowlark and horned lark present in 13% and 22%, respectively (Ogden and Hornocker 1977). Steenhof and Kochert (1988) found ground squirrels to be the primary prey during the breeding season in Idaho's Snake River Birds of Prey Natural Area.

Less is known about prairie falcon food habits during winter, though small mammals and birds continue to play a major role. Horned larks are the main food for prairie falcons in winter wheat areas (Snow 1974, Beauvais and Enderson 1992) and in the Snake River Birds of Prey Natural Area (Prokop 1995). Wintering prairie falcons have

also been observed hunting microtine rodents in harvested hay fields and chasing upland game birds and rock doves (Beauvais and Enderson 1992). The home range size in winter is less than what is reported for the nesting season, ranging between 12-68 km^2 (4.6-26 mi^2) (Beauvais and Enderson 1992). Prokop (1995) reported that home range size did not vary between sexes in winter.

LIMITING FACTORS

In Washington, prairie falcons are limited by the availability of cliffs suitable for nesting that are adjacent to steppe and shrub-steppe habitats (Denton 1975). Prey abundance within their home ranges also limits prairie falcons. Ground squirrels, western meadowlarks (*Sturnella neglecta*), and horned larks (*Eremophila alpestris*) are important prey (Marti and Braun 1975, Ogden and Hornocker 1977, Becker 1979, Boyce 1985). Human habitation near nesting cliffs limits prairie falcon use, as do agricultural practices that reduce available prey (Denton 1975). In winter, the availability of avian prey, particularly horned larks, is important to the survival of resident prairie falcons (Snow 1974).

MANAGEMENT RECOMMENDATIONS

Homes and other sources of human activity should be placed no closer than 805m (2640 ft) from prairie falcon nest sites (Denton 1975). Prairie falcons commonly occur where human habitation is absent. As difficult as it may be to protect existing nest sites, creating new sites suitable for continued, long-term use may be even more difficult (Mayer and Licht 1995).

Native steppe and shrub-steppe habitats should be maintained near prairie falcon nesting sites to ensure falcon survival and nesting success. These habitats are important for maintaining populations of the prairie falcons' prey. Studies of shrub-steppe in Washington indicate that the western meadowlark and the horned lark are the most common shrub-steppe birds (Dobler 1996). They are also the 2 most common bird species in prairie falcon diets (Squires et al. 1989). In addition, *Spermophilus* ground squirrels are commonly associated with native steppe and shrub-steppe habitats, and they also make up a significant portion of the prairie falcon's diet (Ogden and Hornocker 1977, Steenhof and Kochert 1988).

Widespread rodent control should not occur within prairie falcon foraging areas, because ground squirrels are common prey items, and foraging prairie falcons may depend on food located a great distance from the nest (Haak 1982). The foraging area is approximated by using the dimensions of the home range, which can be as large as 389 km^2 (150 mi) (Haak 1982). If rodenticides or other chemical treatments are planned for areas where prairie falcons exist, refer to Appendix A for contacts that can assist in assessing chemical treatments and their alternatives.

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KEY POINTS

Habitat Requirements

- Prairie falcons inhabit the arid environments of eastern Washington, nesting on cliffs in arid steppe and shrub-steppe habitat.
- Prairie falcons use a wide variety of cliffs, from those made of basalt that are 122 m (400 ft) tall to scant escarpments raised only 6 m (20 ft) above sloping canyon walls.

- Nest sites are often on a sheltered ledge or in a pothole in the cliff, and prairie falcons often use abandoned stick nests built by other raptors.
- Most nest sites are located over 800 m (.5 mi) from human habitation.
- Most nests occur within one-quarter mile of water.
- Prairie falcon nest sites are located within foraging territories. Breeding home range can be as large as 389 km^2 (150 mi^2).
- Prairie falcons forage on a variety prey common to shrub-steppe environments. Ground squirrels (*Spermophilus* spp.), western meadowlarks and horned larks are primary prey items during the breeding season.

Management Recommendations

- Human habitation limits the use of nesting cliffs and should not occur within 800 m (0.5 mi) of known nests.
- Steppe and shrub-steppe habitats should be maintained within the range of prairie falcons to provide a sufficient prey base.
- Widespread control of ground squirrels and other rodents should be limited to areas outside of prairie falcon foraging areas. If rodenticides or other chemical treatments are being considered in areas with prairie falcons, refer to Appendix A for contacts useful when assessing chemical treatments and their alternatives.
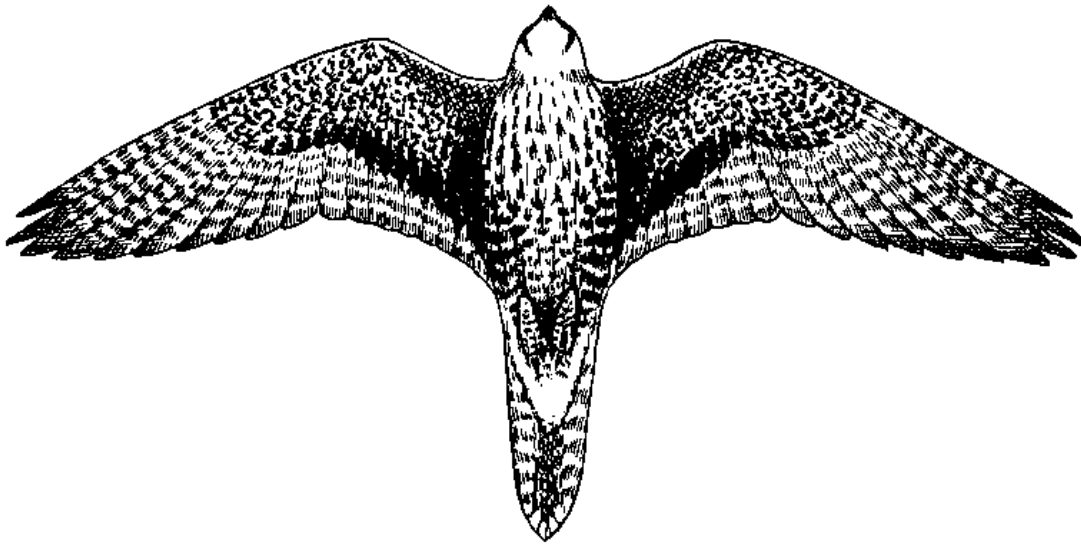

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Peregrine Falcon

Falco peregrinus

Last updated: 1999

Illustrations by Frank L. Beebe; used with permission of Royal British Columbia Museum; http://royalbcmuseum.bc.ca/

Written by David W. Hays and Ruth L. Milner

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Peregrine falcons occur nearly worldwide. In Washington, nesting may occur in all but the driest parts of the state (see Figure 1). Naturally occurring breeding sites are verified along the outer coast, in the San Juan Islands, and in the Columbia Gorge. Young birds have been introduced in unoccupied historical habitat in Skamania, Lewis, Spokane, Asotin, and Yakima counties.

RATIONALE

The peregrine falcon is a State Endangered[1] species. Peregrine falcon populations have increased in Washington since chlorinated hydrocarbon pesticides were banned in the

Figure 1. Washington distribution of the peregrine falcon, *Falco peregrinus*. Dark shading indicates breeding areas. Light shading in dicates wintering areas. Map derived from Washington Department of Fish and Wildlife data files.

United States, and through the success of reintroduction programs. Their numbers and distribution are still limited however, due primarily to the lingering effects of pesticides and the lack of suitable nesting sites. Nest sites need to be in close proximity to adequate food sources and free from human disturbance.
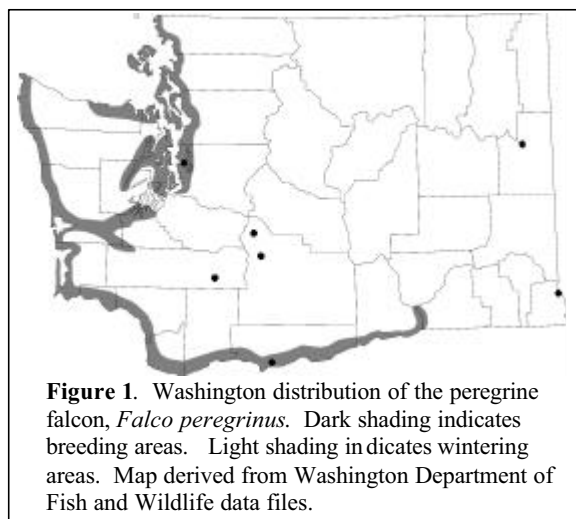
HABITAT REQUIREMENTS

Peregrine falcons usually nest on cliffs, typically 45 m (150 ft) or more in height. They will also nest on off-shore islands and ledges on vegetated slopes. Eggs are laid and young are reared in small caves or on ledges. Nest sites are generally near water. The birds are sensitive to disturbance during all phases of the nesting season (1 March through 30 June) (Pacific Coast American Peregrine Falcon Recovery Team 1982, Towry 1987). Disturbance can cause desertion of eggs or young, and later in the breeding season can cause older nestlings to fledge prematurely.

Peregrines feed on a variety of smaller birds that are usually captured on-the-wing. Hunting territories may extend to a radius of 19-24 km (12-15 mi) from nest sites (Towry 1987).

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[1] On April 12, 2002, the Washington Fish and Wildlife Commission downlisted the species from endangered to sensitive

In winter and fall, peregrines spend much of their time foraging in areas with large shorebird or waterfowl concentrations, especially in coastal areas (Dekker 1995). At least 3 western Washington areas support significant numbers of winter resident peregrines annually: the Samish Flats, Grays Harbor, and the Sequim area (Dobler 1989).

LIMITING FACTORS

Peregrine falcon populations declined worldwide as a result of sublethal doses of chlorinated hydrocarbon pesticides, especially DDT and dieldrin. Chemical contamination of the prey base resulted in reduced eggshell thickness, and consequently poor hatching success and survival of young peregrines (Snow 1972). Although these chemicals are now banned in the United States, eggshell thinning and other effects of pesticide contamination are still seen in some peregrine pairs (Peakall and Kiff 1988). Contamination probably results from consuming prey species that winter in countries that continue to use DDT and other organochlorine pesticides, from persistent pesticide residue remaining at the breeding grounds, or from current, illegal use of these chemicals in the United States (Henny et al. 1982, Stone and Okoniewski 1988).

Additionally, peregrines may be limited in some parts of their range by availability of nesting sites in proximity to an adequate food source.

MANAGEMENT RECOMMENDATIONS

Breeding peregrine falcons are most likely to be disturbed by activities taking place above their nest (eyrie) (Herbert and Herbert 1969, Ellis 1982). Ellis (1982) recommended buffer zones of "no human activity" around peregrine falcon breeding sites in Arizona that ranged from 0.8 km to 4.8 km (0.5-3.0 mi), with wider buffer zones recommended for activities above the breeding cliff. These buffer distances were based on incidental observations of peregrine responses to various disturbances. In Washington, buffer zones of 4.8 km (3.0 mi) may not be necessary. However, human access along the cliff rim should be restricted within 0.8 km (0.5 mi) of the nest from March through the end of June (F. Dobler, personal communication). Human activities on the face of, or immediately below, nest cliffs should be restricted from 0.4-0.8 km (0.25-0.5 mi) of the nest during this time (F. Dobler, personal communication). Where falcon nests are already established in proximity to humans there is no need to eliminate trails, picnic grounds, or other facilities except where the birds are evidently disturbed by the human activities. However, further facilities should not be established within 0.4-0.8 km (0.25-0.5 mi) of the eyries (Ellis 1982). Cliff tops above the eyrie should remain undeveloped.

Ellis (1982) suggested that logging be curtailed within 1.6 km (1 mi) of occupied peregrine eyries in Arizona. In Washington, forest practices are reviewed by the Department of Fish and Wildlife when occurring within 0.4 km (0.25 mi) of an eyrie during any season, and within 0.8 km (0.5 mi) of an occupied eyrie during the breeding season (Washington Administrative Code 222-16-080, 1,f).

Eyries occurring within non-forested lands, and those eyries not subjected to forest practices or forest practice rules, should be similarly considered through the development of a site specific peregrine management plan when activities near nests are considered. Male peregrines require perches within sight of the eyrie. Preserve all major perches around the nest and on ridges or plateaus above the nest by retaining all snags and large trees (F. Dobler, personal communication).

Aircraft should not approach closer than 500 m (1,640 ft) above a nest (Fyfe and Olendorff 1976). Closer approaches may cause peregrines to attack planes or may cause a frantic departure from the nest. Falcons startled from the eyrie have been known to damage eggs or nestlings (Nelson 1970).

Powerlines and other wires may be serious hazards to peregrine falcons. Wherever possible, powerlines should be routed away from eyries (Olsen and Olsen 1980).

Applications of pesticides that could potentially affect passerine birds should be avoided around occupied peregrine eyries during the breeding season. Some chemicals such as organochlorines, organophosphates, strychnine, and

carbofuran can impact birds by causing toxicosis or death, or by contaminating their tissues. Other pesticides may be less toxic to birds, but will increase mortality of young passerines by directly reducing their food supply, thus indirectly reducing the prey available to peregrines (Driver 1991). Reduced or contaminated food sources will negatively affect peregrine falcons. Appendix A provides useful contacts to help assess the use of pesticides, herbicides, and their alternatives.

Wetlands, especially intertidal mudflats, estuaries, and coastal marshes, are key feeding areas in winter. Wetlands used regularly by peregrine falcons at any time of the year should receive strict protection from filling, development, or other excessive disturbances that could alter prey abundance. Do not apply pesticides to areas where winter prey species congregate. Lead shot should not be used in waterfowl areas where peregrine falcons feed. Peregrines can tolerate human presence at wintering sites if they are not harassed and if abundant prey remains.

Maintain all large trees and snags in areas where peregrine falcons feed in winter. These perches are important for roosting and for hunting at terrestrial sites. Snags and debris located on mud flats should also be left for winter perching and roosting.

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KEY POINTS

Habitat Requirements

- Peregrine falcons nest in cliffs that are 45 m (150 ft) or more in height.
- Peregrines feed on a variety of smaller birds.
- Hunting territories may extend to a radius of 24 km (15 mi) from nest sites.
- These falcons winter along coastal areas with large shorebird or waterfowl concentrations.

Management Recommendations

- Avoid disturbance during the breeding season (March through June); restrict access to cliff rims where nests are built within 0.8 km (0.5 mi) and within 0.4 km (0.25 mi) of cliff faces.
- Avoid forest practices within 0.8 km (0.5 mi) of eyrie cliffs during the breeding season. If logging does occur, retain all trees on top of the cliff ridge.
- Develop site management plans for Eyries when considering land uses outside of forested environments or for non-forest practice activities.
- Preserve all major perches around nests by retaining all snags and large trees.
- Aircraft should not approach closer than 500 m (1,500 ft) above a nest.
- Route powerlines away from eyries.
- Avoid applying pesticides that affect birds near eyries. Refer to Appendix A for contacts useful in assessing pesticides, herbicides, and their alternatives.
- Avoid applying pesticides to areas where winter prey species congregate.
- Do not use lead shot in peregrine winter feeding areas.
- Maintain large trees and snags as perches in winter peregrine feeding localities.
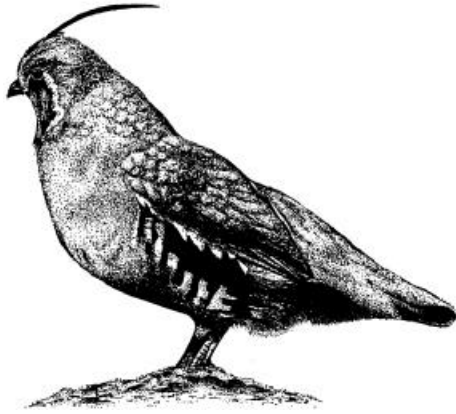
Mountain Quail
Oreortyx pictus

Last updated: 1999

Written by David A. Ware, Michelle Tirhi, and Becky Herbig

GENERAL RANGE AND WASHINGTON DISTRIBUTION

The mountain quail ranges from southwestern British Columbia, through Washington and central Idaho south to the mountainous regions of California, Nevada, and Baja California (American Ornithologists' Union 1983). Mountain quail have been introduced into Alabama, British Columbia, Colorado, Hawaii, Idaho, Montana, Nebraska, Nevada, and Oregon (Heekin 1991). Mountain quail also have been introduced into Washington; however, along the Columbia and Snake rivers there are scattered populations that may be extensions of Oregon flocks (see Figure 1).

The healthiest populations of mountain quail in western Washington appear in Kitsap County (B. Tweit, personal communication). Localized populations also persist in logged areas of Grays Harbor, Thurston, and Mason

Figure 1. Range of the mountain quail, *Oreortyx pictus*, in Washington. Map derived from Washington Department of Fish and Wildlife data files.

counties (G. Shirato, personal communication). Incidental sightings have been reported on Fort Lewis, Pierce County (J. Stevenson, personal communication) and in Cowlitz, Jefferson, King, Lewis, Pacific, Pierce, Snohomish, Asotin, Columbia, Garfield, Kittitas, and Klickitat counties (Brennan 1989; Kessler 1990; B. Tweit, personal communication; G. Shirato, personal communication). Scattered sightings have also been reported along the southern portion of Hood Canal and in Skamania County (Hunn and Mattocks 1980), as well as in western Yakima County (L. Stream, personal communication). Many of the localized sightings are thought to be the result of captive flocks being released by hobbyists.
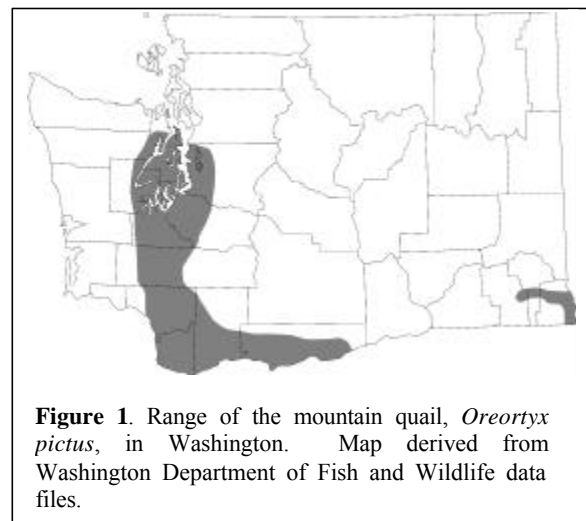
RATIONALE

Mountain quail are uncommon game birds that are at the edge of their range in Washington. Eastern Washington populations are thought to have declined in recent years largely from declining habitat quality. Because of their secretive nature and reliance on brushy habitats that are usually associated with riparian zones, they are not capable of extensive movements away from suitable patches of habitat. Once these habitats are degraded or removed, mountain quail become isolated from other habitat that may be available.

HABITAT REQUIREMENTS

Mountain quail are associated with mixed evergreen-deciduous forests, regenerating clearcuts, forest and meadow edges, chaparral slopes, shrub-steppe, and mixed forest/shrub areas, characteristically in overgrown brushy areas (Johnsgard 1973, American Ornithologists' Union 1983, Brennan 1989, Crawford 1989, Kessler 1990). Tall, dense cover is a requirement for the majority of activities throughout the year (Johnsgard 1973, Gutiérrez 1975) and mountain quail are seldom found far from this cover (Brennan 1993).

In western Washington, mountain quail may be found at sea level in areas cleared for development that contain stands of Scotch broom (*Cytisus scoparius*) and madrone (*Arbutus* spp.) (G. Shirato, personal communication). In arid regions, such as in southeastern Washington, typical habitat consists of deciduous shrub thickets below talus and cliffs, and alder (*Alnus* spp.) thickets along streams (Yocom and Harris 1953, Brennan et al. 1987). In such arid settings, free-flowing water is essential (Ormiston 1966, Leopold 1972, Gutierrez 1975) and mountain quail are often found in close proximity to both water and escape cover (Brennan et al. 1987). Mountain quail commonly inhabit slopes of 20-60% (Miller 1950, Gutiérrez 1980) and have been observed using slopes of 60-110% (P. Heekin, personal communication).

Nesting

In spring, mountain quail seek brush, hardwood, and conifer communities for nesting (R. Gutiérrez, personal communication). Johnsgard (1973) and Kessler (1990) characterized nesting cover as large shrubs and young trees in dense clusters. Nests are typically well concealed and situated beneath roots, brush, grass clumps, bank edges, or at the base of a dead shrub in patches of live shrubs (P. Heekin, personal communication). Miller (1950) reported a mean vegetational height of 0.5 m (1.6 ft) at nest sites. Nests may also be found next to rocks or logs. Some birds nest in their winter range and others move to higher ground, such as forest or farmland edges (Ormiston 1966). In Idaho, nests were located between 713 m and 1,426 m (2,340-4,680 ft) on slopes 60-110% (P. Heekin, personal communication). Nests were situated in relatively open stands of conifer/mountain shrub cover having a fairly dense understory.

Brood Rearing

In mid-summer, mountain quail broods move to the cool, moist bottoms of draws and canyons (Ormiston 1966). Such movements may be related to the availability of preferred foods within the daily cruising range of water (Ormiston 1966, Gutiérrez 1975). In Idaho, broods 2 to 3 weeks old were located in relatively open cover, often on or near game trails (P. Heekin, personal communication).

Winter

In late fall, mountain quail often migrate to lower elevation winter range (Bent 1963, Johnsgard 1973). They winter in brushy thickets, canyons, and along the borders of farms and woodlands (Yocom and Harris 1953) where mixed trees, shrubs, and herbs exist (Kessler 1990). Mountain quail remain below the snow-line, moving up or down in elevation depending on weather conditions (Ormiston 1966). In Idaho, the mean straight-line distance moved from nest site to winter range was 648 m (2,126 ft) (P. Heekin, personal communication).

Loafing and Roosting Cover

Loafing and roosting cover consists of dense vegetation approximately 2-3 m (5-6 ft) in height (Miller 1950). Mountain quail in west-central Idaho have been observed night roosting in hawthorn (*Crataegus* spp.) trees 3-4 m (10-13 ft) above ground level and loafing at the base of dead shrubs (P. Heekin, personal communication).

Escape Cover

Escape cover is typically 1.5-2 m (5-6.5 ft) high with fairly dense growth (Miller 1950). Where this cover type is not available, quail use slopes of 36% or more to escape (Johnsgard 1973). Trees, such as ponderosa pine (*Pinus ponderosa*), firs (*Abies* spp.), and oaks (*Quercus* spp.) may also be important.

Food

Mountain quail feed primarily on vegetable matter (Ormiston 1966, Rue 1973 *in* Heekin 1991); animal matter typically comprises <5% of the diet (J. Crawford, personal communication). Food species for mountain quail include lotus (*Lotus* spp.), smooth sumac (*Rhus glabra*), hackberry (*Celtis* spp.), serviceberry (*Amelanchier* spp.), grape (*Vitis* spp.), gooseberry (*Ribes* spp.), elderberry (*Sambucus* spp.), snowberry (*Symphoricarpos* spp.), manzanitas (*Arctostaphylos* spp.), nightshade (*Solanum* spp.), chickweed (*Stellaria* spp.), blue-eyed Mary (*Collinsia* spp.), hawthorn (*Crataegus* spp.), sweet clover (*Trifolium* spp.), thistle (*Cirsium* spp.), ragweed (*Ambrosia* spp.), teasel (*Dipsacus* spp.), scotchbroom, fringecup (*Lithophragma* spp.), composite seeds (*Madia* spp.), poison oak (*Rhus diversoloba*), geranium (*Geranium* spp.), and lupine (*Lupinus* spp.) (Yocom and Harris 1953, Ormiston 1966, Kessler 1990). Mast (tree seed) is eaten in abundance and includes the seeds of pines, Douglas fir (*Pseudotsuga menziesii*), and black locust (*Robinia pseudoacacia*). Acorns, legumes, tubers, roots, and weed seeds may also be consumed. Ormiston (1966) observed seeds of grasses, hawthorn, pines, sweet clover, thistles, ragweed, and teasel in the fall diet in Idaho. The winter diet is comprised of seeds of large annuals and perennials and fruits of woody species such as hawthorn, acorn meats, pine seeds, and greens (Ormiston 1966, Johnsgard 1973).

LIMITING FACTORS

An inadequate food supply caused by habitat loss throughout mountain quail range is considered a major limiting factor (Miller 1950; R. Gutiérrez, personal communication). The loss of winter habitat from dams and water impoundments, residential development, intensive agriculture, and the deterioration of wintering and breeding grounds as a result of overgrazing also limits mountain quail (Brennan 1990, P. Heekin, personal communication). Timber harvest does not appear to limit mountain quail if the cut site is allowed natural regrowth and invasion by brush species (R. Gutiérrez, personal communication). Excessive timber harvest [>200-400 ha (500-1,000 ac)] may negatively impact mountain quail (Leopold 1977; R. Gutiérrez, pers. comm.); however, this has not been proven (R. Gutiérrez, personal communication).

Water has been reported as a limiting factor (Rahm 1938, Ormiston 1966, Gutiérrez 1975, Miller and Stebbins 1964 *in* Gutiérrez 1975) and may be a problem in southeastern Washington (Kessler 1990). An increased water supply due to greater rainfall has resulted in higher breeding success in arid regions (Gutiérrez 1975, 1980; Brennan et al. 1987). The loss of riparian habitat in arid portions of mountain quail range is a serious threat to their stability (R. Gutiérrez, personal communication).

MANAGEMENT RECOMMENDATIONS

Habitat preservation is the key to mountain quail management in Washington (Kessler 1990). In eastern Washington, mountain quail persist in relatively isolated populations interconnected by corridors of riparian brush communities. These corridors serve as avenues for dispersal and movement between breeding and wintering habitat, as well as provide food and cover in close proximity to water sources (Brennan 1993). Removal of riparian brush communities should be avoided within the range of the mountain quail. The burning of decadent shrub fields should be avoided unless performed as a mosaic burn (P. Heekin, personal communication).

Herbicides that destroy brushy habitat should be avoided where management for mountain quail is a priority. Landowners are encouraged to use integrated pest management that targets specific pests or noxious weeds, pest population thresholds to determine when to use pesticides or herbicides, and crop rotation/diversity and beneficial insects to control pests (Stinson and Bromley 1991). Appendix A provides useful contacts to help assess the use of pesticides, herbicides, and their alternatives.

The interspersion of shrubby cover [covering 20-50% of the ground area (Miller 1950)] should be given major consideration. Ideal habitat consists of a variety of plants at various heights (Miller 1950). The creation of edges between cover types is of lesser importance in habitat management (Miller 1950, Gutiérrez 1975). Management should protect and/or provide a variety of micro-habitats within the mountain quail range including mixed evergreen-deciduous forests, openings, forest and meadow edges, chaparral slopes, shrub-steppe, and mixed forest-shrub areas. Tall, dense cover in close proximity to water should receive priority in management consideration.

Clearcutting extremely large blocks of coniferous and deciduous forests [>200 ha (500 ac)] should be avoided where mountain quail are known to exist. Land managers should be encouraged to replant logged areas with a variety of tree species or allow natural regeneration of sites (J. Crawford,personal communication; R. Gutiérrez, personal communication). Small harvested areas; selective harvest which maintains several mature, standing trees; harvest which retains slash and/or slash piles; and harvested sites which are not subject to broadcast burning have been beneficial to mountain quail in west-central Idaho (P. Heekin, personal communication).
Every effort should be made to protect or provide water sources within mountain quail range, especially along riparian corridors. Livestock use of riparian corridors should be avoided as heavy grazing by sheep and cattle may be detrimental to mountain quail habitat (Gutiérrez 1975). Where water is lacking, watering devices should be installed (Miller 1950). Water devices should be placed in or near heavy cover to reduce predation (P. Heekin, personal communication).

Public education programs targeting habitat removal and water diversion issues associated with residential development are desirable where mountain quail management is priority (P. Heekin, personal communication). Furthermore, mountain quail are often attracted to and concentrate at bird feeders during the winter months. The concentration of birds at these sites increases the threat of predation by both natural and introduced predators. People that maintain bird feeders should be discouraged from placing feeders in open areas which are highly visible to predators (P. Heekin, personal communication).

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KEY POINTS

Habitat Requirements

- Mountain quail are associated with mixed evergreen-deciduous forests; regenerating clearcuts, selective cuts, and seed-tree cuts; forest and meadow edges; chaparral slopes; shrub-steppe; and mixed forest/shrub areas.
- Mountain quail require tall, dense cover over 20-50% of the area.
- A source of free-flowing water such as that found in riparian zones is critical to mountain quail occupying arid regions.
- Mountain quail nest in brush, shrubs, hardwood, and conifer communities.
- Loafing and roosting cover consists of dense vegetation approximately 2-3 m (5-6 ft) in height.
- Mountain quail winter in brushy thickets, along canyons, and about farms and woodland borders.
- Mountain quail feed on fruits, mast, acorns, legumes, tubers, roots, and seeds of grasses, weeds, flowering plants, and insects.

Management Recommendations

- Tall, dense cover (covering 20-50% of the ground area) in close proximity to water sources should be retained in areas where mountain quail management is a priority.
- Protect riparian brush communities within the range of the mountain quail.
- Encourage the use of integrated pest management within the mountain quail primary management zone. Refer to Appendix A for contacts useful when assessing pesticides, herbicides, and their alternatives.
- The burning of decadent shrub fields should be avoided unless performed as a mosaic burn.
- Public education should be encouraged where managing for mountain quail is a priority, and should target habitat removal and water diversion issues associated with residential development. The avoidance of placing bird feeders in open areas highly visible to predators should also be addressed.
- Minimize livestock use of riparian habitat.
- Protect or provide a variety of micro-habitats.
- Avoid clearcutting large areas of coniferous and deciduous forests (>500 ac).
- Encourage the planting of multiple tree and shrub species and/or allowing natural regeneration in areas subject to timber harvest.
- Install watering devices where water is lacking in or near dense cover.

Chukar
Alectoris chukar

Last revised: 1999

Written by David A. Ware and Michelle Tirhi

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Chukars are native to Asia, the Middle East, and southern Europe. They have been introduced into rocky, arid, mountainous areas from southern British Columbia south to Baja California and east to western Colorado (Udvardy 1977, Dunn et al. 1987). In southern Alberta, Arizona, New Mexico, and South Dakota only remnant populations exist (Johnsgard 1973).

In Washington, chukars are mainly found along deep river canyons in the arid regions east of the Cascade Mountains. The primary management zone includes portions of the middle and upper Columbia River and its tributaries, the Banks Lake area, the lower Yakima River and its tributaries, and the eastern portion of the Snake River (see Figure 1).
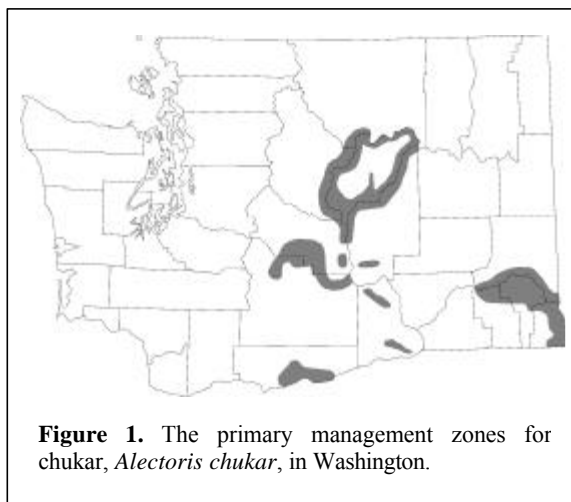
Figure 1. The primary management zones for chukar, *Alectoris chukar*, in Washington.

RATIONALE

The chukar, a recreationally important game bird, is one of the most popular upland game species in Washington. From 1991 to 1995, an average of 8,000 hunters a year reported pursuing chukars in Washington. Habitat is limited by the availability of talus or rocky slopes.

HABITAT REQUIREMENTS

Chukars flourish in mesic (moist) and semi-arid portions of shrub-steppe habitat characterized by steep, rocky, dry slopes (Galbreath and Moreland 1953, Christensen 1954, Molini 1976, Oelklaus 1976, Carmi-Winkler et al. 1987). The habitat is described as dense to open, with non-spiny shrubs, perennial and annual grasses, and forbs (Molini 1976). Galbreath and Moreland (1953) and Molini (1976) identified the optimum range as 50% sagebrush

(*Artemisia* spp.)-cheatgrass (*Bromus tectorum*)-bunchgrass (*Agropyron* spp.); 45% talus slope, rock outcrops, cliffs, and bluffs; 5% brushy creek bottoms and swales; and steep slopes (up to 40).

In Washington, chukar habitat consists of talus areas containing bromegrasses, bunchgrasses, and sagebrush at elevations of 175-1,220 m (575-4,000 ft) (Moreland 1950). Oelklaus (1976) found Douglas hackberry (*Celtis douglasii*) communities, smooth sumac (*Rhus glabra*) stands, and poison ivy (*Toxicodendron* spp.) clones along rivers and riparian corridors used extensively by chukars throughout the Snake and Columbia river canyons. Chukars are apparently not agricultural inhabitants and typically exist in areas unoccupied by other upland birds (Moreland 1950). Big sagebrush (*Artemisia tridentata*) is the predominant shrub and cheatgrass brome the predominant grass throughout the chukar range (Galbreath and Moreland 1953, Molini 1976). However, a variety of native and non-native shrubs and grasses are used.

Nesting

Most chukar nests are located under low-growing scabland sagebrush, 90-120 m (300-400 ft) above creek bottoms in heavy sagebrush areas mixed with bunch- and bromegrasses (Galbreath and Moreland 1953). Hens may also seek more gentle terrain in which to nest (Alkon 1983).

Roosting, Loafing, and Dusting Sites

Chukars typically roost and loaf on the ground beneath sagebrush, under rock outcrops, or in open rocky areas (Christensen 1970). Chukars often roost on peninsulas. Rock outcrops, Douglas hackberry, and smooth sumac communities may be used for loafing (Oelklaus 1976) depending on availability. Dusting is very important and occurs alongside trails and roads, or near water sites (Christensen 1970).

Food

Chukars feed primarily on exotic grasses and the seeds of weedy forbs (Galbreath and Moreland 1953, Bohl 1957, Christensen 1970, Kam et al. 1987). Cheatgrass (both seeds and leaves) is the most important yearly food item for chukars throughout their range (Galbreath and Moreland 1953, Harper et al. 1958, Christensen 1970). In Washington, cheatgrass and wheat comprise the main diet of the chukar year-round (Galbreath and Moreland 1953). When chukars are in close proximity to agricultural fields, they may feed on available grains, seeds, and green shoots (Sandfort 1954, Christensen 1970). Insects are an important source of food during the summer and early fall (W. Molini, personal communication).

Water

The summer range of the chukar depends upon the distribution and availability of water (Galbreath and Moreland 1953, Christensen 1970). Oelklaus (1976) consistently found chukars concentrated around rivers and tributaries in Idaho. Oelklaus (1976) also found chukars moving away from tributaries that dried up in the summer and fall to those that remained. In eastern Washington, chukars have been observed feeding on ripe fruits of hawthorne (*Crataegus* spp.), common chokecherry (*Prunus virginiana*), and serviceberry (*Amelanchier* spp.) in July and August in part to fulfill their water needs (Galbreath and Moreland 1953).

LIMITING FACTORS

Grasses, particularly cheatgrass, and water are the 2 components necessary for chukar survival (Oeklaus 1976). Severe winters may limit local populations and have been known to adversely effect chukar populations in Nevada, Idaho (Christensen 1970), and Washington (Galbreath and Moreland 1953). Low precipitation, especially droughts, are deleterious to these birds (Christensen 1958).

MANAGEMENT RECOMMENDATIONS

Of primary importance in maintaining good chukar production is the availability of green grasses, especially cheatgrass (Christensen 1958). Chukars rely on sagebrush stands within semi-arid sagebrush grasslands (Galbreath and Moreland 1953). Reduction of sagebrush within primary chukar management zones should be avoided. Management practices that significantly impact insect populations will likely decrease chukar numbers and should be avoided (W. Molini, personal communication).

The summer range of the chukar depends on the availability of water. Therefore, water improvement and development can be used to expand their distribution and possibly increase the chukar population (Christensen 1970). The protection and improvement of existing water supplies should receive priority in chukar habitat management (Christensen 1970). This would include reconstructing livestock watering troughs and other watering developments to insure a permanent water supply for chukars and other wildlife. Providing escape ramps and supplemental bird drinking basins to stock water tanks used by livestock would also benefit chukars. Gallinaceous guzzlers [1,300 L (350 gal)] placed within 45 m (148 ft) of steep, rocky escape cover or near the bottom of draws, gullies, and/or ravines provide the most benefits to chukars (W. Molini, personal communication). Chukars require some form of protective cover around water sources. Therefore, plant shrub cover around watering devices (Galbreath and Moreland 1953).

Douglas hackberry communities, sumac stands, and poison ivy clones along rivers and riparian corridors throughout the range of the chukar should be retained (Oelklaus 1976). Landowners and land managers are encouraged to use integrated pest management that targets specific pests or noxious weeds, uses pest population thresholds to determine when to use pesticides or herbicides, and utilizes crop rotation/diversity and beneficial insects to control pests (Stinson and Bromley 1991). For more information on integrated pest management, refer to Appendix A, for contacts to help assess the use of pesticides, herbicides, and their alternatives.

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KEY POINTS

Habitat Requirements

- Chukars inhabit dense to open portions of shrubland associated with perennial and annual grasses and forbs.
- Optimum range is 50% sagebrush-cheatgrass-bunchgrasses; 45% talus slope, rock outcrops, cliffs, and bluffs; 5% brushy creek bottoms and swales; and steep slopes (up to 40).
- Big sagebrush and cheatgrass predominate throughout the chuckar's range.
- Chukars nest under low-growing scabland sagebrush, 90-120 m (300-400 ft) above creek bottoms in heavy sagebrush areas mixed with bunch- and bromegrasses.
- Chukars roost and loaf on the ground beneath sagebrush or under rock outcrops, in Douglas hackberry and in smooth sumac communities.
- Chukars dust alongside trails and roads or near water sites.
- Chukars feed mostly on cheatgrass as well as grains, seeds, and green shoots when available.

Management Recommendations

- Protect sagebrush in semi-arid sagebrush grasslands used by chukars.
- Management practices which significantly impact insect populations will likely decrease chukar numbers and should be avoided.
- Protect and/or improve existing water supplies throughout chukar range.
- Provide escape ramps and supplemental bird drinking basins to stock water tanks used by livestock.
- Gallinaceous guzzlers [1,300 L (350 gal)] placed within 45 m (148 ft) of steep, rocky escape cover or near the bottom of draws, gullies, and/or ravines provides the most benefits to chukars.
- Plant shrub cover around watering devices.
- Retain Douglas hackberry communities, sumac stands, and poison ivy clones along rivers and riparian corridors.
- Encourage the use of integrated pest management within the chukar primary management zone. For more information on integrated pest management, refer to Appendix A for contacts useful in assessing pesticides, herbicides, and their alternatives.
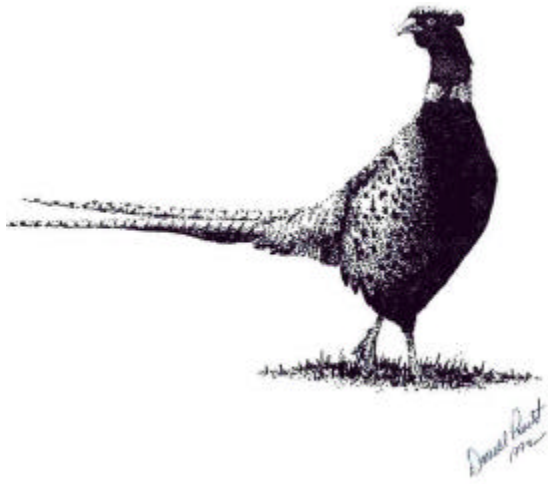
Ring-necked Pheasant
Phasianus colchicus

Last updated: 1999

Written by David A. Ware and Michelle Tirhi

GENERAL RANGE AND WASHINGTON DISTRIBUTION

The ring-necked pheasant is native to Asia and has been extensively introduced throughout North America. Ring-necked pheasants range from central Canada through the northern United States and southward into New Mexico, Texas, Louisiana, and Mississippi (Dumke et al. 1984, Dahlgren 1988, Droege and Sauer 1990).

Ring-necked pheasants are found in most agricultural areas throughout Washington. However, they are only considered a priority species within the primary management zone delineated by Washington Department of Fish and Wildlife's Game Division (see Figure 1).

Figure 1. Primary management zone of the ring-necked pheasant, *Phasianus colchicus*, in Washington. Map developed by Washington Department of Fish and Wildlife Game Division.

RATIONALE

The ring-necked pheasant, a recreationally important game species, is the most popular upland game bird in Washington. Ring-necked pheasants are currently the focus of a major habitat restoration program. Pheasants are dependent on agricultural habitats and they thrive in non-crop vegetation around cultivated crops. As shrub-steppe habitats were converted to agriculture, pheasant populations grew. However, with today's improved farming technology and management practices, pheasants have undergone a tremendous decline as indicated by harvest surveys (Washington Department of Fish and Wildlife 1996). This has resulted in significant declines in hunter numbers and associated recreation. There were over 110,000 pheasant hunters in 1981. In 1995, that number declined to 29,000. Pheasant harvest declined from over 500,000 to 70,000 birds from 1981 to 1995.

HABITAT REQUIREMENTS

Ring-necked pheasants require permanent retention-type cover to sustain populations and use a variety of agricultural cover types. In Washington, prime cover occurs near irrigated farmlands containing cattail patches (*Typha* spp.) mixed with willow (*Salix* spp.) (Blatt 1975, Foster et al. 1984). Riparian/shrub tree bottoms in dryland wheat areas of eastern Washington that are not grazed by livestock also provide excellent habitat. Thickets and shrubs provide shelter and shade; woody plants and thorny shrubs provide escape cover; wetland areas and weedy patches provide roost and loaf sites; and cattail, willow, and bulrush sloughs (*Scirpus* spp.) provide escape and

thermal cover during winter. Fence rows, roadside ditches, and field edges with adequate vegetation provide travel corridors. In Britain, pheasants have been observed roosting in trees and in ditches in areas void of trees (D. Hill, personal communication).

Where adequate habitat exists, pheasants may spend their entire life in an area approximately 256 ha (640 ac) in size. Prime ring-necked pheasant habitat contains approximately 25-50% uncultivated land and 50-75% cultivated land (having 20-75% small grain crops and/or 30-40% field corn crops) (Warner et al 1984).

Roadsides, canals, and drainage banks have good potential for pheasants and other upland wildlife (Joselyn and Tate 1972, Snyder 1974, Varland 1985, Warner et al. 1987). The use of such linear cover depends on the proximity to other prime breeding habitats (Warner and Joselyn 1986), the density and height of cover (Wiegers 1959, Hoffman 1973, Warner et al. 1987), and the width of linear cover (Linder et al. 1960, Gates and Hale 1975).

Nesting and Brood Rearing

Undisturbed cover provides the best nesting and brood rearing habitat. Areas containing new vegetation are preferred; where this is lacking, residual vegetation is used. Alfalfa, wheat, and grass hayfields are often selected as nest sites (Galbreath and Ball 1969; Snyder 1982, 1984). This choice of nesting habitat is the most precarious due to harvest and cultivation. Pastures, woodlots, orchards, row crops, wetlands, and untilled sites adjacent to cropland are also used for nesting (Gates 1970; J. Tabor, personal communication). Ring-necked pheasants typically nest in the tallest [15 cm (6 in) residual cover and 25 cm (10 in) for current growth] herbaceous vegetation available (Washington Department of Wildlife 1987). In Britain, Hill (personal communication) has observed pheasants nesting under area of bramble (*Rubus* spp.) intertwined with grasses that provides both open ground cover and overhead concealment. Nest predation actually increased when nests were situated in clumps of obvious vegetation (D. Hill, personal communication). In Wisconsin, undisturbed grasslands or hayfields with adequate residual cover and wetlands provide key nesting and brood-rearing habitat (Gatti 1983).

Roadsides could provide important nesting areas if managed properly (Trautman 1982, Warner and Joselyn 1986, Hill and Robertson 1988). Warner et al. (1987) commonly found pheasants nesting on roadsides when prime nesting habitat was unavailable. Haensly et al. (1987) cautioned that strip cover, such as that found at roadsides, may also have a higher rate of predation in comparison to more extensive habitats used for nesting.

Brood-rearing habitat includes shrubs, tree rows, grain fields (corn or sorghum), and cool-season grasses (Nelson et al. 1990), which provide both dense hiding cover and adequate food supplies. Optimal brood-rearing habitat contains a high proportion of broad-leaved plants which are a key source of insects and seeds. Optimal brood-rearing habitat also provides overhead concealment from predators and open space at ground level for ease of movement of chicks. Broods typically range over large areas and various vegetative communities in search of food during the first 2 weeks of life (D. Hill, personal communication). Often areas containing the highest densities of preferred foods are avoided, such as weed fields (D. Hill, personal communication).

Roosting

Roosting takes place in grasslands and stubble fields except during severe winter weather when low, herbaceous vegetation (Labisky 1956, Robertson 1958), cattails, and marshy vegetation are preferred (Olsen 1977). In Washington's Columbia Basin, wet meadows containing rush (*Juncus* spp.) are used throughout the year as roosting sites (J. Tabor, personal communication).

Loafing

Loafing areas contain minimal ground cover but dense overhead concealment, such as bushy vegetation, ragweed (*Ambrosia* spp.), or summercypress (*Kochia* spp.). These areas usually provide dusting sites, sunlight, or shade depending upon the needs of the pheasant (Ginn 1962).

Winter

Ideal winter habitat provides food and woody plants for cover (Hill and Robertson 1988). In South Dakota, wetlands lacking snow accumulation are ideal wintering sites (A. Leif, personal communication). In Washington, pheasants mainly winter in dense willow stands and cattail patches on sites 2-6 ha (5-15 ac) in size which are within 1 km (0.6 mi) of cultivated crops (Blatt 1975, Foster et al. 1984). In Great Britain, the highest density of wintering pheasants are located in small woodlots with convoluted boundaries which maximizes the edge:area ratio with surrounding tilled land (D. Hill, personal communication). Multi-row shelterbelts, windbreaks, fencerows, and shrub-type cover which is not grazed by livestock also provide good winter cover.

Food

Ring-necked pheasants feed primarily on cultivated grains, including corn, wheat, barley, peas, and oats (Trautman 1952, DeSimone 1975, Hill and Robertson 1988). Beans, rice, and sorghum are eaten in smaller quantities. Weed and grass seeds are also important food items, especially when waste grain is unavailable (Hiatt 1947, Trautman 1952, Olsen 1977, Wise 1986). In winter, wild fruits are consumed and may include the fruits of chokecherry (*Aronia* spp.), wild rose (*Rosa* spp.), snowberry (*Symphoricarpos* spp.), hawthorn (*Crataegus* spp.), and serviceberry (*Amelanchier* spp.). Insects and gastropods are eaten in small quantities by adults. Insects are consumed in larger quantities by hens during the breeding season and by chicks and juveniles (Loughrey and Stinson 1955; Korschgen 1964; Olsen 1977; A. Leif, personal communication). Species eaten include grasshoppers, snails, beetles, ants, cutworms, crickets, plant bugs, and sawfly larvae. During egg laying, hens consume large amounts of snail shells and high calcium grit to help in egg shell production (Wise 1986).

LIMITING FACTORS

Loss of permanent nesting and winter cover on irrigated lands is the primary factor limiting the ring-necked pheasant (Kimball et al. 1956 in Allen 1956, Washington Department of Game 1957, MacMullan 1961, Blatt 1975, Burger 1988, Hart 1990). Specific problems include the loss of cattail and willow stands, woody plants, windbreaks, and brushy fencerows (Warner et al. 1984). Pesticides have been shown to lower chick production (Labisky and Lutz 1967, Borg et al. 1969 in Potts 1986) and chick viability, (Rudd and Genelly 1956) as well as degenerate the nervous system.

MANAGEMENT RECOMMENDATIONS

Irrigated farmlands within the Columbia Basin Project, the Yakima Valley, and riparian areas in south Whitman, northern Garfield, Columbia, and Walla Walla counties should be considered high priority areas for ring-necked pheasants. Optimal feeding and wintering areas are 1 km (0.6 mi) (Hart 1990) to 1.2 km (0.75 mi) apart (Blatt 1975). Hill (personal communication) recommends maintaining many small plots of woodland with a maximum distance of 500-750 m (1,600-2,500 ft) between woodlots and permanent winter cover. On public lands, legumes and/or native grasses should be planted as nesting cover and shrubs and woody plants as winter cover. Multi-species food plots should be established near permanent cover. At the landscape level, habitat management for pheasants should include a mosaic of different crops and residual cover interspersed with plots of permanent cover (D. Hill, personal communication).

Fence rows, waterways, cattail and willow patches, thickets, shrubs, and other woody plants on irrigated private farmlands should be protected and enhanced. Farmers should be encouraged to delay alfalfa cutting 1 week or longer to increase nesting success (Hartman and Fisher 1984) and/or grow winter wheat, seed alfalfa, or grass seed crops. Strips of standing corn should be left in fields for winter food. Undisturbed grasslands and hayfields containing residual cover should be preserved (Gatti 1983). Where these components are lacking, the provision of large, square-shaped fields 4-32 ha (10-80 ac) in close proximity [3 km (2 mi)] to winter cover would enhance pheasant nesting and brood-rearing (Gatti 1983). Private landowners may also be encouraged to retire lands of marginal grazing or crop value, especially lands with moderate to high erosion risks (Gatti 1983).

Livestock grazing should be restricted or excluded on isolated tracts throughout pheasant range, in riparian areas, in woody cover, and on prime wintering, nesting, and roosting grounds (Wechsler 1986; Hart 1990; J. Tabor, personal communication). Fences should be constructed around ponds to exclude cattle and increase nesting cover.

In areas of low precipitation, protect or plant dense stands of warm- and cool-season grasses and legumes for nesting (Warner and Joselyn 1986). If weed control on these areas is necessary, mow between 1 August and 1 September (late summer) to allow hens to bring off a brood and allow vegetation to regrow prior to winter dormancy (Hoffman 1973, Wechsler 1986, Hart 1990).

Pesticide spraying should be avoided within prime pheasant habitat (Hoffman 1973). Where spraying is unavoidable, use a spot spraying technique verses blanket spraying (Wechsler 1986). Incorporate 6 m (20 ft) strips around the perimeter of cereal grain fields which would not receive chemical treatment (Potts 1986; A. Leif, personal communication). Landowners are encouraged to use integrated pest management that targets specific pests or noxious weeds, pest population thresholds to determine when to use pesticides or herbicides, and crop rotation/diversity and beneficial insects to control pests (Stinson and Bromley 1991; L. Peterson, personal communication). See Appendix A for useful contacts for assistance when assessing pesticides, herbicides, and their alternatives.

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KEY POINTS

Habitat Requirements

- Irrigated farmlands containing cattail patches mixed with willow and ungrazed riparian/shrub tree habitat in dryland wheat areas provide suitable retention cover for ring-necked pheasants.
- Ring-necked pheasant habitat contains approximately 25-50% idle land and 50-75% cultivated land (having 20-75% small grain crops and/or 30-40% field corn crops).
- Pheasants nest in undisturbed cover (May-July) found in alfalfa and wheat fields, grass hayfields, pastures, woodlots, orchards, row crops, wetlands, roadsides, and untilled areas adjacent to cropland.
- Nests are placed in tall, dense herbaceous vegetation [minimum15 cm (6 in) residual cover and 25 cm (10 in) current growth].
- Brood rearing habitat includes shrubs, tree rows, grain fields (corn or sorghum), and cool-season grasses with an abundance of broad-leaved plants and insects for chicks.
- Pheasants roost in grasslands, stubble fields, cattails, marshy vegetation, and wet meadows containing rush.
- Preferred loafing areas contain minimal ground cover and dense overhead concealment.
- Pheasants winter in dense willow stands and cattail patches 2-6 ha (5-15 ac) in size and 1 km (0.6 mi) from cultivated crops. Multi-row shelterbelts, windbreaks, fencerows, ungrazed shrub-type cover, and wetland vegetation also provides key wintering habitat.
- Pheasants feed primarily on cultivated grains, including corn, wheat, barley, peas and oats, weed and grass seeds, wild fruits, and insects.

Management Recommendations

- Optimal feeding and wintering areas are 1-1.2 km (0.6-0.75 mi) apart, preferably 500-750 m (1,600-2,500 ft).
- Plant legumes and/or native grasses as nesting cover and shrubs and woody plants as winter cover.
- Establish multi-species food plots (>2 acres in blocks) near permanent cover.
- Manage strip cover (roadsides, canals, and drainage banks) in areas of medium to high precipitation [>25 cm (10 in)]. Maintain or plant dense stands of warm- and cool-season grasses and legumes in areas of low precipitation. If weed control is necessary, mow between 1 August and 1 September.
- Discourage the removal and annual burning of fence rows, waterways, cattail and willow patches, thickets, shrubs, and other woody plants on irrigated private farmlands.
- Encourage farmers to delay alfalfa cutting to increase nesting time and/or grow other less hazardous crops.
- Leave scattered, standing grain in fields for winter food.
- At the landscape level, habitat management for pheasants should include a mosaic of different crops and residual cover, interspersed with tracts of permanent cover.
- Livestock grazing should be restricted and/or excluded on isolated tracts, woody cover, riparian areas, and on wintering grounds. Restrict livestock by placing fences around ponds.
- Avoid the use of pesticides within prime pheasant habitat where possible. Refer to Appendix A when assessing pesticides, herbicides, and their alternatives.
- Use spot spraying (verses blanket spraying) where spraying pesticides is unavoidable and establish a 6 m (20 ft) conservation headland (buffer) around the perimeter of cereal fields.
- Encourage the use of integrated pest management within the ring-necked pheasant primary management zone.

Blue Grouse

Dendragapus obscurus

Last updated: 1998

Written by David A. Ware

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Blue grouse are found throughout western North America, including the offshore islands of British Columbia, Canada. Their range extends from the southern portions of Alaska and the Yukon, south along the Pacific Coast to northern California. The range continues east, encompassing the Cascade and Sierra Nevada mountains of the Pacific Northwest and California, and the northern and central Rocky Mountains from Canada to Arizona (Aldrich 1963, Johnsgard 1973).

In Washington, blue grouse are found in mountainous areas wherever open coniferous forests are present (see Figure 1; Soil Conservation Service 1969). They are closely associated with true fir (*Abies* spp.) and Douglas fir (*Pseudotsuga menziesii*) forests (Johnsgard 1973). Hunter survey results from the 1995 season indicated that blue grouse were harvested from all counties except Adams, Benton, Franklin, Grant, Island, San Juan, and Whitman (Washington Department of Fish and Wildlife 1996).
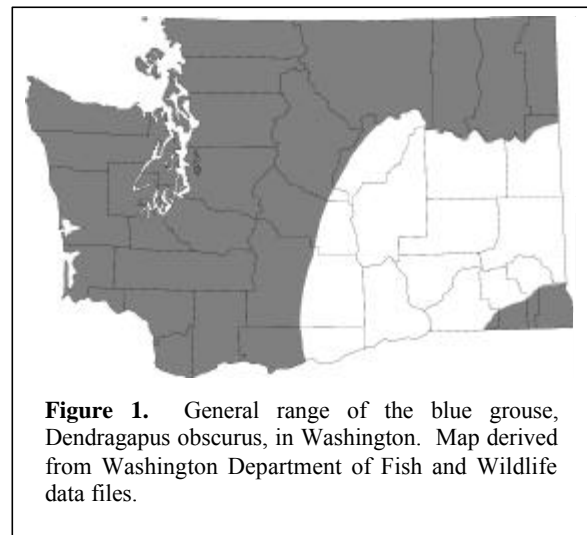
Figure 1. General range of the blue grouse, Dendragapus obscurus, in Washington. Map derived from Washington Department of Fish and Wildlife data files.

RATIONALE

The blue grouse is a recreationally important species that is vulnerable to habitat loss or degradation.

HABITAT REQUIREMENTS

Blue grouse breed in open foothills and are closely associated with streams, springs, and meadows. Much of the food they require comes from the succulent vegetation that grows in these areas. During spring and summer blue grouse use stream bottoms and areas with gentle slopes (Washington Department of Game 1961). In the fall they migrate to higher elevations where they spend the winter feeding on fir needles (Soil Conservation Service 1969). Large fir trees are a food source for wintering blue grouse and are required for roost sites. Blue grouse exhibit strong site fidelity to their wintering areas (Cade 1984).

Diet

True fir and Douglas fir needles constitute 60% of blue grouse diet west of the Cascade Mountains (Beer 1943). In other areas they are often supplemented with larch (*Larix* spp.) and pine (*Pinus* spp.) needles (Boag 1963). Important forbs and grasses in drier climates include balsamroot (*Balsamorhiza* spp.), buckwheat (*Eriogonum* spp.), dwarf mistletoe (*Phoradendron* spp.), dandelion (*Taraxacum* spp.), false dandelion (*Agoseris* spp.), strawberry (*Fragaria* spp.), clover (*Trifolium* spp.), sedge (*Carex* spp.), daisy or fleabane (*Erigeron* spp.), knotweed (*Polygonum* spp.), manzanita or bearberry (*Arctostaphylos* spp.), huckleberry (*Vaccinium* spp.), pussy toes (*Antennaria* spp.), elderberry fruit (*Sambucus* spp.), hawksbeard (*Crepis* spp.), dock (*Rumex* spp.), starwort (*Stellaria* spp.), and lupine (*Lupinus* spp.) (Beer 1943, Boag 1963). A study on Vancouver Island indicated that 90% of adult blue grouse diets consisted of bracken fern (*Pteridium aquilinum*), willow (*Salix* spp.), Oregon grape (*Berberis* spp.), blackberry (*Rubus* spp.), huckleberry, salal (*Gaultheria* spp.), and cat's ear (*Hypochaeris* spp.) (Johnsgard 1973). Insects are also an important food source, especially for young chicks during their first 10 days of life (Beer 1943).

Breeding Areas

Conifer thickets, their edges, and adjacent clearings are characteristic of high quality breeding habitat for blue grouse. Selective logging and small clearcuts have the potential to produce good blue grouse habitat by creating uneven aged timber stands with numerous 20-60 year-old thickets (Martinka 1972). Nests are usually located near logs or under low tree branches in open timber (Johnsgard 1973). Smith (1990) found that in Idaho, nesting occurs in brushy areas and that sites with tall sagebrush were preferred.

Mussehl (1962) stated that broods use areas with high plant density and diversity and high canopy coverage. Bare ground should be less than 11%, and the average effective height of grass and forbs should be 20 cm (8 in). Grass and forb cover in areas of highest use range from 53-85%. The forb component of high use areas is 11-41%. Typically, broods feed within 90 m (295 ft) of brush/tree cover. As the broods get older, they switch to riparian areas and shrubby vegetation (Mussehl 1962).

LIMITING FACTORS

Reforestation practices that include high density replanting, herbicide application, and fertilization result in rapid tree canopy closure which reduces blue grouse use (Bendell and Elliott 1967, Zwickel and Bendell 1985). In drier areas, intense grazing of open lowland forests reduces the quality and availability of breeding habitat (Mussehl 1962, Seaburg 1966, Zwickel 1972).

MANAGEMENT RECOMMENDATIONS

Streams, springs, and wet meadows should be safeguarded from potential damage due to livestock grazing and logging operations. Lush vegetation, shrubs, and deciduous trees associated with such areas should be retained for blue grouse brooding and feeding habitat. Grazing should be managed for maximum forb production. The grazing intensity should be light enough to allow grass/forb vegetation to reach a standing height of 20 cm (8 in) (Mussehl 1962, Seaburg 1966). Preferred brooding areas for blue grouse include grass and forb communities that are up to 30 cm (12 in) high. Moderate grazing from May through August or grazing deferred until after 1 August, preserves nesting, brooding, and feeding cover (Soil Conservation Service 1969). Heavy grazing on lower slopes can be deleterious to blue grouse habitat (Johnsgard 1973).

Reforestation activities should address the needs of blue grouse. Succession is naturally rapid, but it is accelerated by dense plantings of Douglas fir. Allowing the tops of hills and low-productivity sites to remain unplanted would be beneficial to blue grouse as breeding areas (Johnsgard 1973, Zwickel and Bendell 1985). Forbs should always be included in seed mixes when reseeding forest land and range where blue grouse occur (Seaburg 1966). Mussehl

(1962) showed that blue grouse preferred sites composed of at least 11% forbs. Openings in densely forested areas such as Vancouver Island, Canada, are important to blue grouse. Logging activity and fire in the low to mid-elevations can open up the forest canopy which may improve breeding habitat.

Cade (1984) recommended using clearcuts smaller than 250 m (820 ft) across and leaving at least 40 trees/ha (16 trees/ac) that have a minimum 24 cm (9 in) diameter on wintering areas. Selective cuts or long rotations greater than 60 years are also better for wintering blue grouse than clearcuts (Cade and Hoffman 1990). Winter roost areas should be retained, including mature, mistletoe-laden Douglas fir thickets near ridges (R. McKeel, personal communication; M. Quinn, personal communication).

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KEY POINTS

Habitat Requirements

- Blue grouse use open, low- to mid- elevation forests for breeding areas. They can be found in close association with streams, springs, and meadows.
- Forest openings <250 m (820 ft) best allow for blue grouse movement across them.
- Areas where vegetation is comprised of 11-40% broadleaf plants (forbs) are preferred.
- Rangeland with vegetation averaging 20 cm (8 in) tall provides brood rearing habitat from May through August.
- Broods use areas with high plant density and diversity and high canopy coverage.
- Insects are an important food source for very young chicks (<10 days old).
- Needles from true fir (*Abies* spp.) and Douglas fir (*Pseudotsuga menziesii*) are an important food source.
- Blue grouse winter in true fir and Douglas fir forests at higher elevations.

Management Recommendations

- Streams, springs, and wet meadows should be safeguarded from potential damage due to livestock grazing and logging operations. Lush vegetation, shrubs, and deciduous trees associated with such areas should be retained for blue grouse brooding and feeding habitat.
- Grazing should be light so that an effective height of 20 cm (8 in) for grasses and forbs is maintained from May through August, or grazing should be postponed until after 1 August.
- Timber harvest in areas known to contain wintering or breeding blue grouse should be restricted to selective cutting or clearcuts smaller than 250 m (820 ft).
- At least 40 trees/ha (16/ac) with diameters >24 cm (9 in) should be left standing when timber harvest occurs in areas inhabited by blue grouse.
- Revegetation efforts should aim for a high percentage of forbs and a variety of trees rather than single plantings that include 1 or 2 species.
- Known winter roosts should be retained, including mature Douglas fir thickets near ridges.
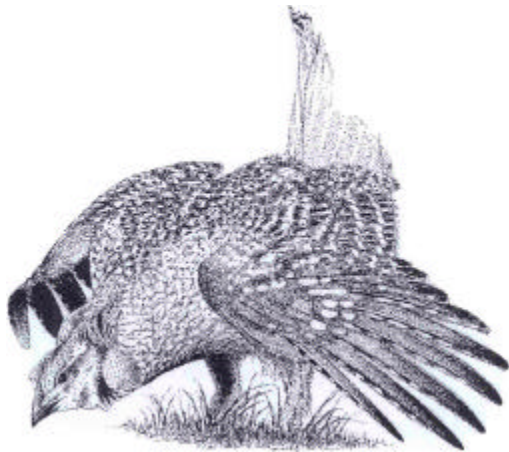
Sharp-tailed Grouse
Tympanuchus phasianellus

Last updated: 2003

Written by Michael A. Schroeder and Michelle Tirhi

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Sharp-tailed grouse (*Tympanuchus phasianellus*) were originally found throughout substantial portions of central and western North America, including a large portion of Canada and Alaska (Hays et al. 1998). Although there are 6 subspecies of sharp-tailed grouse in North America, only the Columbian subspecies (*T. p. columbianus*) is found in Washington. Columbian sharp-tailed grouse were originally distributed in shrub-steppe, steppe, and meadow-steppe habitats from southern British Columbia, through northeastern California, Utah, Colorado, Wyoming and western Montana (Yocom 1952, Jewett et al. 1953, Aldrich and Duvall 1955, Aldrich 1963, Daubenmire 1970).
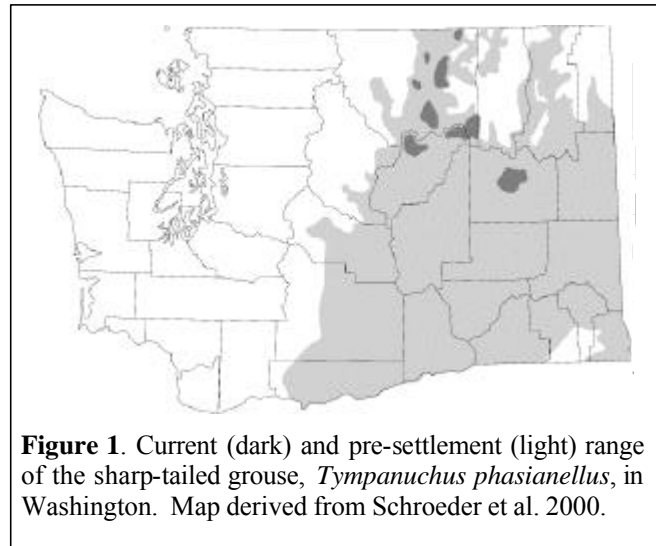

Figure 1. Current (dark) and pre-settlement (light) range of the sharp-tailed grouse, *Tympanuchus phasianellus*, in Washington. Map derived from Schroeder et al. 2000.

The current range of sharp-tailed grouse in Washington is restricted to eight small, isolated populations in the north-central portion of the state (see Figure 1; Washington Department of Fish and Wildlife 1995, Hays et al. 1998, Schroeder et al. 2000). The largest of these remaining populations is near the Swanson Lakes Wildlife Area in Lincoln County, Nespelem in Okanogan County, and the Tunk-Siwash valleys in the Okanogan River valley (Schroeder et al. 2000). Sporadic sightings outside these primary distribution areas have been reported in Lincoln, Douglas, Okanogan and Asotin counties (Schroeder et al. 2000). Sharp-tailed grouse management areas are currently being designated by the Department of Fish and Wildlife that include portions of Okanogan, Lincoln, Douglas, Chelan and Grant counties (Stinson, in preparation; see also Washington Department of Fish and Wildlife 1995).

RATIONALE

The Columbian sharp-tailed grouse was petitioned for federal listing as a threatened or endangered species under the Endangered Species Act, but the petition was rejected by the U.S. Fish and Wildlife Service after it was determined that populations in southeastern Idaho, north-central Utah, and northwestern Colorado were relatively robust (Warren 2000). Although the sharp-tailed grouse is classified as a game species in Washington, hunting was suspended in 1988 (Washington Department of Fish and Wildlife 1995); the grouse is currently listed as a state-threatened species (Hays et al. 1998). The distribution of sharp-tailed grouse in Washington has severely decreased

since pre-settlement times due to the conversion of native habitat to cropland and to the degradation and fragmentation of remaining shrub- and grass-dominated habitats (Schroeder et al. 2000). Approximately 76% of Washington's sharp-tailed grouse habitat has been lost to conversion since the late 1800s (Schroeder et al. 2000). Protection and enhancement of remaining habitats is critical to the long-term management and survival of this species in Washington (Washington Department of Fish and Wildlife 1995).

HABITAT REQUIREMENTS

General Vegetation

Sharp-tailed grouse depend on grass-dominated habitats intermixed with patches of deciduous trees and shrubs for food and cover throughout the year (Connelly et al. 1998). In Washington, sharp-tailed grouse were historically associated with shrub-steppe, steppe, and meadow-steppe (hereafter referred to collectively as shrub-steppe), riparian, and mountain shrub habitats (Daubenmire 1970, Zeigler 1979, Giesen and Connelly 1993, Schroeder et al. 2000). Sharp-tailed grouse habitat is characterized by a high diversity and quantity of shrubs including common chokecherry (*Prunus virginiana*), bittercherry (*Prunus emarginata*), water birch (*Betula occidentalis*), serviceberry (*Amelanchier alnifolia*), snowberry (*Symphoricarpos* spp.), hawthorn (*Crataegus* spp.), wild rose (*Rosa* spp.), aspen (*Populus tremuloides*), big sagebrush (*Artemisia tridentata*), three-tipped sagebrush (*Artemisia tripartita*), and antelope bitterbrush (*Purshia tridentata*) (Washington Department of Fish and Wildlife 1995). Herbaceous vegetation often includes bluebunch wheatgrass (*Pseudoroegneria spicata*), Idaho fescue (*Festuca idahoensis*), arrowleaf balsamroot (*Balsamorhiza sagittata*), lupine (*Lupinus* spp.), yellow salsify (*Tragopogon dubius*), milkvetch (*Astragalus* spp.), and yarrow (*Achillea* spp.) (Jones 1966, Zeigler 1979, Oedekoven 1985, Marks and Marks 1988, Meints 1991, Washington Department of Fish and Wildlife 1995).

Breeding Display Grounds (leks)

During spring, males congregate on display sites (leks) to breed with females (Connelly et al. 1998). Leks are typically located on knolls and ridges with relatively sparse vegetation (Hart et al. 1952, Rogers 1969, Oedekoven 1985). Leks are typically surrounded by nesting habitat, often outward from the lek to a distance of about 2 km (1.2 mi) (Marks and Marks 1988, Giesen and Connelly 1993). There is no evidence that lek habitat is limiting, especially because males have been observed displaying on a variety of sites that comprise a range of plant conditions (e.g., croplands, roads, native rangelands grazed by livestock) (Hays et al. 1998).

Nesting and Brood Rearing

Sharp-tailed grouse are ground nesters, preferring relatively dense cover provided by clumps of shrubs, grasses and/or forbs (Ammann 1963, Hillman and Jackson 1973, Meints et al. 1992). Residual grasses and forbs from the previous year's growth are particularly important for concealment and protection of nests and broods (Hart et al. 1952, Parker 1970, Zeigler 1979, Oedekoven 1985, Meints et al. 1992, Giesen and Connelly 1993, Hays et al. 1998). In research studies, visual obstruction readings (VOR; i.e., quantitative measure of vertical plant cover) were found to be greater at nest sites than at random sites (Kobriger 1980, Marks and Marks 1987, Meints 1991, McDonald 1998).

In Washington, McDonald (1998) found that litter cover, bare ground, and visual obstruction differed between nest and random sites within 5 meters of nests. Litter cover and visual obstruction were significantly greater at nest sites, while bare ground was significantly less at nest sites. McDonald (1998) found VOR readings of 24 cm (9.5 in) within 5 m (20 ft) of all nests, and successful nest sites had higher VOR readings than unsuccessful nests (28 cm vs. 23 cm). In addition, litter cover at successful nest sites was greater than 80 percent.

Fields enrolled in agricultural set-aside programs (e.g., federal Conservation Reserve Program [CRP]) are often used by nesting grouse (Sirotnak et al. 1991, McDonald 1998, Schroeder et al. 2000). After eggs hatch, hens with broods move to areas where succulent vegetation and insects can be found (Hamerstrom 1963, Bernhoft 1967, Sisson 1970,

Gregg 1987, Marks and Marks 1987, Klott and Lindzey 1990). In late summer, riparian areas and mountain-shrub communities are preferred (Giesen 1987).

Winter

Throughout winter, patches of deciduous trees and shrubs in upland and riparian areas provide food and protective cover (Zeigler 1979, Oedekoven 1985, Marks and Marks 1988, Meints 1991, Giesen and Connelly 1993). Although sharp-tailed grouse will feed on cultivated grain crops in Washington, deciduous shrubs and trees (e.g., water birch) appear to be critical when snow conditions are such that access to wheat is restricted (Zeigler 1979).

Food

Food items consumed by sharp-tailed grouse in spring and summer include wild sunflower (*Helianthus* spp.), common chokecherry, sagebrush, serviceberry, salsify, dandelion (*Taraxacum* spp.), bluegrass (*Poa* spp.), and brome (*Bromus* spp.) (Marshall and Jensen 1937, Hart et al. 1952, Jones 1966, Parker 1970). Although juvenile and adult grouse consume insects, chicks consume the greatest quantity of insects during the first few weeks of life (Parker 1970). The fruits, seeds, and buds of deciduous trees and shrubs (e.g., chokecherry, serviceberry, snowberry, wild rose, hawthorn, aspen, and water birch) and wheat and corn where available, are consumed throughout the winter (Marshall and Jensen 1937, Buss and Dziedzic 1955, Marks and Marks 1988, Giesen and Connelly 1993).

LIMITING FACTORS

The conversion of native shrub-steppe habitat to cropland over most of the pre-settlement range of sharp-tailed grouse is the primary cause of long-term population declines (Buss and Dziedzic 1955, Hays et al. 1998, Schroeder et al. 2000). Grassland habitat has decreased from 25% of the eastern Washington landscape to 1%, while shrub-steppe has decreased from 44% to 16% (McDonald and Reese 1998). Remaining areas of suitable habitat are relatively small and highly fragmented. Within the currently occupied range of sharp-tailed grouse, the degradation, removal and fragmentation of winter habitat appears to be the most significant limiting factor (Hays et al. 1998). Specific management concerns include grazing, removal of native shrubs and trees in riparian and mountain shrub communities, urban development, orchard development, fire, and permanent flooding of historic wintering habitat by dams along the Columbia River system (Oedekoven 1985, Giesen 1987, Marks and Marks 1987, Washington Department of Fish and Wildlife 1995, Connelly et al. 1998, Schroeder et al. 2000).

MANAGEMENT RECOMMENDATIONS

Conversion of Shrub-Steppe

Most of the remaining shrub-steppe habitats are characterized by relatively shallow soil; hence, they are usually undesirable for crop production (Dobler et al. 1996, Jacobson and Snyder 2000, Vander Haegen et al. 2001). Nevertheless, additional conversion of shrub-steppe habitat for development and/or crop production within sharp-tailed grouse management areas should be discouraged (Washington Department of Fish and Wildlife 1995). The retention of remaining shrub-steppe in Douglas, Lincoln and Okanogan counties is especially important (Washington Department of Fish and Wildlife 1995).

Vegetation Removal

Vegetation removal should be discouraged within 2 km (1.2 mi) of active or potential lek sites, especially during the breeding season (Giesen and Connelly 1993, Washington Department of Fish and Wildlife 1995). In some cases, limited sagebrush treatment that improves the productivity and diversity of desirable grasses, forbs, and shrubs, with careful pre-treatment assessment and post-treatment management, might be considered (Washington Department of

Fish and Wildlife 1995). Deciduous shrubs and trees in sharp-tailed grouse habitat should be retained (Giesen and Connelly 1993). In addition, manipulation of vegetation that reduces or disturbs riparian habitats should not occur within 100 m (328 ft) of streams, including dry and intermittent streams (Giesen and Connelly 1993, Washington Department of Fish and Wildlife 1995). Vegetative cover should be maintained at a visual obstruction reading of 24 cm (9.5 in) within nesting habitat (McDonald 1998).

Fire

Controlled burning should not be considered for any type of sharp-tailed grouse habitat unless the action is part of a carefully considered overall plan to restore shrub-steppe habitat and the likelihood of beneficial results for the species is high (Washington Department of Fish and Wildlife 1995). Any fire plan should carefully consider the potential spread of weeds and exotic annuals, loss of sagebrush, response of existing vegetation to different fire intensities and seasons, and the conditions of adjacent lands (Washington Department of Fish and Wildlife 1995). Fire can be used to improve grassland habitat and control invasion by conifer species (Giesen and Connelly 1993, Hays et al. 1998). Livestock control following planned burns and wildfires is essential to permit the establishment of native shrubs and herbaceous vegetation (Brown 2000). Because the availability of critical wintering habitat is likely the most significant limiting influence on sharp-tailed grouse (Washington Department of Fish and Wildlife 1995), any burning conducted in wintering habitat should be done with extreme caution as a means to restore habitat, and only very small portions of wintering habitat should be burned during any given season.

Grazing and Browsing

Large herbivores (wild and domestic) can significantly influence and alter plant community composition and structure to varying degrees among different ecosystems (Daubenmire 1940, Augustine and McNaughton 1998, Opperman and Merenlender 2000). The forbs and bunchgrasses native to shrub-steppe in Washington are most likely not adapted to severe grazing because large grazing animals were presumably not present in large numbers for several thousand years prior to the introduction of domestic livestock (Mack and Thompson 1982, Lyman and Wolverton 2002).

Over-grazing (i.e., repeated grazing that exceeds the recovery capacity of the vegetation and creates or perpetuates a deteriorated plant community) is often detrimental to sharp-tailed grouse habitat (Yocom 1952, Sisson 1970, Zeigler 1979, Klott and Lindzey 1990, Giesen and Connelly 1993, Washington Department of Fish and Wildlife 1995). Management for sharp-tailed grouse habitat should be conducted to establish a relatively lush composition of perennial bunchgrasses and forbs (McDonald 1998), and grazing management should maintain habitat in good to excellent ecological condition as defined by the Natural Resources Conservation Services technical guidelines (Ulliman et al. 1998). In shrub-steppe habitats, it is difficult to provide acceptable levels of visual obstruction in nesting and brood-rearing habitats with more than light grazing (Sisson 1976, McDonald 1998). Consequently, light grazing ($\leq$25% removal of annual herbaceous growth; [Holechek et al. 1999, Galt et al. 2000]) or no grazing may by necessary for habitat improvement (McDonald 1998). It is especially important that these levels of grazing not be exceeded in areas where habitat restoration is the objective (Galt et al. 2000), during drought years (Holechek et al. 2003), and/or following fires (Brown 2000).

Light grazing combined with rest rotation on a yearly basis may be compatible with sharp-tailed grouse management (Giesen and Connelly 1993). No grazing may be necessary where the habitat has been previously degraded and habitat restoration is the goal (Kirsch et al. 1973, McDonald 1998). Cattle can also harm nests through trampling (McDonald 1998). McDonald (1998) recommends deferring grazing until July (after the nesting season) in sharp-tailed grouse habitat in Washington. Livestock use of riparian areas should be managed or eliminated to minimize the loss of associated shrubs and trees (Giesen and Connelly 1993, Paulson 1996). Grazing is discouraged in areas where encroachment by noxious weeds is a problem. If necessary, wildlife resource agencies may consider means of reducing the impacts of wild ungulates on grouse habitat that might include the alteration of supplemental feeding programs, adjustments to hunting regulations, and temporary fencing.

Biological soil crusts are a common feature of many shrub-steppe plant communities, particularly in the lowest precipitation zones (Belnap et al. 2001). Biological crusts are comprised of lichens, mosses, cyanobacteria, green algae, microfungi, and other bacteria that might indirectly benefit grouse through aiding nitrogen fixation of plants, increasing the nutrient value of plants, increasing native plant germination rates, and by inhibiting the expansion of exotic species including cheatgrass (Belnap et al. 2001; J. Belnap, personal communication). These organisms form a living soil crust that is easily damaged by grazing (Daubenmire 1940, Mack and Thompson 1982, Belnap et al. 2001). Belnap et al. (2001) describes grazing practices that can help reduce damage to biological soil crusts. Although most soil crust studies were conducted in more arid environments, precipitation levels in some of these studies rival the drier areas of eastern Washington. Research is needed to fully understand the ecological function, impacts of disturbance, and the means to reduce impacts to biological crusts in eastern Washington's shrub-steppe.

Chemical Treatments

Herbicides and insecticides may negatively affect sharp-tailed grouse habitat by removing forbs and deciduous shrubs used for cover and by eliminating insects used for food (Oedekoven 1985, Hays et al. 1998). Land managers should be encouraged to use integrated pest management that targets specific pests or noxious weeds, to use pest population thresholds to determine when to use pesticides or herbicides, and to use crop rotation/diversity and beneficial insects to control pests (Stinson and Bromley 1991). For more information on alternatives such as integrated pest management, contact the county Washington State University Cooperative Extension Service or the USDA Natural Resource Conservation Service. Additional contacts are found in Appendix A.

Human Disturbance

All mechanical, physical and audible disturbances should be avoided during the breeding season (March through June) within 2 km (1.2 mi) of active lek sites (Giesen and Connelly 1993). Wind turbines should not be located in habitat known to be occupied by sharp-tailed grouse because this species avoids vertical structures and is sensitive to habitat fragmentation (U.S. Fish and Wildlife Service 2003). In known grouse habitat, avoid placing turbines within 8 km (5 mi) of known leks (U.S. Fish and Wildlife Service 2003). Viewing and censusing sharp-tailed grouse leks should be conducted in a way that minimizes disturbance of birds. If public interest in viewing leks is high, agencies should consider providing and supervising viewing opportunities, perhaps with specific viewing blinds. If public use appears to be impacting breeding behavior, closures and/or timing restrictions may be necessary on public lands.

Predation

Predator management should include the use of facilities that minimize perching by raptors (e.g., perch guards; Bureau of Land Management et al. 2000), removal of artificial nest sites for predators such as the common raven (*Corvus corax*), and control of dumps and/or livestock feeding stations that may concentrate and/or enhance predator populations (Washington Department of Fish and Wildlife 1995). Raptor-proofing techniques might include placing power-lines underground, covering horizontal surfaces (e.g., ledges) and other structures with steeply angled slanting boards or sheets metal, or placing low-voltage, electrically charged wires over perching structures. Because sharp-tailed grouse rely on grass and shrub cover for concealment from predators, activities that reduce tall residual grass and shrubs, especially in nesting areas, should be avoided (Giesen and Connelly 1993). In general, management that retains or produces good quality grouse habitat should be used as the most cost-effective tool for minimizing the negative effects of predation (Schroeder and Baydack 2001).

Conservation and Restoration

Research has shown that sharp-tailed grouse depend on deciduous trees/shrubs for winter food and that the lack of winter habitat may be a limiting factor in some areas (Marks and Marks 1988, Giesen and Connelly 1993, Schroeder et al. 2000). Therefore, planting appropriate vegetation in suitable sites (e.g., along streams, draws, or springs), preferably within 6.5 km (4 mi) of actual or potential breeding habitat (Meints et al. 1992) should occur in areas marked for conservation or restoration. These considerations should be included in the guidelines for future agricultural set-aside and/or conservation programs (such as CRP). Recommended deciduous shrub and tree species include water birch, aspen, chokecherry, hawthorn, snowberry and serviceberry (Washington Department of Fish and Wildlife 1995). Management practices to rejuvenate or increase mountain shrub communities within breeding complexes should be restricted to $\leq 25\%$ of this cover type annually. Shrub-steppe restoration and enhancement in areas where this native habitat has been removed (e.g., croplands) or degraded may benefit sharp-tailed grouse (Washington Department of Fish and Wildlife 1995). Restoration would include seeding with a combination of native shrubs, perennial forbs and bunchgrasses. Land management should also include the control of noxious weeds that compete with native vegetation.

Agricultural set-aside programs (such as the Conservation Reserve Program, Grassland Reserve Program) in sharp-tailed grouse areas should be supported (Washington Department of Fish and Wildlife 1995). The set aside programs should be structured to promote growth of a diversity of perennial bunchgrasses and forbs, annual retention of residual cover, and restoration of deciduous shrubs (Hays et al. 1998, Boisvert 2002). The use of species of limited habitat value like smooth brome (*Bromopsis inermis*) and intermediate/pubescent wheatgrass (*Thinopyrum intermedium*) should be discouraged (Boisvert 2002, A. Sands personal communication).

Local and regional government programs should be reviewed to ensure they address long-term conservation of sharp-tailed grouse populations and habitat. Specifically, critical areas protection that falls under Washington's Growth Management Act are intended to protect State Threatened, Endangered and Sensitive species and can be an effective conservation tool. Local development regulations could require mitigation standards and provide incentives to reduce impacts from projects that potentially affect sharp-tailed grouse habitat. Many resource agencies, including Washington Department of Fish and Wildlife, have staff that can provide assistance in critical areas planning.

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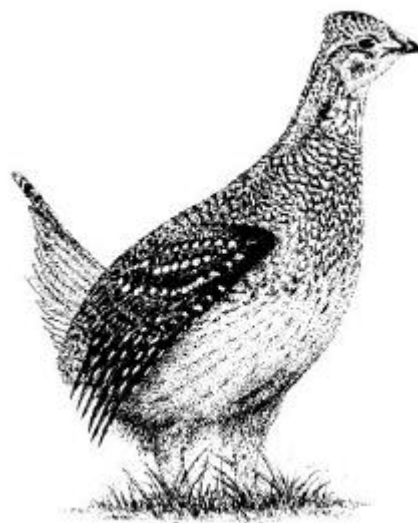
KEY POINTS

Habitat Requirements

- Sharp-tailed grouse occupy a variety of habitats in eastern Washington, including steppe, meadow-steppe, shrub-steppe, riparian, and mountain shrub.
- Buds, seeds, and fruits of chokecherry, serviceberry, snowberry, wild rose, hawthorn, aspen, and water birch are important winter food species for sharp-tailed grouse.
- Residual perennial bunchgrasses and forbs are the preferred nesting habitat of sharp-tailed grouse. Residual herbaceous growth from the previous growing season is a necessary component of sharp-tailed grouse nesting habitat.
- Sharp-tailed grouse depend on grass-dominated habitats intermixed with patches of deciduous trees and shrubs for food and cover throughout the year.

Management Recommendations

- Vegetation manipulation should be avoided (herbicide application, burning, mechanical treatment) for reasons other than sharp-tailed grouse habitat improvement within 2 km (1.2 mi) of active or potential lek sites, within 100 m (328 ft) of streams, or within winter habitat.
- Conversion of shrub-steppe habitat should be avoided within sharp-tailed grouse management areas.
- Vegetative cover should be maintained at a visual obstruction reading of 24 cm (9.5 in) within nesting habitat.
- Controlled burning should be avoided within any type of sharp-tailed grouse habitat unless the action is part of a carefully considered overall plan to restore shrub-steppe habitat and the likelihood of beneficial results for the species is high.
- Grazing management that improves and/or maintains habitat in good to excellent condition should be supported.
- Light grazing levels ($\leq 25\%$ removal of annual herbaceous growth) or cessation of grazing to improve habitat conditions should be maintained.
- Grazing should be managed or eliminated within riparian areas to minimize the loss of associated shrubs and trees.
- Herbicide and insecticide use should be discouraged where sharp-tailed grouse occur, and encourage the use of integrated pest management.
- All physical and audible disturbances should be avoided from March through June within 2 km (1.2 mi) of active lek sites.
- Native shrubs and perennial native forbs and bunchgrasses should be reseeded to restore sharp-tailed grouse habitat.
- Land managers should control noxious weeds and prevent noxious weed encroachment in suitable sharp-tailed grouse habitat.
- The use of agricultural set aside programs (e.g., Conservation Reserve Program, Grassland Reserve Program) should be supported in sharp-tailed grouse areas dominated by cropland.
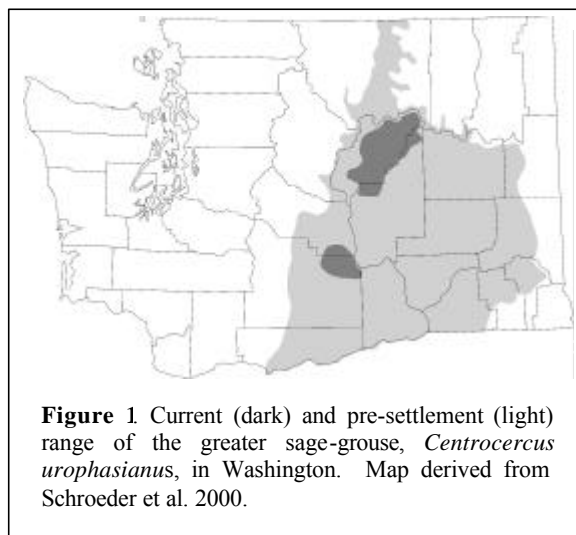
Greater Sage-Grouse

Centrocercus urophasianus

Last updated: 2003

Written by Michael A. Schroeder, Derek Stinson and Michelle Tirhi

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Greater sage-grouse (*Centrocercus urophasianus*) are closely tied to the distribution of big sagebrush (*Artemisia tridentata*) throughout much of their range (Schroeder et al. 1999). Prior to settlement by people of European descent, sage-grouse were distributed from southern British Columbia, Alberta, and Saskatchewan to eastern California, northern Arizona, and western portions of Oklahoma, Kansas, Nebraska, South Dakota and North Dakota. The core of the distribution was in Washington, Oregon, Nevada, Idaho, Utah, Colorado, Wyoming and Montana. The newly described Gunnison sage-grouse (*Centrocercus minimus*) was found primarily in northwestern New Mexico, southeastern Utah, and southwestern Colorado (Young et al. 2000).

Figure 1. Current (dark) and pre-settlement (light) range of the greater sage-grouse, *Centrocercus urophasianu*s, in Washington. Map derived from Schroeder et al. 2000.

Sage-grouse historically occurred throughout the shrub-steppe and meadow-steppe (hereafter referred to collectively as shrub-steppe) communities of eastern Washington (Yocom 1956, Schroeder et al. 2000). They were observed in abundance in 1805 by members of the Lewis and Clark expedition near the confluence of the Columbia and Snake Rivers (Zwickel and Schroeder 2003). Currently, the state has two relatively isolated breeding populations; one in Douglas-Grant Counties (. 650 grouse), and one in Kittitas-Yakima Counties (. 350 grouse) (see Figure 1; M. Schroeder, personal observation). Sporadic sightings outside the primary distribution have been reported in Benton, Yakima, Kittitas, Grant, Lincoln and Okanogan Counties. Sage-grouse management areas are currently being mapped and include portions of Yakima, Kittitas, Benton, Grant, Douglas, Lincoln and Okanogan Counties (Stinson, in preparation; see also Washington Department of Fish and Wildlife 1995).

RATIONALE

Greater sage-grouse in the state of Washington became a candidate for federal listing as threatened under the Endangered Species Act after a recent petition for listing precipitated a status review (Warren 2001). Although the sage-grouse is classified as a game species in Washington, hunting was terminated in 1988 (Washington Department of Fish and Wildlife 1995); they currently are listed as a state-threatened species (Hays et al. 1998). The distribution of sage-grouse in Washington has been dramatically reduced since pre-settlement times due to the conversion of shrub-steppe to cropland, and the degradation and fragmentation of the remaining habitat (Schroeder et al. 2000). Conserving, restoring and enhancing remaining habitat is critical to the survival of this species (Washington Department of Fish and Wildlife 1995).

HABITAT REQUIREMENTS

General Vegetation

Sage-grouse depend on sagebrush (*Artemisia* spp.), primarily big sagebrush, for food and cover throughout the year in Washington (Schroeder et al. 1999). Other important cover species include threetip sagebrush (*Artemisia tripartita*), stiff sagebrush (*Artemisia rigida*), rabbitbrush (*Chrysothamnus* spp.), bitterbrush (*Purshia tridentata*) and gray horsebrush (*Tetradymia canescens*) (Washington Department of Fish and Wildlife 1995). Common grasses and forbs include Sandberg bluegrass (*Poa sandbergii*), bluebunch wheatgrass (*Pseudoroegneria spicata*), needle-and-thread (*Stipa comata*), Indian ricegrass (*Oryzopsis hymenoides*), Idaho fescue (*Festuca idahoensis*), prickly lettuce (*Lactuca serriola*), yellow salsify (*Tragopogon dubius*), milkvetch (*Astragalus* spp.), and microseris (*Microseris* spp.). Relatively dense shrub cover is important during winter and, and a combination of shrub, grass, and forb cover is important during the nesting season (Connelly et al. 2000).

Breeding Display Grounds (leks)

During spring, males congregate on display sites (leks) to breed with females (Schroeder et al. 1999). Leks are typically located in open areas near relatively dense stands of sagebrush (> 20% canopy coverage) used for food and escape cover (Dalke et al. 1963, Autenrieth 1981, Emmons and Braun 1984, Roberson 1984, Klebenow 1985). In north-central Washington, most documented leks are in wheatfields (M. Schroeder, personal observation). Sage-grouse leks are often located near nesting areas (Wallestad and Pyrah 1974, Berry and Eng 1985, Connelly et al. 1988, Gibson 1996). The typical distance between nests and the nearest leks ranges from 1.3 to 3.4 km (0.8 to 2.1 mi) (Wallestad and Pyrah 1974, Petersen 1980, Autenrieth 1981, Wakkinen et al. 1992, Fischer et al. 1993). In the fragmented shrub-steppe of eastern Washington, the nest-lek distance averages 5.1 km (3.2 mi) (Schroeder 1994). Typical characteristics of productive habitat are 15-25% sagebrush coverage in both arid and mesic (moist) sites; ≥ 15% perennial grass/forb cover on arid site; ≥ 25% perennial grass/forb cover on mesic sites (Connelly et al. 2000). Grass/forb cover tends to be higher in Washington (Schroeder 1994, Sveum et al. 1998a).

Nesting and Brood Rearing

Sage-grouse commonly nest in habitat containing sagebrush approximately 30-80 cm (12-31 in) in height, and relatively tall (>20 cm [8 in]), dense (> 40% grass and forb cover) herbaceous cover (Gray 1967, Wallestad and Pyrah 1974, Crawford and DeLong 1993, Gregg et al. 1994, Schroeder 1995, Sveum 1995, Connelly et al. 2000, Livingston and Nyland 2002). Although sage-grouse prefer to nest under sagebrush, they will nest under other plant species (Klebenow 1969, Wallstad and Pyrah 1974, Connelly et al. 1991). Nest success is directly related to higher horizontal and vertical cover at the nest site (Wallestad and Pyrah 1974, Gregg 1991, Connelly et al. 2000). In Washington, sage-grouse select nest sites that contain thicker and taller vegetation as opposed to other regions (Schroeder 1994, Sveum et al. 1998a). At the Yakima Training Center, Livingston and Nyland (2002) found that at the site level, females usually selected shrubs that provided overhead nest concealment and were surrounded by heavy bunchgrass cover >18 cm (7 in) in height.

Broods prefer open sagebrush-dominated habitats with an abundance of insects and succulent forbs (Klebenow 1969, Peterson 1970, Wallestad 1975, Klott and Lindzey 1990, Drut et al. 1994, Sveum et al. 1998b). As plants mature and dry, hens move their broods to habitats with green vegetation such as wet meadows, irrigated farmland or areas at higher elevations (Oakleaf 1971, Connelly et al. 1988, Klott and Lindzey 1990, Fischer et al. 1996, Connelly et al. 2000). Brood habitats in Washington also include areas enrolled in the federal Conservation Reserve Program (Conservation Reserve Program unpublished data).

Winter

Sagebrush provides escape cover and a majority of the dietary requirements for sage-grouse in winter (Connelly et al. 2000). They prefer sagebrush $\geq$25 cm (10 in) high above the ground or snow, with 10-30% canopy coverage (Eng and Schladweiler 1972, Wallestad and Schladweiler 1974, Wallestad 1975, Autenrieth 1981, Connelly et al. 2000). Good wintering areas are found at a variety of elevations, and include windswept ridges and sagebrush flats (Eng and Schladweiler 1972, Wallestad and Schladweiler 1974, Wallestad 1975, Autenrieth 1981). Winter habitat selection is often dependent on snow-depth (Hays et al. 1998). During winter, Robertson (1991) reported that migratory sage-grouse in southeastern Idaho made average daily movements of 752 m (2467 ft) and occupied an area >140 km^2 (54 mi^2). Wallestad (1975) reported that winter home range size varied between 11 and 31 km^2 (4-12 mi^2) in Montana.

Food

Sagebrush is a crucial component of the sage-grouse diet year-round, particularly during late autumn, winter and early spring (Remington 1983, Remington and Braun 1985, Welch et al. 1988, 1991; Myers 1992). Forbs are important food items for sage-grouse during spring, summer and early autumn; especially for hens prior to egg laying (Wallestad et al. 1975, Barnett and Crawford 1994, Drut et al. 1994). Pre-laying hens require a diet of forbs rich in calcium, phosphorus and protein in order to produce healthy clutches (Barnett and Crawford 1994). Thus, the condition of breeding habitats used by pre-laying hens plays an important role in overall reproductive success (Barnett and Crawford 1994, Coggins 1998).

Broods feed heavily on insects during their first weeks of life (Klebenow and Gray 1968, Peterson 1970, Johnson and Boyce 1990, Drut et al. 1994, Pyle and Crawford 1996). As chicks grow, they eat more forbs, gradually switching to a diet that consists primarily of forbs (Peterson 1970). Forbs consumed include desert parsley (*Lomatium* spp.), hawksbeard (*Crepis* spp.), prickly lettuce, common dandelion (*Taraxacum officinale*), mountain dandelion (*Agoseris* spp.), western yarrow (*Achillea millefolium*), pale agoseris (*Agoseris glauca*), clover (*Trifolium* spp.), yellow salsify, everlasting (*Antennaria* spp.), vetch (*Vicia* spp.), milkvetch, alfalfa (*Medicago sativa*), aster (*Aster* spp.) and long-leaf phlox (*Phlox longifolia*) (Wallestad et al. 1975, Drut et al. 1994, Barnett and Crawford 1994). The availability of forbs and insects influences sage-grouse chick survival (Johnson and Boyce 1991).

LIMITING FACTORS

In Washington, the lack of extensive good quality shrub-steppe vegetation limits sage-grouse (Washington Department of Fish and Wildlife 1995, Hays et al. 1998, Schroeder et al. 2000). Habitat loss, degradation and fragmentation of shrub-steppe can be attributed to land conversion, development, grazing, sagebrush removal and burning, erosion, mining, military activity, noise, power lines and roads (Klebenow 1972, Braun 1986, Swenson et al. 1987, Hofmann 1991, Remington and Braun 1991, Washington Department of Fish and Wildlife 1995, Schroeder et al. 2000).

MANAGEMENT RECOMMENDATIONS

Conversion of Shrub-Steppe

The reduction in sage-grouse numbers and distribution is primarily attributed to the loss, fragmentation, and degradation of shrub-steppe habitat through land conversion and mismanagement (Braun 1998). Most of the remaining shrub-steppe habitats are characterized by relatively shallow soil; hence they are usually undesirable for crop production (Dobler et al. 1996, Jacobson and Snyder 2000, Vander Haegen et al. 2000). Nevertheless, further conversion of shrub-steppe habitat within sage-grouse management areas should be strongly discouraged (Washington Department of Fish and Wildlife 1995). Despite the importance of shrub-steppe to many declining Species of Concern, conversion of shrub-steppe habitat on public and private lands is continuing (Hays et al. 1998). Conservation of shrub-steppe habitat in and around croplands in Douglas County is also extremely important because these sites are a source of sagebrush seed that germinate on the extensive lands that are enrolled in the Federal Conservation Reserve Program in this county (Hays et al. 1998).

Sagebrush Alteration

Removal or alteration of sagebrush should be avoided within sage-grouse management areas, particularly near leks, brood-rearing and in nesting and wintering areas (Connelly et al. 2000). Sage-grouse depend upon sagebrush stands for most of their life needs throughout the year, therefore sagebrush should not be eradicated (Connelly et al. 2000). Sagebrush should not be removed within 300 m (984 ft) of sage-grouse foraging sites along riparian areas, meadows, lakes, and farmlands (Connelly et al. 2000). Sagebrush removal should not occur where live sagebrush cover is <25% in nesting areas, and <30% in wintering areas (Connelly et al. 2000). Sagebrush should also not be controlled on slopes $\geq$ 20% and/or on slopes with shallow soils where big sagebrush is <30 cm (12 in) in height (Call and Maser 1985). Anyone planning to remove sagebrush should carefully consider the method of removal (fire, mechanical means, herbicides), amount removed, species removed, post-removal management, mitigation measures, and the effects on the sage-grouse population (see references in contact section for assistance).

Fire

Wildfires pose a substantial threat to sage-grouse in Washington and occupied habitat should be a high priority for fire suppression and prevention (Connelly et al. 2000). Prescribed fire has been used to reduce sagebrush that in turn increases grass and forb cover (Pyle and Crawford 1996). However, Wambolt et al. (2002) pointed out that there is no empirical evidence demonstrating the benefits of fire to sage-grouse.

Where fire is used as a management tool to restore potential habitat, controlled burns are recommended in late April to early May when fuels left from the prior growing season are able to carry a relatively cool fire (Autenrieth 1981). These prescribed fires should be $\leq$ 50 ha in size and cover less than 20% of an area used by sage-grouse during winter within any 20–30 year interval (depending on estimated recovery time for the sagebrush habitat) (Connelly et al. 2000). Because the availability of critical wintering habitat is likely the most significant limiting influence on sage-grouse, any burning conducted in wintering habitat should only be done with extreme caution as a means to restore habitat, and only very small portions of wintering habitat should be burned during any given season (Connelly et al. 2000). Avoid using fire without including plans to control cheatgrass competition in the understory (e.g., through the use of a pre-emergent herbicide [e.g., Oust[®], Plateau[®]]) where an increase of or an invasion by cheatgrass (*Bromus tectorum*) is likely (Connelly et al. 2000). Annual grassland establishment following fire is very detrimental to sagebrush habitat integrity (Young and Longland 1996). In addition, habitat recovery following a fire may require several decades before sagebrush regrowth is sufficient to support sage-grouse (Connelly et al. 2000). Changes in livestock management (e.g., exclusion, change in season and/or intensity of use) following planned burns and wildfires is essential to the reestablishment of native shrubs and forbs (Beck and Mitchell 2000).

Fire should not be used in breeding habitat dominated by Wyoming big sagebrush (Connelly et al. 2000). Controlled burning should not be considered for any type of sage-grouse habitat unless the action is part of a carefully considered overall plan to restore shrub-steppe habitat and the likelihood of beneficial results for the species is high (Washington Department of Fish and Wildlife 1995).

Grazing and Browsing

Livestock grazing has been a common use of shrub-steppe lands within the range of sage-grouse in Washington (Hays et al. 1998). Although it is difficult to document positive effects of livestock grazing on sage-grouse, the existence of healthy sage-grouse populations in areas long grazed suggests that certain grazing levels may be compatible with sage-grouse populations (Wambolt et al. 2002). Vegetation characteristics of sage-grouse breeding, brood-rearing, and winter habitats (Table 1) should be used as guidelines in developing livestock grazing management plans, but these plans should also consider the long-term sustainability of the habitat, the likelihood of drought, and the potential for expansion of noxious weeds.

Light grazing in sage-grouse habitat should be managed for optimum growth and reproduction of native sagebrush, forbs and grasses (Table 1) (Beck and Mitchell 2000). The type and stocking rates of livestock, season of use, and grazing duration should be carefully planned based on available forage resources, and monitored on a site specific basis, with the goal of providing optimal sage-grouse habitat (Beck and Mitchell 2000) and long-term sustainability. This is particularly important in nesting areas, where sage-grouse are dependent on residual cover for concealment from predators. During drought periods (≥ 2 consecutive years), it may be necessary to reduce stocking rates or change livestock management practices if herbaceous height requirements for cover (Table 1) during the nesting and brood-rearing periods are not met (Gregg et al. 1994, Sveum 1995, Connelly et al. 2000, Livingston and Nyland 2002).

Biological soil crusts are a common feature of many shrub-steppe plant communities, particularly in the lowest precipitation zones (Belnap et al. 2001). Biological crusts are comprised of lichens, mosses, cyanobacteria, green algae, microfungi, and other bacteria that might indirectly benefit grouse through aiding nitrogen fixation of plants, increasing the nutrient value of plants, increasing native plant germination rates, and by inhibiting the expansion of exotic species including cheatgrass (Belnap et al. 2001; J. Belnap, personal communication). These organisms form a living soil crust that is easily damaged by livestock grazing (Daubenmire 1940, Mack and Thompson 1982, Belnap et al. 2001). Belnap et al. (2001) describes grazing practices that can help reduce damage to biological soil crusts. Although most soil crust studies were conducted in more arid environments, precipitation levels in some of these studies rival the drier areas of eastern Washington. Research is needed to fully understand the ecological function, impacts of disturbance, and the means to reduce impacts to biological crusts in eastern Washington's shrub-steppe.
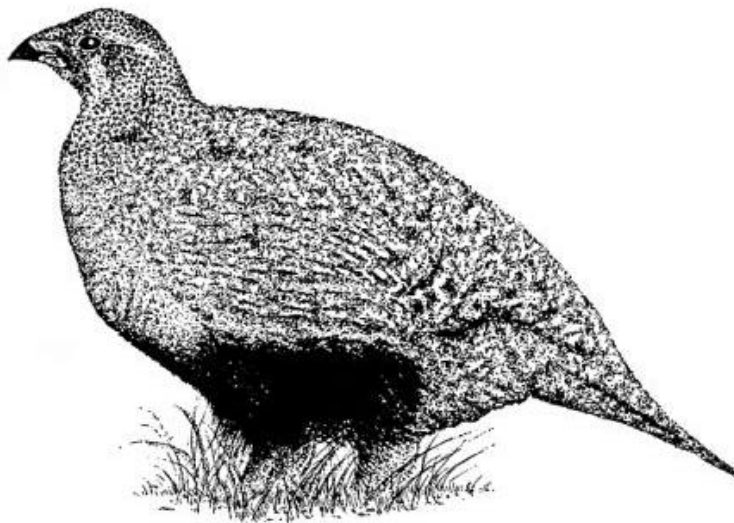
Table 1. Characteristics of sagebrush communities needed for productive sage-grouse habitat (Connelly et al. 2000).

	Breeding		Brood-rearing		Winter [e]	
	Height (cm)	Canopy (%)	Height (cm)	Canopy (%)	Height (cm)	Canopy (%)
Mesic (moist) sites [a]						
Sagebrush	40 – 80	15 – 25	40 – 80	10 – 25	25 – 35	10 – 30
Grass-forb	> 18 [c]	≥ 25 [d]	variable	> 15	N/A	N/A
Arid sites [a]						
Sagebrush	30 – 80	15 – 25	40 – 80	10 – 25	25 – 35	10 – 30
Grass-forb	> 18 [c]	≥ 15 [d]	variable	> 15	N/A	N/A
Area [b]	> 80		> 40		> 80	
Approximate period of use	late winter – late spring		late spring – early autumn		autumn – late winter	
General characteristics	Open areas surrounded by sagebrush.		Open sagebrush-dominated habitats with an abundance of insects/succulent forbs.		Areas that allow sagebrush access under various snow conditions.	

a. Mesic and arid sites should be defined on a local basis; annual precipitation, herbaceous understory, and soils should be considered (Tisdale and Hironaka 1981, Hironaka et al. 1983).
b. Percentage of seasonal habitat needed with indicated conditions.
c. Measured as "droop height"; the highest naturally growing portion of the plant.
d. Coverage should exceed 15% for perennial grasses and 10% for forbs; values should be substantially greater if most sagebrush has a growth form that provides little lateral cover (Schroeder 1995).
e. Values for height and canopy coverage are for shrubs exposed above snow.

Wild (as well as domestic) herbivores can significantly influence and alter plant community composition and structure to varying degrees among different ecosystems (Augustine and McNaughton 1998, Opperman and Merenlender 2000). The forbs and bunchgrasses native to shrub-steppe in Washington are not tolerant to intensive and prolonged grazing because large grazing animals were presumably not present in large numbers for several thousand years prior to the introduction of domestic livestock (Mack and Thompson 1982, Lyman and Wolverton 2002). In some instances, the exposure of sagebrush communities to deer (*Odocoileus* spp.) and elk (*Cervus elaphus*) browsing can suppress the production, germination and survival of sagebrush and increase the production of annual plant species (McArthur et al. 1988, Singer and Renkin 1995), potentially influencing grouse habitat. If necessary, wildlife resource agencies may consider means of reducing the impacts of wild ungulates on grouse habitat that might include altering supplemental feeding programs, adjusting hunting regulations, and temporary fencing.

The effects of livestock grazing on shrub-steppe vegetation largely depend on the timing, frequency, and intensity of grazing. Over-grazing (i.e., repeated grazing that exceeds the recovery capacity of the vegetation and creates or perpetuates a deteriorated plant community) should be discouraged within sage-grouse management areas (Washington Department of Fish and Wildlife 1995, Beck and Mitchell 2000, Connelly et al. 2000). Frequent heavy grazing (i.e., removal of >50% of current year's growth) deteriorates the species composition and structure of native plant communities (Holechek et al. 1999). Although light grazing of healthy shrub-steppe may not cause habitat degradation (Klebenow 1981, Call and Maser 1985, Beck and Mitchell 2000), the intensity of grazing that is tolerable is not clear, but may be ≤ 25% utilization of the current year's growth of key forage species (Galt et al. 2000, Holechek et al. 2003). It is especially important that this level of grazing not be exceeded in areas where habitat restoration and maintenance is the objective (Galt et al. 2000), during drought years (Holechek et al. 2003), and/or following fires (Beck and Mitchell 2000). When habitat is degraded by over-grazing, recovery of the native plant community likely requires a dramatic reduction (if not a cessation) of grazing for a long period of time (Anderson and Inouye 2001). However, restoring severely altered habitat (e.g., area devoid of its native species and seed sources) often requires more than simply removing cattle to recover the native plant community (Bunting et al. 2002).

Chemical Treatments

Herbicides may be necessary to improve sage-grouse habitat where noxious weeds have replaced native vegetation (Washington Department of Fish and Wildlife 1995). Herbicide application should be followed with restoration efforts designed to enhance native vegetation or establish a desirable plant community. The herbicide 2,4-D should not be used for sagebrush control because its application results in a significant loss of native forbs (Call and Maser 1985). Tebuthiuron (e.g., Spike®) should not be used, except in small scale experiments, until it is demonstrated that it has no long-lasting impacts to sage-grouse habitat (Connelly et al. 2000).

Insecticides should not be applied to sage-grouse summer habitat, particularly organophosphorus and carbamate insecticides, which are highly toxic (Blus et al. 1989). Insects are the primary food source for young sage-grouse chicks, and insecticide use can be directly and indirectly detrimental to sage-grouse (Beck and Mitchell 2000).

Land managers should be encouraged to use integrated pest management that targets specific pests or noxious weeds, to use pest population thresholds to determine when to use pesticides or herbicides, and to use crop rotation/diversity and beneficial insects to control pests (Stinson and Bromley 1991). For more information on alternatives such as integrated pest management, contact your county Washington State University Cooperative Extension Service or the USDA Natural Resource Conservation Service. Additional contacts are found in Appendix A.

Human Disturbance

Disturbances should be minimized from mid-February through early June within breeding and nesting areas (Hofmann 1991). Although nesting areas have been generally defined as locations within 3.2 km (2 mi) of leks, recent studies suggest that many nests are >3 km (2 mi) from leks (Wallestad and Pyrah 1974, Autenrieth 1981, Connelly et al. 1988, Eberhardt and Hofmann 1991, Wakkinen et al. 1992, Schroeder 1994).

Viewing and censusing sage-grouse leks should be conducted in a way that avoids disturbing the birds (Call and Maser 1985). Agencies should not provide lek locations to people who wish to view birds without supervision (Connelly et al. 2000). If public interest in viewing leks is high, agencies should consider constructing viewing blinds at specific locations for public use (Connelly et al. 2000). Camping on or near active leks should not be permitted (Connelly et al. 2000). On the Yakima Training Center, vehicle activity has been shown to disturb sage-grouse in critical areas (e.g., leks) (Hays et al. 1998). Therefore, activity on roads traversing sage-grouse leks should be restricted during hours when birds are active (sunset - 3 hours after sunrise) during the lekking season.

Fences, utility wires, and other structures can be hazardous to flying grouse. New and existing fences should be made more visible with flagging or by other means, within 1 km (0.6 mi) of sage-grouse habitat (Connelly et al. 2000). Woven wire fences negatively influence sage-grouse because they cannot quickly fly or travel through them (Braun 1998). Utility wires can also create hazards for sage-grouse (Borell 1939). Wind turbines should not be located in habitat known to be occupied by sage-grouse because this species avoids vertical structures and is sensitive to habitat fragmentation (U.S. Fish and Wildlife Service 2003). In grouse habitat, avoid placing turbines within 8 km (5 mi) of known leks (U.S. Fish and Wildlife Service 2003). The expansion of roads near shrub-steppe habitat used by grouse leads to habitat loss and fragmentation, direct mortality (Braun 1998), and the spread of invasive weeds. Consequently, limitations should be placed on the expansion of roads within grouse habitat.

Predation

The establishment of red fox and other non-native predators should be prevented in sage-grouse habitat (Connelly et al. 2000). Avoid building tall structures that provide raptor perch sites, such as utility structures, within 3 km (1.9 mi) of sage-grouse habitat. If structures are unavoidable or already exist, they should be modified to discourage raptors from perching on them (Connelly et al. 2000). Raptor-proofing techniques might include, but are not limited to placing power-lines underground, covering horizontal surfaces (e.g., ledges) and other structures with steeply angled slanting boards or sheets metal or placing low-voltage, electrically charged wires over perching structures. Fences with adjacent pathways (e.g., trails, roads) negatively impact sage-grouse because they provide travel

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corridors for potential predators (Braun 1998). Additionally, fences with wood posts provide perch sites for potential avian predators (Braun 1998).

Habitat alteration associated with grazing, drought, and wildfire may increase the rate of predation on juveniles, but this relationship is unclear and predation has not been identified as a major limiting factor for sage-grouse (Gregg et al. 1994, Connelly and Braun 1997, Schroeder and Baydack 2001). In general, management that retains or produces good quality grouse habitat should be used as the most cost-effective tool for minimizing the negative effects of predation (Schroeder and Baydack 2001).

Conservation and Restoration

Restoration of degraded shrub-steppe is a priority (Washington Department of Fish and Wildlife 1995). Efforts to restore depleted or converted habitat should concentrate on reestablishing locally adapted, native shrub-steppe vegetation (Connelly et al. 2000) and reducing grazing pressure when necessary (Beck and Mitchell 2000). Where introduced species are the only available alternative, use species that mimic the structural characteristics of the native species and that provide food (Connelly et al. 2000). Seeding of areas with highly competitive and structurally dissimilar species such as crested wheatgrass (*Agropyron cristatum* or *Agropyron desertorum*), intermediate wheatgrass (*Agropyron intermedium*), pubescent wheatgrass (*Agropyron trichophorum*), or smooth brome (*Bromus intermis*) should be discouraged (Beck and Mitchell 2000, Connelly et al. 2000, A. Sands, personal communication). Habitats that have been degraded should be managed to promote habitat recovery. Areas that possess an understory of native forbs and bunchgrasses prior to wildfire may not need re-seeding (M. Livingston, personal communication). However, sagebrush seeding might be necessary depending on fire size and intensity as well as the distance to seed sources.

Agricultural set-aside programs (such as the Conservation Reserve Program and the Wetlands Reserve Program) and other types of voluntary conservation incentive programs (e.g., Candidate Conservation Agreements, Partners for Fish and Wildlife) should be encouraged in sage-grouse management areas in Washington (Washington Department of Fish and Wildlife 1995). Set-aside conservation programs should be structured to encourage enrollees to plant a diverse range of perennial shrubs, grasses, and forbs and to retain annual residual cover (Hays et al 1998).

Local and regional government programs should be reviewed to ensure they address long-term conservation of sage-grouse populations and habitat. Specifically, critical areas protection that falls under Washington's Growth Management Act are intended to protect State-listed species and can be an effective conservation tool. Local development regulations could require mitigation standards and provide incentives to reduce impacts from projects that potentially affect sage-grouse habitat. Many resource agencies, including Washington Department of Fish and Wildlife, have staff that can provide assistance in critical areas planning.

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KEY POINTS

Habitat Requirements

- Sage-grouse depend on sagebrush for food and cover. Big sagebrush is a predominant species in sage-grouse habitat.
- During spring, males congregate on display sites (leks) to breed with females. Leks are typically located in open areas near relatively dense stands of sagebrush used for food and escape cover.
- Sage-grouse commonly nest in habitat containing sagebrush approximately 30-80 cm (12-31 in) in height, and relatively tall, dense herbaceous cover.

- Broods require an abundance of insects and forbs and often use wet meadows, irrigated farmland and areas at higher elevations.
- Sage-grouse winter in relatively dense sagebrush. Good wintering areas are found at a variety of elevations, and include windswept ridges and sagebrush flats.
- Adult sage-grouse feed almost entirely on sagebrush and forbs year-round. Forbs are consumed in spring, summer and early autumn. Insects and forbs are a critical food source to chicks.

Management Recommendations

- Conversion of shrub-steppe habitat is strongly discouraged.
- Removal or alteration of sagebrush is discouraged within sage-grouse management areas, particularly near leks and in nesting and wintering areas. Sagebrush should not be removed within 300 m (984 ft) of sage-grouse foraging areas along riparian areas, meadows, lake beds, and farmlands.
- Sagebrush removal should not occur where live sagebrush cover is <25% in nesting areas, and <30% in wintering areas, on slopes $20% and/or on slopes with shallow soils where big sagebrush is <30 cm (12 in) in height.
- Prescribed fires should be # 50 ha in size and cover less than 20% of an area used by sage-grouse during winter within any 20–30 year interval (depending on estimated recovery time for the sagebrush habitat). Because the availability of critical wintering habitat is likely the most significant limiting influence on sage-grouse, any burning conducted in wintering habitat should only be done with extreme caution as a means to restore habitat, and only very small portions of wintering habitat should be burned during any given season. Avoid using fire where increase of or invasion by cheatgrass is likely.
- Develop grazing management plans based on the vegetation characteristics of sage-grouse breeding, brood-rearing, and winter habitats (see Table 1).
- Grazing in sage-grouse breeding, brood-rearing, and winter habitats should be light enough to promote long-term sustainability of habitat and stocking rates should be reduced during drought.
- Dramatically reduce or cease all grazing for a long time period when site is degraded by over-grazing to allow recovery of the native plant community. The cessation of grazing alone will likely not restore sites that have been completely overtaken by annual species.
- Insecticides should not be applied to sage-grouse summer habitat. Organophosphorus and carbamate insecticides are especially toxic.
- Use integrated pest management techniques within sage-grouse management areas.
- Minimize human disturbances from mid-February through early June within breeding and nesting areas. Restrict activity on roads traversing sage-grouse leks during hours when birds are active during lek season.
- Avoid building powerlines, wind turbines and other tall structures within 3 km (1.9 mi) of grouse habitat or within 8 km (5 miles) of leks. Fences should be constructed or modified in a manner that will reduce associated mortality.
- Support agricultural set-aside programs (such as the Conservation Reserve Program and the Wetlands Reserve Program) in sage-grouse management areas. Set-aside conservation programs should be structured to encourage enrollees to plant a diverse range of perennial shrubs, grasses, and forbs and to retain annual residual cover.

Wild Turkey
Meleagris gallopavo

Last updated: 1999

Written by John T. Morgan, David A Ware, Michelle Tirhi, and Ruth L. Milner

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Wild turkeys (*Meleagris gallopavo*) are native to North America. They have been successfully introduced into approximately 10 states outside of what is thought to be their ancestral range. They currently occur in 49 states, three Canadian provinces, and northern Mexico (Kennamer et al. 1992).

Three subspecies of wild turkey have been introduced in Washington. Merriam's turkeys occur in the northeastern and south-central part of the state, eastern wild turkeys occur west of the Cascades, and Rio Grande turkeys occur in the southeastern corner and scattered locations in the central part of the state (see Figure 1).
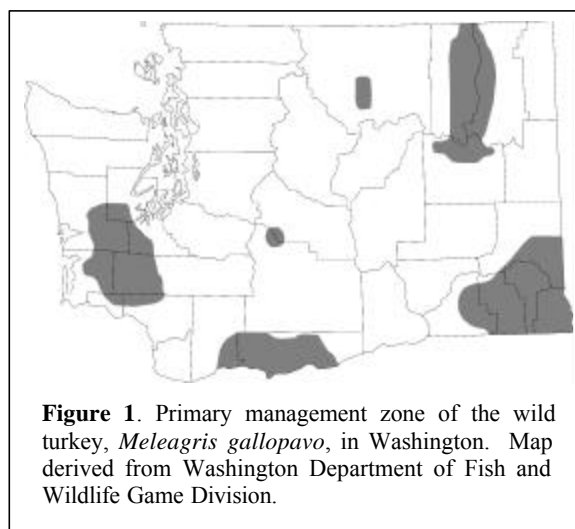
Figure 1. Primary management zone of the wild turkey, *Meleagris gallopavo*, in Washington. Map derived from Washington Department of Fish and Wildlife Game Division.

RATIONALE

Wild turkeys are a state game species and have high recreational value both for consumptive and nonconsumptive purposes. They are vulnerable to habitat loss or degradation.

HABITAT REQUIREMENTS

Wild turkeys are habitat generalists, adapting to a variety of conditions across their range (Dickson et al. 1978). However, the 2 habitat features wild turkeys depend on are trees and grasses. Trees provide food, escape cover, and roost sites, while grasses provide food for adults and an environment that allows poults (juvenile turkey) to efficiently forage for insects (Porter 1992).

Turkeys have been introduced to Washington and are established in a variety of habitats, though each population exists in habitat similar to that from which it came. Turkeys in western Washington are from the eastern subspecies, and occur in forests with open understories interspersed with agricultural areas and natural openings. Turkeys in

northeast and southern Washington are native to the southwestern United States (Merriam's subspecies), and use hardwood draws and riparian areas associated with mature ponderosa pine. They are also associated with pine-oak habitats in south-central Washington. Turkeys in southeast and central Washington are from the Rio Grande subspecies, which originated in the south-central United States. They have become established in very open areas, such as open ponderosa pine, grasslands, and shrub-steppe interspersed with agricultural areas.

Nesting

Turkeys nest in a variety of habitats, though the key component appears to be lateral or horizontal cover (Porter 1992). Horizontal cover includes terrain and/or dense woody and herbaceous vegetation that helps conceal the nest (Beasom and Wildon 1992, Hurst and Dickson 1992, Lewis 1992, Shaw and Mollohan 1992, Wunz and Pack 1992). These conditions are found in timbered stands with a dense understory, fields, clearcuts, utility right-of-ways, young pine plantations, and some agricultural fields. In south-central Washington, Mackey (1982) noted that turkey nests were typically found at the base of a tree, partially covered by dead limbs or understory vegetation, in oak, oak/pine, or oak/fir forest types.

Shaw and Mollohan (1992) described Merriam's turkey nest sites as having complete protection on one side (either dense vegetation or terrain), dense cover on the remaining 3 sides between 0.0 m and 0.5 m (0-1.5 ft), and unrestricted visibility on 3 sides from 0.5 m to 0.9 m (1.5-3.0 ft). Also, nest sites had relatively solid cover 2.4-3.7 m (8-12 ft) above the nest and a forest canopy overhead. In south-central Washington, turkeys were found nesting in areas with understory height averaging 63 cm (25 in), understory canopy coverage of 36%, and forest canopy coverage of 70% (Mackey 1982). In parts of Washington without oak, turkeys nest in stands of other timber species with characteristics similar to that found by Mackey (1982) in south-central Washington.

Brood Range

Porter (1992) described three ingredients essential for brood habitat during the first 8 weeks after hatch. First, there must be an environment that produces insects and in which poults can efficiently forage. Additionally, good brood habitat must have features to permit frequent foraging throughout the day. Lastly, brood habitat must provide enough cover to hide poults while simultaneously allowing the adult female an unobstructed view to avoid predators. All of these must occur within a relatively small area because the weekly home range of a turkey brood has been reported as only 30 ha (75 ac) and a total summer home range of 100 ha (250 ac) (Speake et al. 1975, Porter 1980).

Brood habitat for wild turkeys consists of timbered areas adjacent to grassy openings. Grassy, herbaceous areas provide poults with insects for forage and cover from predators. Trees are also needed for thermal cover to protect poults from cold, wet conditions, particularly during the first 2 weeks after hatching, and as escape cover once poults can fly (10-12 days after hatching). Ideal brood habitat in Minnesota has been described as a 4:1 field-to-forest ratio (Porter 1980). Vegetation approximately 30-70 cm (12-28 in) in height allows poults to hide while allowing females to see predators (Porter 1980). Edge is important because broods usually remain near the field-forest ecotone during the first 2 weeks after hatching and later venture further into openings. Habitats meeting such conditions include forest stands interspersed with pastures and hayfields, utility right-of-ways, savannas, and cutover lands in early stages of succession.

In south-central Washington, broods were found to prefer oak and pine/oak habitats over open rangeland habitats during the first 2 weeks after hatching (Mackey 1982). This was probably because these forest types are very open (51-60% canopy coverage) and can provide an adequate insect prey base as well as cover. In parts of the state with denser forest canopy, interspersion of open areas will be much more important for brood habitat.

Roosting

Stands providing good roosting habitat are sheltered from prevailing winds and contain tall, large diameter trees with sizable horizontal branches, high canopy coverage and basal area (Hoffman 1968, Boeker and Scott 1969, Crockett 1973, Hauke 1975). Single large trees are apparently not used for roosting unless they are associated with a stand (Phillips 1980, Mackey 1984). In south-central Washington, Mackey (1982) found that only Douglas-fir stands met the criteria of good roosting habitat as listed above, though he did find smaller sized ponderosa pine and oak trees used as well. In Oregon, roosts are typically located in multi-layered, mature, mixed-conifer cover types, specifically ponderosa pine and Douglas-fir in the winter and ponderosa pine in the spring (Lutz and Crawford 1987a). In Montana, Jonas and Eng (1964) found that turkeys most often used mature ponderosa pine communities for roosting.

Fall and Winter

During fall and winter, turkeys switch to habitats that offer the best food resources, environmental conditions, and thermal cover for protection from colder temperatures and snow. Typically, this means greater use of stands of larger trees with greater canopy coverage and basal area; springs, seeps, and other riparian areas with denser vegetation; and areas with more abundant hard mast. It also means a decreased use of open areas (Beasom and Wilson 1992, Hurst and Dickson 1992, Shaw and Mollohan 1992, Wunz and Pack 1992). Turkeys may also exhibit an increase in flocking behavior during winter, particularly if available food is concentrated in specific areas (Thomas et al. 1966, 1973; Wunz and Pack 1992).

Food

Poults feed exclusively on high protein invertebrates in the first and second week after hatching, and by the third week they have switched to a diet dominated by plants (Jonas and Eng 1964, Rumble 1990, Hurst 1992, Rumble and Anderson 1996). The diet of both juvenile and adult turkeys is comprised of 75-85% plant matter and the remainder animal matter (Hurst 1992). Important year-round food items include fruits, grains, hard masts, insects, and the green leaves, flowers, and seeds of grasses, forbs, and sedges (Jonas and Eng 1964, Smith and Browning 1967, Burke 1982, Mackey 1982, Wise 1987, Rumble 1990, Hurst 1992, Rumble and Anderson 1996). During spring and summer, wild turkeys often prefer natural grassy meadows and agricultural fields due to the abundance of insects found within them (Burke 1982). Mast-producing tree and understory species are also an important food source (Wunz and Pack 1992). In fall and winter when green vegetation becomes scarce, turkeys switch to a diet composed more of grass seeds, fruits, ponderosa pine nuts, acorns, and other hard mast. Agricultural crops (wheat, barley, oats, legumes) also can serve as a valuable fall/winter food source. During the winter months, turkeys have been observed feeding on cow manure spread on croplands, corn stubble, and hay strips bordering fields of stubble corn (Vander Haegen et al. 1989).

Water

Turkeys can meet their needs for moisture through berries and other succulent vegetation when available. Whether or not turkeys drink water appears to depend on its availability and the ability of food items to provide moisture (Wunz and Pack 1992). When forage cannot meet their needs, turkeys obtain water from pools, ditches, streams, rivers, lakes, wetlands, snow, and dew. Turkeys in moist environments need less free water than those in more arid areas (Beasom and Wilson 1992, Hurst and Dickson 1992, Shaw and Mollohan 1992, Wunz and Pack 1992). Thus, turkeys in the eastern U.S. probably rely less on open water than those in the southwest or plains states. However, during times of drought or in drier eastern environments, open water may be important. Likewise, in more mesic western habitats, open water may be less important.

LIMITING FACTORS

Turkeys are limited by a number of natural and artificial factors. The northern natural range of turkeys in the east seems to be limited by the condition, depth, and duration of snowfall (Healy 1992). In the mid-west, central, and southwest United States, the range of the turkey is limited by the availability of trees. Nest and poult predation may significantly impact wild turkey populations when natural (predation, disease) and human-related (hunting, habitat change) mortality occur in conjunction (Miller and Leopold 1992). Because turkeys need an interspersion of forest and open areas, any management activities that disrupt this habitat diversity or degrade the habitat may impact local turkey populations. For instance, timber operations to open up areas for development or agricultural expansion may eliminate too much of the forest cover and food resource. On the other hand, forest thinning or creation of small openings may benefit turkey populations in some situations. Heavy grazing of grassy openings and understory vegetation may limit turkey populations by reducing food for adults and cover for nests and poults.

MANAGEMENT RECOMMENDATIONS

Regardless of subspecies or location in the state, the basic habitat requirement for wild turkeys is adequate quality, quantity, and distribution of forested and open areas. This can be achieved in mature, mast-producing forests with appropriate brood (open areas) and winter range (dense forest) areas. The actual density of forest cover, species composition, and proportion of forest and open areas will vary in different parts of the state. In areas with limited mast-producing trees, such as western Washington, agricultural fields and/or artificially constructed food plots may be needed to maintain turkey populations.

Mast Producing Vegetation - Wild turkey habitat should be managed so that 50-75% of the area is composed of mature, mast producing tree species. In Washington, this would mean maintaining species such as oak and ponderosa pine. Mackey (1982) found that the forest component of his study area in south-central Washington accounted for 74% of the landscape. Pine/oak habitat was the most preferred type for daytime use by turkeys during all seasons. In areas where food sources are scarce, mast-producing shrubs and small trees should be planted as orchards or as edges in clearings. When reseeding, sow a mixture of grasses and forbs that provide both food and cover for turkeys.

Forest Cover - Forest cover should be maintained in areas where wild turkeys exist. Forested areas are used extensively for nesting, roosting, escape and thermal cover, and even brood rearing in more open forest types. In stands lacking pine and oak, protection of mature timber is still important for cover and roosting habitat. Mackey (1982) noted that Douglas-fir stands were used extensively as roost sites. Sites used by roosting turkeys averaged greater canopy coverage (74%), greater canopy height [19 m (62 ft)], and greater basal area [34 m^2/ha (148 ft^2/ac)] than control plots (Mackey 1982). To maintain such characteristics in areas inhabited by turkeys, it is recommended that timber harvesting be done selectively and that clearcuts >12 ha (30 ac) should be avoided. Where logging is unavoidable, maintain a tree basal area 20 m^2/ha (87 ft^2/ac)(Mackey 1984). Turkeys frequently use access roads and trails. Therefore, roads created for timber harvest should be closed, gated, seeded, or tank-trapped following timber operations.

Brood Habitat - Brood-rearing habitat can be achieved through maintenance or creation of open timbered areas and/or natural and artificial openings in denser forest. Open areas can be created or maintained through selective timber harvest, prescribed burns, periodic mowing, and chemical treatments (Wunz and Pack 1992).

Livestock Grazing - Livestock grazing also may be used to maintain natural openings. Continuous light grazing seems to be compatible with wild turkey management (Beasom and Wilson 1992). Various types of grazing rotation systems have been described as providing for turkey food production but not as being good for nesting (Merrill 1975). To reduce the negative impacts of livestock grazing in turkey habitat, provide grazing exclosures within existing grazing systems. Blakey (1944 *in* Beasom and Wilson 1992) recommends that 40-200 ha (100-500 ac) be excluded from grazing within each 1,200-2,000 ha (3,000-5,000 ac) of rangeland for 24 months. As an alternative or in addition to constructing exclosures, roadside and railroad rights-of-ways or other fenced-out exclosures can be managed for turkeys. Where ungrazed areas are available, provide moderate grazing intensities on remaining areas to stimulate food plant growth (Beasom and Wilson 1992).

Land Management Activities - Turkeys are sensitive to disturbance at their nest sites (Lutz and Crawford 1987b); therefore, major land management activities in nesting habitat should be minimized during April, May, and early June. Construction of houses within turkey habitat should be restricted to nonforested areas that are larger than 2 ha (5 ac) in size (Mackey 1982).

Water - In more arid landscapes, a source of free water should be provided for turkeys. Suggestions from Beasom and Wilson (1992) include: providing water through ground-level ponds or catchments as opposed to standard livestock water troughs; fencing small, ground-level watering sites to exclude livestock; in rotational grazing systems, maintaining water in deferred pastures; in short-duration grazing sites, maintaining a fenced-out water site at least 0.4 km (0.25 mi) from the main livestock watering facility; and constructing gallinaceous guzzlers in more arid regions. Gallinaceous guzzlers collect rainfall on an impermeable apron and store the water in underground tanks that have access ramps for the birds.

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KEY POINTS

Habitat Requirements

- Trees and grass are prominent features of wild turkey habitat.
- Wild turkeys use a combination of forested and open habitats, including conifers, hardwoods, mixed woodlands, riparian areas, open grasslands, and edges of agricultural fields.
- Wild turkeys nest in timber stands with dense understories, weedy fields, clearcuts, utility rights-of-ways, young pine plantations, and agricultural fields. Typical vegetation provides dense cover up to 0.5 m (1.5 ft), unrestricted visibility from 0.5-1.0 m (1.5-3.0 ft), and a canopy of understory and forest trees above the nest.
- Brood range includes open forested areas and natural and artificial openings within close proximity to timbered areas. Ground vegetation should be 30-70 cm (12-28 in) in height to protect poults.
- Good roosting habitat includes stands of timber that are sheltered from prevailing winds and that contain trees that are larger in height, canopy cover, diameter at breast height, and basal area than trees in other stands.
- In climates with more severe winter conditions, turkeys will decrease their use of open areas and will increase their use of stands of larger trees with greater canopy coverage and basal area. Springs, seeps, and other riparian areas, as well as areas with more abundant hard mast, are also used during the winter.
- Poults feed exclusively on high protein invertebrates in the first and second weeks after hatching.
- The diet of juveniles and adults is comprised of 15-25% animal matter and 75-85% plant matter, including green vegetation, grasses, forbs, sedges, fruits, grains, and mast.
- Good turkey range has an adequate supply of water.

Management Recommendations

- Wild turkey habitat should be managed so that 50-75% of the area is composed of mature, mast-producing timber species.
- Timber should be managed through selective cuts in pine and oak habitats, and through selective cuts or small clearcuts [<12 ha (30 ac)] in Douglas-fir habitats. Avoid logging within known roost sites.
- Natural openings should be maintained and created where lacking. Unused logging roads should be closed and reseeded with grasses and legumes, and planted with shrubs and small trees.
- In areas inhabited by turkeys, grazing should be managed through light, continuous use, or with a deferred-rotation system. Provide grazing exclosures within any grazing system.
- Livestock and other disturbances to nesting habitat should be restricted from April to early June.
- Housing development should be restricted to non-forested areas larger than 2 ha (5 ac) in size.
- Sources of free water should be provided in more arid landscapes.

Sandhill Crane
Grus canadensis

Last updated: 2000

Written by Kelly A. Bettinger and Ruth Milner

GENERAL RANGE AND WASHINGTON DISTRIBUTION

The breeding range of the sandhill crane (*Grus canadensis*) includes Siberia, Alaska and Northern Canada, the Great Lakes, and portions of Idaho, Washington, Oregon, Nevada, and California. It also includes the southeastern United States, Cuba, and the Isle of Pines (Tacha et al. 1992). Six migratory populations with distinct wintering areas are recognized. These are the Lower Colorado River, Central Valley, Rocky Mountain, Pacific Flyway, Mid-continent, and Eastern populations. Three additional populations breeding in the southeastern United States and Cuba are nonmigratory (Tacha et al. 1994). Cranes breeding in Washington belong to the Central Valley population and winter in the Central Valley of California (Kramer et al. 1983, Pogson and Lindstedt 1991). This was most recently confirmed when 2 colts banded at Conboy Lake National Wildlife Refuge (NWR) in June 1996 were sighted again near Glenn, California, in January of 1997 (J. D. Engler, personal communication). Migrants moving through Washington belong to both the Central Valley and Pacific Flyway populations.
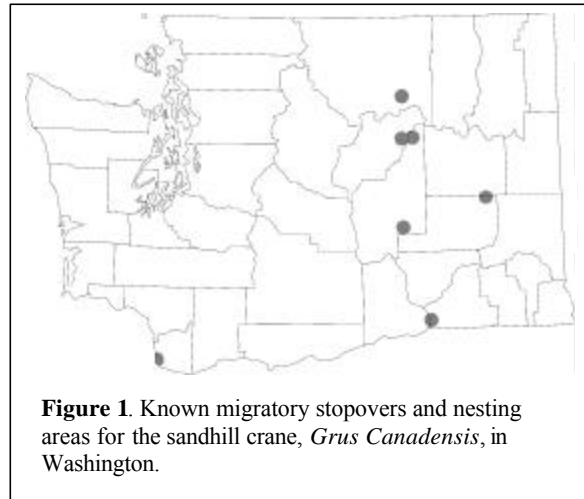
Figure 1. Known migratory stopovers and nesting areas for the sandhill crane, *Grus Canadensis*, in Washington.

Of the 6 recognized subspecies of sandhill cranes, only the greater sandhill crane (*Grus canadensis tabida*) breeds in Washington. According to Jewett et al. (1953), the breeding range was formerly more widespread in Washington and occurred both east and west of the Cascade crest. Historic eastern Washington locales included Okanogan, Collville, Spokane, Prescott, Rockland, Cashmere, Fort Simcoe, and Camas Prairie. Fewer historic western Washington breeding sites are known. Cooper and Suckley (1860) reported sandhill cranes breeding on interior prairies of western Washington, though their most specific location description was "on prairies near Steilacoom." They also reported that sandhill cranes were very abundant on the south Puget Sound prairies during autumn migration.

Between 1975 and 1987, a single pair of sandhill cranes nested at Conboy Lake NWR in Klickitat County (see Figure 1). Since 1988, 2 to 6 pairs/year are known to have nested on the refuge, and in 1996 there were 9 confirmed breeding pairs (Anderson et al. 1996). Nesting cranes were discovered recently at a second site in Washington on the Yakama Indian Reservation in Yakima County, where 1 pair nested in 1994 and 1995, and 2 pairs nested in 1996 (Leach 1995; R. Leach, personal communication).

Migrants of 2 other subspecies, the lesser sandhill crane (*G. c. canadensis*) and the Canadian sandhill crane (*G. c. rowani*), occur in Washington during spring and fall. The largest concentrations are found in the central Columbia Basin. In the spring, lesser sandhills migrating to northwest Canada and Alaska enter Washington east of the Cascades south of Pasco. They regularly stop near Moses Lake and Ephrata in Grant County, and near Mansfield in Douglas County before continuing north through the Okanogan Valley (see Figure 1; Littlefield and Thompson 1981, Kramer et al. 1983). Lesser sandhill cranes migrating west of the Cascades enter the state near Sauvie Island in the Columbia River, and either move north through the Puget Sound region or follow the coast, passing over Cape Flattery toward Vancouver, British Columbia. The same routes are used in the fall (Littlefield and Thompson 1981). Migrating greater sandhill cranes that breed in British Columbia and Canada probably use similar routes.

Breeding sandhill cranes arrive at Conboy Lake NWR in early March. Most nesting occurs from April to June, though a newly hatched colt has been observed as late as early July (H. Cole, personal communication). Breeding cranes and their surviving young leave the state between late September and mid-October.

RATIONALE

The sandhill crane is a State Endangered species. Sandhill cranes are in jeopardy of extinction in Washington because of their limited distribution, low numbers, poor breeding success and colt survival, and loss of shallow marshes or wet meadows for feeding and nesting (Safina 1993). In addition, a large percentage of their wintering habitat is privately owned and subject to potential alteration (Lewis 1980, Pogson and Lindstedt 1991).

HABITAT REQUIREMENTS

Sandhill cranes use large and small tracts of open habitat where visibility is good from all vantage points. Wet meadows, marshes, shallow ponds, hayfields, and grainfields are all favored for nesting, feeding, and roosting. Emergent wetland vegetation is a key component of nesting territories, and nests are typically placed on piles of emergent vegetation, grass, and mud (Safina 1993, Baker et al. 1995). At Conboy Lake NWR, nesting usually takes place in shallow-water marshes with dense emergent plant cover, including reed canarygrass (*Phalaris arundinacea*) and rushes (*Juncus* spp). Bulrushes (*Scirpus* spp.) are often used for nesting in southeastern Oregon (Littlefield and Ryder 1968), but such vegetation is not common at Conboy Lake NWR. Pairs return to the same territory and even the same approximate nest location every year (Littlefield and Ryder 1968, Walkinshaw 1989).

Sandhill cranes are omnivorous, feeding on grains, plant material, invertebrates, amphibians, and small mammals (Reinecke and Krapu 1986, Tacha et al. 1992, Davis and Vohs 1993). Wet meadows or grasslands are used as feeding grounds and are sometimes used for nesting (U.S. Fish and Wildlife Service 1978, Littlefield 1995a). Grainfields and pastures are also important feeding areas (Littlefield and Ryder 1968). Wet meadow or marsh habitats used by sandhill cranes in Washington occur in forested areas (predominantly lodgepole pine [*Pinus contorta*], Douglas-fir [*Pseudotsuga menziesii*], ponderosa pine [*Pinus ponderosa*], and/or grand fir [*Abies grandis*]), and in more open conditions where they are surrounded by grasslands, shrublands, and/or agricultural lands (Tacha et al. 1992).

LIMITING FACTORS

Sandhill cranes are limited by the availability of large tracts of undisturbed marshes or meadows for feeding and nesting, and by adequate water levels during the nesting period (Safina 1993). Low nesting success and colt survival, with subsequent low annual recruitment of new birds into the population can result in a decline of breeding pairs over time (Stern et al. 1985, Stevens 1991, Littlefield 1995b,c).

Sandhill cranes are extremely wary, requiring isolated sites with good nesting cover. Repeated disturbance often results in nest desertion and increases the likelihood of predation on unattended nests (Safina 1993). Pedestrian and vehicle traffic, construction, timber harvest, and low-flying aircraft can potentially disturb breeding and roosting

cranes (Kramer et al. 1983, Norling et al. 1992, Joe Engler, personal communication). Additionally, structures such as power lines and wire fences can pose hazards to cranes that may collide with or become entangled in the wires (U.S. Fish and Wildlife Service 1978, Kramer et al. 1983, Walkinshaw 1989, Morkill and Anderson 1991, Brown and Drewien 1995).

Predator populations near sandhill crane nesting areas can seriously hamper nesting success (Stern et al. 1985). Losses of eggs and chicks to predators have greatly impacted crane numbers on the Malheur National Wildlife Refuge in Oregon (Littlefield 1995b,c). Coyotes (*Canis latrans*) are the most serious predator, followed by ravens (*Corvus corax*), raccoons (*Procyon lotor*), and mink (*Mustela vison*). A combination of habitat improvement (increasing non-woody vegetative cover) and predator control has been highly successful in increasing the breeding crane population on the Malheur National Wildlife Refuge (Littlefield 1995b,c).

Livestock can also cause problems for nesting sandhill cranes. Grazing reduces vegetative cover for nests which can result in increased nest depredation (Braun et al. 1975, Littlefield and Paullin 1990, Littlefield 1995b). Eggs and young are also at risk of being trampled by cattle where spring and summer grazing is allowed (Schlorff et al.1983). Cattle trails into emergent wetlands provide easy access for mammalian predators, and habitat deterioration from mowing or grazing reduces the small mammal populations that are the favored prey of predators. This leaves predators more likely to feed on alternative prey such as crane eggs and chicks. In addition, cattle crush emergent vegetation while using it for bedding in winter, resulting in decreased cover for crane nests in April and May (Littlefield and Paullin 1990).

Nesting areas must have water shallow enough to support emergent vegetation. Cranes prefer to roost in water less than about 20 cm (8 in) deep (Lovvorn and Kirkpatrick 1981, Norling et al. 1992). Increasing water depth can flood and destroy nests, while lowering water levels can improve predator access to nests. Decreased water levels in June and July can cause a shortage of moist soil and aquatic invertebrates required by young cranes during their first 6 weeks of life, resulting in their starvation (Schlorff et al. 1983).

MANAGEMENT RECOMMENDATIONS

In order for sandhill cranes to survive in Washington, their breeding, migration, and wintering habitats need to be protected and enhanced. It is crucial that further losses of Washington's remaining wetlands are prevented. In some instances, the creation of additional habitat should be considered (Safina 1993, Tacha et al. 1994).

Disturbing cranes during the breeding season (March to September) should be avoided. Road and foot travel should be avoided within 400 m (1,312 ft) of nests, and logging operations within 800 m (2,625 ft) of crane nests should be curtailed during the breeding season (Schlorff et al. 1983). Avoid aircraft activity or keep to high altitudes over areas used by cranes (Kramer et al. 1983). In addition, construction and development within 1.2 km (0.75 mi) of nest sites should be avoided (Joe Engler, personal communication).

New power line corridors should be located away from crane migration and breeding sites, or buried underground. Line markers or other devices should be installed on existing transmission lines that pose hazards to cranes (Kramer et al. 1983, Morkill and Anderson 1991, Brown and Drewien 1995).

All fences that are not essential to controlled grazing and that are near areas used by sandhill cranes, should be removed to prevent cranes from becoming entangled in fence wires (U.S. Fish and Wildlife Service 1978, Walkinshaw 1989).

Predator populations may need to be controlled around nesting areas. A combination of habitat improvement (increasing non-woody vegetative cover) and predator control has been shown to be effective (Littlefield 1995b,c).

Livestock grazing at sandhill crane breeding sites should be limited or eliminated. Grazing and cattle trails reduce vegetative cover for crane nests, increase predator access, and increase the risk of crane eggs and young being trampled by livestock (Braun et al. 1975, Schlorff et al. 1983, Littlefield and Paullin 1990, Littlefield 1995b).

Changes in water levels should be avoided while sandhill cranes are nesting. New water projects such as dams or irrigation ditches that would alter water levels and cause negative changes to vegetation should be avoided in important crane breeding or migration areas (Schlorff et al. 1983).

Meadows should be mowed and hayed no earlier than mid-August to prevent mortality of flightless young cranes hiding in the tall vegetation (Schlorff 1983). Detailed knowledge of a given year's nesting chronology, or of when particular foraging sites are used, could allow for timing flexibility.

Mowing and hay removal conducted after 15 August may benefit cranes by providing feeding areas. All hay should be removed and residual hay cleaned up immediately after mowing to prevent mold development. "Moldy" hay provides favorable conditions for aspergillosis, which is known to infect young cranes (U.S. Fish and Wildlife Service 1978).

Fall plowing of crane feeding habitat should be avoided. Waste grain is more useful if knocked over rather than left standing (Johnson and Stewart 1972). Wheat is the preferred grain to attract cranes to a feeding site, though barley and corn are favored as well (Littlefield 1986, Sugden et al. 1988).

U.S. Fish and Wildlife Service guidelines for managing greater sandhill cranes of the Central Valley population suggest maintaining ponds and wetlands within 3.2 km (2 mi) of grain sites to provide roost sites for cranes (U.S. Fish and Wildlife Service 1978). In Saskatchewan, Canada, 90% of sandhill cranes foraged in fields within 8.0 km (5.0 mi) of their night roost sites, and observations of cranes decreased with distance from roost centers (Sugden et al. 1988). On the Malheur National Wildlife Refuge in southeast Oregon, all grainfields are within 7.6 km (4.7 mi) of night roosts (Littlefield 1986).

New construction or traffic increases within 800 m (2,625 ft) of feeding areas should be avoided. Additionally, low flying aircraft should be avoided over areas used by cranes (Kramer et al. 1983).

The construction of roads and buildings within 500 m (1,640 ft) of known night roost locations should be avoided. Preferred night roost sites used during migration are usually located away from paved or gravel roads, single dwellings, and bridges (Norling et al. 1992).

Hunting activity should be avoided near established roosts, or restricted to 4 hours after sunrise until 2 hours before sunset. Hunting should also be avoided near major feeding areas (Lovvorn and Kirkpatrick 1981, Littlefield 1986).

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KEY POINTS

Habitat Requirements

- Sandhill cranes use large and small tracts of open habitat where visibility is good from all vantage points.
- Wet meadows, marshes, shallow ponds, pastures, hayfields, and grainfields are all used for nesting, feeding, and/or roosting.
- Dense, emergent wetland vegetation is a key component of nesting territories. Nests are typically placed on piles of emergent vegetation, grass, and mud.
- Ideal nesting locations have good visibility, are near feeding areas, and are free from human disturbance.
- Migrating sandhill cranes use roost sites with shallow water (<20.0 cm [8.0 in]) deep) that are close to feeding sites and are free from human disturbance
- Sandhill cranes are highly omnivorous, feeding on grains, plant material, invertebrates, amphibians, and small mammals.

Management Recommendations

- Sandhill cranes should not be disturbed during their breeding season (March - September).
- Vehicle and foot traffic should be avoided within 400 m (1,312 ft) of nesting areas during the breeding period (March - September).
- Logging should be avoided within 800 m (2,625 ft) of nests during the breeding period.
- Aviation balls or other markers should be used to make existing transmission lines visible to flying cranes.
- Avoid building new power lines in areas used by cranes, or place lines underground.
- All unnecessary wire fences should be removed from areas used by cranes.
- Cattle should be excluded from crane nesting marshes.
- Predator control may be necessary in some situations.
- Water levels should not be altered in wetlands used by cranes. New water projects that might alter water levels or change vegetation should be avoided in nesting or migration areas.
- Meadows should be mowed after 15 August, and all hay should be removed soon after mowing to prevent mold.
- Grainfields should not be fall-plowed; waste grain should be knocked down.
- Wetlands should be maintained within 3 km (2 mi) of upland feeding areas.
- Construction and road building should be avoided within 800 m (2,625 ft) of feeding areas.
- The construction of new roads or buildings should be avoided within 500 m (1,640 ft) of night roosts.
- Hunting near roosts should be avoided, or restricted from 4 hours after sunrise until 2 hours before sunset.

GENERAL RANGE AND WASHINGTON DISTRIBUTION
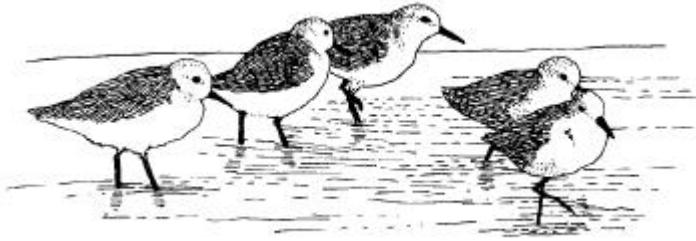
Shorebirds are represented in Washington by many families, including plovers, oystercatchers, avocets and stilts, sandpipers, snipes, and phalaropes (Paulson 1993). In Washington, shorebirds occur as year-round residents, breeding or summer residents, spring and/or fall migrants, and migrants that winter in the region (Table 1). Some species, such as the killdeer and spotted sandpiper, have resident and migrant sub-populations.

The vast majority of wintering and migratory shorebirds in Washington occur at coastal estuaries (Figure 1). These areas include the Columbia River estuary, Willapa Bay, Grays Harbor, coastal Washington beaches, the Strait of Juan de Fuca, Hood Canal, the San Juan Islands, and the Greater Puget Sound region (Figure 1). The highest counts of wintering birds are from Willapa Bay (38,000-90,000

Figure 1: Primary wintering and migratory ranges of shorebirds associated with estuaries and/or shoreline habitats in Washington. Various shorebird species are also associated with freshwater or other upland habitats that are difficult to generalize and identify on a map of this scale (see text). Map derived from the literature.

shorebirds; Buchanan and Evenson 1997), Grays Harbor (approximately 20,000 shorebirds annually during 1979-1988; Paulson 1993, Brennan et al. 1985), and the northern estuaries of Puget Sound (>10,000 shorebirds at several estuaries and >50,000 shorebirds in the region; Evenson and Buchanan 1995, 1997).

The most significant areas during migration include Grays Harbor (>one million shorebirds during spring; Herman and Bulger 1981), Willapa Bay (>100,000 shorebirds during spring; Buchanan and Evenson 1997), and the many estuaries of Puget Sound (>50,000 shorebirds during spring; Evenson and Buchanan 1997). Species such as the red-necked phalarope may occur in large numbers offshore during migration (Jehl 1986). Other significant wintering and migratory staging areas in the region include Boundary Bay and the Fraser River delta in southern coastal British Columbia, Canada (Butler and Campbell 1987, Butler 1994, Vermeer et al. 1994).

Other habitats in western Washington are also important for shorebirds. Flocks of black-bellied plovers and dunlins occasionally occur at non-estuarine sites in western Washington (e.g., flooded fields in the Wynoochee and Chehalis River valleys) during migration or winter periods (J. Buchanan, unpublished data). Some of these birds may have been temporarily displaced by flooding (Strauch 1966) or other conditions that reduced prey availability at coastal estuaries (Townshend 1981). Large numbers of shorebirds forage and roost on ocean beaches during winter (Buchanan 1992) and migration (Myers 1988-89, Myers et al. 1986). Other important habitats include rocky shorelines and the pelagic zones (Paulson 1993).

Compared to the coastal region, shorebirds are far less abundant at wintering and migratory stop-over areas in the eastern part of the state where they occur at widely scattered ponds, "potholes" and lakes, marshes, flooded fields,

and riverine systems (Paulson 1993). As is true in other interior regions in North America, the seasonal distribution and abundance of shorebirds in this part of the state is somewhat unpredictable in that the suitability of shorebird habitats in many areas is dependent on changing water levels that are sensitive to varying water use practices, drought, and other environmental conditions (Fredrickson and Reid 1990, Skagen 1997). The highest counts of migratory shorebirds (most counts are <1,000 birds) in the interior region of Washington are from Lake Lenore (i.e., red-necked phalarope), Soap Lake, Turnbull National Wildlife Refuge, Yakima River delta, and water bodies near Reardan (Paulson 1993). It is likely that other areas of concentrated use by shorebirds have not been documented. In Washington, the primary breeding ranges of the American avocet, black-necked stilt, and Wilson's phalarope occur within the Columbia Plateau region in the eastern part of the state.

Breeding and Wintering Ranges

The breeding distribution of migrant shorebirds includes species that nest locally, such as the spotted sandpiper and American avocet (Jewett et al. 1953), and also species that nest in the arctic and subarctic, such as the dunlin and western sandpiper. The wintering range of nearctic shorebirds is vast, extending from southeastern Alaska to southern South America (Morrison 1984) and generally falls within 3 categories: 1) wintering areas primarily within North America, 2) wintering areas extending throughout much of the western hemisphere, and 3) wintering areas primarily within South America.

Distribution of Age and Sex Classes

The age and sex compositions of some shorebird populations vary spatially and temporally across their ranges. Examples of local or regional spatial segregation can be found, although the population structure of most species is poorly known. For example, adult male and juvenile western sandpipers winter primarily in western North America whereas most females of this species winter in South America (Page et al. 1972). Additionally, populations of wintering dunlins exhibit pronounced local and regional segregation by age class (Kus et al. 1984, van der Have and Nieboer 1984, Buchanan et al. 1986).

Temporal segregation of age and sex classes occurs during migration in many species (Morrison 1984, Butler et al. 1987). In Washington, this segregation involves 2 of the most abundant species in western North America, the western sandpiper and dunlin (Page and Gill 1994). An understanding of spatial and temporal segregation can be important for population and habitat management, because habitat loss or degradation at certain wintering or migratory staging areas may significantly impact specific age or sex classes of these or other species at the local, regional, or population level.

RATIONALE

Over 40 species of shorebirds occur in Washington throughout their breeding and nonbreeding seasons (Paulson 1993, Gill et al. 1994). Two of these, the snowy plover (*Charadrius alexandrinus*) and the upland sandpiper (*Bartramia longicauda*), are listed as State Endangered species (the upland sandpiper may be approaching extirpation in Washington). During the nonbreeding period, most shorebird species in Washington aggregate in large single- or multi-species flocks at estuaries, beaches, wetlands, or other foraging and/or roosting locations. Because of the limited distribution of these habitats, and the propensity of shorebirds to form large aggregations, shorebirds are vulnerable to habitat loss; chemical, metal or oil pollution; various disturbance factors; and other potentially significant impacts.

Many shorebird species are long-distance migrants that travel thousands of miles between wintering and breeding areas. The availability of wintering sites and migratory staging areas has decreased throughout North America due to the destruction of biologically rich but economically important areas used by these birds (Page and Gill 1994, Skagen 1997). The number and quality of these sites likely constrains shorebird populations during the nonbreeding season (Myers 1983, Senner and Howe 1984, Myers et al. 1987b), although habitat loss can adversely impact

shorebird populations at any season (Evans and Pienkowski 1984, Goss-Custard and Durell 1990, Sutherland and Goss-Custard 1991).

Nearly all of Washington's shorebird species are represented by individual birds en route to wintering grounds in Central or South America or breeding grounds in Alaska, Canada or the Russian Far East. A number of sites in Washington support substantial shorebird populations (Herman and Bulger 1981, Evenson and Buchanan 1995, Buchanan and Evenson 1997) and qualify as important regional or hemispheric sites in the Western Hemisphere Shorebird Reserve Network (Myers et al. 1987a). Moreover, the region as a whole supports huge numbers of birds during winter and migration. Consequently, during one season or another, this region supports substantial segments of shorebird populations that are truly international in their distribution (Gratto-Trevor and Dickson 1994). For this reason, shorebird populations and the habitats they use in Washington are integral components of a greater hemispherical population of birds and must be managed from this international perspective (Gill et al. 1994).

Large-scale censuses of shorebirds conducted in Britain (Prater 1981, Moser 1987), the Canadian Arctic (Gratto-Trevor et al. 1998), and eastern North America (Howe et al. 1989, Morrison et al. 1994a) indicate that populations of many species are declining. Long-term research from migratory staging areas in eastern North America indicates that several species of shorebirds, including some that also migrate through Washington, have experienced significant population declines along the east coast (scientific names are presented in Table 1): black-bellied plover, semipalmated plover, whimbrel, ruddy turnstone, red knot, sanderling, semipalmated sandpiper, least sandpiper, and short-billed dowitcher (Howe et al. 1989, Morrison et al. 1994a). Populations of American golden-plover, lesser yellowlegs, red-necked phalarope, and red phalarope are also thought to have declined in Canadian breeding areas (Haig et al. 1997, Sauer et al. 1997, Gratto-Trevor et al. 1998).

Other species have experienced population declines as well. For example, the size of the wintering population of rock sandpipers along the Pacific coast of Oregon, Washington, and British Columbia declined suddenly and dramatically (and appears to have shifted north to Alaska) in association with the 1982-83 El Nino event (Buchanan in review). Black turnstone numbers have also declined along the Pacific Northwest coast (Paulson 1993). Species such as the snowy plover and upland sandpiper have also clearly declined in response to habitat destruction (Washington Department of Fish and Wildlife 1995a, 1995b). Analyses of data collected from Breeding Bird Survey routes throughout Washington indicate the occurrence of significant population declines at one or more spatial or temporal scales for the following four species of locally-nesting shorebirds: spotted sandpiper in the Columbia Basin, (-9.1% between 1966 and 1996), killdeer statewide (-2.3% between 1966 and 1996 and -4.1% between 1980 and 1996), common snipe in the Columbia Basin (-3.2% between 1966 and 1996) and statewide (-5.5% between 1980 and 1996), and Wilson's phalarope in the Columbia Basin (-10.9% between 1980 and 1996) (Sauer et al. 1997).

Table 1. Seasonal abundance and habitat use of shorebirds in Washington. Habitats are described in Paulson (1992, 1993). Bold text refers to primary habitat or area where the species is locally or seasonally common; standard text refers to secondary habitats. Abundance codes are from (Paulson 1993). Seasonal abundance codes may differ from Paulson (1993) based on other available information. Codes with an asterisk (*) represent unique local populations. Abundance codes in parentheses refer to interior Washington.

Species	Abundance by season[a]				Habitat
	Winter	Spring	Summer	Fall	
Black-bellied plover (Pluvialis squatarola)	VA	VA (VU)	FC	VA (U)	**coastal and estuarine sand beaches and mud flats**, exposed shorelines of ponds and lakes, farmland, wet lowland meadow
American golden-plover (Pluvialis dominica)		R		C (U)	**coastal and estuarine mud flats and saltmarsh**, exposed shorelines of ponds and lakes, farmland, alpine/subalpine meadow, wet lowland meadow
Pacific golden-plover (Pluvialis fulva)	VR	R		C	**coastal and estuarine mud flats and saltmarsh**, exposed shorelines of ponds and lakes, farmland, alpine/subalpine meadow, wet lowland meadow
Snowy plover (Charadrius alexandrinus)	U	FC*	FC*	FC*	**coastal sand beaches**
Semipalmated plover (Charadrius semipalmatus)	FC	A (VU)	U	A (U)	**coastal and estuarine sand beaches and mud flats, exposed shorelines of ponds and lakes**
Killdeer (Charadrius vociferus)	C (U)	C (C)	C (C)	C (C)	estuarine mud flats and **saltmarsh; exposed shores of ponds, lakes**, and large rivers; **fresh marsh, wet lowland meadow, grassy areas and farmland**
Black Oystercatcher (Haematopus bachmani)	FC	FC	FC	FC	**coastal rocky shore**
Black-necked Stilt (Himantopus Mexicanus)		VU (U)	(FC)		**shallow marshy ponds and lakes**

Species	Abundance by season[a]				Habitat
	Winter	Spring	Summer	Fall	
American avocet (Recurvirostra americana)		R (FC)	(C)	R (A)	**shallow marshy ponds and lakes**
Greater yellowlegs (Tringa melanoleuca)	VC (VU)	VC (FC)	R	VC (FC)	**estuarine mud flats, shorelines of shallow ponds, lakes and large rivers**, flooded fields
Lesser yellowlegs (Tringa flavipes)		VU (U)		FC (FC)	estuarine mud flats, **shorelines of shallow ponds and lakes**, flooded fields,
Solitary sandpiper (Tringa solitaria)		U (VU)	(R)	VU (U)	**shorelines of shallow ponds and lakes, including those found in wooded settings; flooded fields and other ephemeral freshwater areas**
Willet (Catoptrophorus semipalmatus)	U*	VU (VU)	(U)	VU (VU)	shorelines of shallow ponds and lakes, **estuarine mud flats**
Wandering tattler (Heteroscelus incanus)		FC		FC	**coastal rocky shores**
Spotted sandpiper (Actitis macularia)	U*	U (U)	U (R)	U (VU)	**shorelines of streams, rivers, shallow ponds and lakes, marshes**; rocky shore, estuarine mud flats
Upland sandpiper (Bartramia longicauda)			(VU)		**wet meadow/ grassland**
Whimbrel (Numenius phaeopus)	VU*	VC	FC	VC	**coastal and estuarine sand beaches and mud flats, saltmarsh**
Long-billed curlew (Numenius americanus)	U*	VU (FC)	(FC)	VU (FC)	**dry grassland, farmland; estuarine mud flats**, saltmarsh

Species	Abundance by season[a]				Habitat
	Winter	Spring	Summer	Fall	
Bar-tailed godwit (Limosa lapponica)				R	**coastal and estuarine sand beaches and mud flats**
Marbled godwit (Limosa fedoa)	C*	FC (FC)	R	FC (FC)	**coastal and estuarine sand beaches and mud flats**, exposed shorelines of interior ponds and lakes
Ruddy turnstone (Arenaria interpres)	VU	C		FC	**coastal rocky shore, sand beaches, mud flats**
Black turnstone (Arenaria melanocephala)	C	C		C	**coastal rocky shore**
Surfbird (Aphriza virgata)	C	C		C	**coastal rocky shore**
Red knot (Calidris canutus)	VU	VC	R	U (R)	**estuarine sand and mud flats**, coastal sand beaches
Sanderling (Calidris alba)	VA	VA (R)	VU	VA (U)	**coastal sand beaches**, estuarine sand and mud flats, coastal rocky shore
Semipalmated sandpiper (Calidris pusilla)		VU (U)		U (U)	**Exposed shoreline of shallow ponds**, mud flats
Western sandpiper (Calidris mauri)	VC*	VA (U)	U	VA (C)	**coastal and estuarine sand beaches, mud flats**, and salt marsh; **exposed shoreline of shallow ponds and lakes**; freshwater low marsh
Least sandpiper (Calidris minutilla)	FC	VC (C)		VC (C)	**estuarine mud flats, salt marsh; exposed shoreline of shallow ponds and lakes; freshwater low marsh**
Baird's sandpiper (Calidris bairdii)		VU (U)		FC (FC)	**coastal sand beaches**, mud flats, **exposed shoreline of shallow ponds and lakes, grassy areas, alpine/ subalpine meadow**

	Abundance by season[a]				Habitat
Species	Winter	Spring	Summer	Fall	
Pectoral sandpiper (Calidris melanotos)		VU		C (FC)	**estuarine and freshwater marsh**, mud flats
Sharp-tailed sandpiper (Calidris acuminata)				U	**estuarine salt marsh**, mud flat edges
Rock sandpiper (Calidris ptilocnemis)	FC	FC		FC	**coastal rocky shore**
Dunlin (*Calidris alpina*)	VA	VA (U)	U	VA (VU)	**coastal and estuarine sand beaches and mud flats, flooded fields**, rocky shores
Curlew sandpiper (*Calidris ferruginea*)				R	estuarine marsh, sand beaches, mudflats; freshwater low marsh
Stilt sandpiper (*Calidris himantopus*)				VU (VU)	**fresh and brackish marsh; sewage lagoons,** flooded fields
Buff-breasted sandpiper (*Tryngites subruficollis*)				VU	**grassy areas, coastal sand beaches**
Ruff (*Philomachus pugnax*)				VU	**estuarine mud flats, salt marsh; flooded fields, shallow ponds**
Short-billed dowitcher (*Limnodromus griseus*)		VA (R)	FC	VA (VU)	**estuarine mud flats,** coastal sand beaches, flooded fields, freshwater areas
Long-billed dowitcher (*Limnodromus scolopaceus*)	FC	C (VC)		VC (VC)	**exposed shoreline of shallow ponds and lakes; estuarine mud flats (winter), freshwater marsh**

	Abundance by season[a]				
Species	Winter	Spring	Summer	Fall	Habitat
Common snipe (*Gallinago gallinago*)	FC (U)	U (FC)	U (FC)	FC (FC)	**estuarine and freshwater marsh; flooded grassy fields, farmland**
Wilson's phalarope (*Phalaropus tricolor*)		U (FC)	VU (FC)	VU (FC)	**ponds and lakes, freshwater marsh, sedge meadows**
Red-necked phalarope (*Phalaropus lobatus*)		A (FC)		A (FC)	**marine waters; ponds and lakes**
Red phalarope (*Phalaropus fulicaria*)	U	FC		VC	**off-shore marine waters**

VA = Very Abundant (over 1,000 individuals observed per day), **A** = Abundant (200-1,000 individuals per day), **VC** = Very Common (50-200 individuals per day), **C** = Common (20-50 individuals per day), **FC** = Fairly Common (7-20 individuals per day), **U** = Uncommon (1-6 individuals per day), **VU** = Very Uncommon (more than 6 individuals per season in the region, but not seen every day), **R** = Rare (1-6 individuals per year in the entire region). The list does not include very rare (over 6 total records), casual (2-6 records), or accidental (1 record) species in the region.

[a] Winter refers to the period of local residency following autumn migration. The winter period for most species is November through March. Spring migration for most species is generally April through mid-May although some species begin migrating in Washington during March and others extend into June. Fall migration extends from late June to late October; some fall migrants occasionally remain in Washington until mid-November.

Other species, for which adequate information is lacking, are likely at risk of population-level impacts due to the vulnerability of their primary habitats (species to which Page and Gill [1994] assigned high vulnerability scores [a score ≥ 10 is used here to define 'high'] include American avocet, black-necked stilt, common snipe, killdeer, marbled godwit, snowy plover, upland sandpiper, willet, and Wilson's phalarope) and may be declining (Paulson 1992, Morrison et al. 1994b), although population monitoring data are generally lacking (see exceptions above). Finally, a number of species, including red knot, and various species of plovers, curlews, godwits, and dowitchers suffered substantial, if not catastrophic, population declines between 1870 and 1927 in response to unregulated hunting (Page and Gill 1994; see Cooke 1910, Forbush 1912, Grinnell et al. 1918). Populations of some of these species have not recovered and the likelihood of recovery appears low due to the negative effects of additional or more recent impacts, such as habitat loss (Paulson 1993, Page and Gill 1994).

HABITAT REQUIREMENTS

Most shorebird species exhibit unique migratory strategies that include preferences for specific habitat components (Davidson and Stroud 1996). Research on habitat selection by birds indicates that a range of habitats may be used although certain habitats are preferred and selected when possible (Fretwell and Lucas 1970). Although research on habitat selection by shorebirds has not been conducted in Washington, the habitat preferences of most species are obvious, assuming the predominant patterns of distribution and abundance reflect habitat preference (Ruggiero et al. 1988; Table 1). Some secondary habitats are used on occasion, however, and may be locally important, particularly during periods of adverse weather or depletion of food sources (Warnock et al. 1995, Davidson and Stroud 1996).

Coastal Environments

Most shorebirds in Washington occur as migrants or winter residents (Table 1). During the nonbreeding period, most can be found concentrated at beach or estuarine sites where fat and protein reserves required for overwintering or continued migration are replenished (Evans et al. 1991). The primary habitat requirements of these birds relate to the availability of adequate foraging and roosting areas. The foraging requirements of many shorebirds in western Washington are met primarily in estuarine ecosystems associated with silt or silt/sand intertidal areas and adjacent beaches or salt marshes, where tidal mud flats provide foraging substrates for many species. Black-bellied plover, dunlin, western sandpiper, and dowitchers forage on mud flats with high levels of silt, whereas semipalmated plovers and sanderlings forage in sandy or silt/sand areas (Paulson 1993). Other species, such as rock sandpiper, surfbird, and wandering tattler are found almost exclusively along rocky intertidal shores (Paulson 1993). Many species in eastern Washington use wet meadows, flooded fields and other areas of shallow water. The habitat associations of shorebirds in Washington are summarized in Table 1.

As a group, shorebirds are behaviorally and morphologically adapted to forage in a rather narrow range of microhabitat conditions (Burton 1974, Gerritsen and van Heezik 1985), including exposed tide flats or beaches, shallow water, salt marshes, and even open water. Consequently, the selection of invertebrate prey by shorebirds during the nonbreeding season is related to shorebird morphology and environmental factors that influence prey availability. These factors include tidal range, tidal exposure, wave action and tidal current, substrate slope, sediment mobility, organic pollution, local or regional climate, microhabitat conditions, and invertebrate behavior (Bryant 1979, Pienkowski 1981, Quammen 1982, Ferns 1983, Grant 1984, Hicklin and Smith 1984, Gerritsen and van Heezik 1985, Reise 1985, Esselink et al. 1989, Hockey et al. 1992, Beukema et al. 1993, Nehls and Tiedemann 1993, Wanink and Zwarts 1993, Zwarts and Wanink 1993).

Shorebirds use a variety of habitats for roosting. They often roost in salt marshes adjacent to intertidal feeding areas, even when these areas are extremely limited in size (Brennan et al. 1985, Buchanan 1988). Shorebirds at Grays Harbor and Willapa Bay often roost in large flocks on Pacific beaches, occasionally concentrating near the mouths of small creeks where they bathe and preen (Buchanan 1992). In some areas, shorebirds roost on natural and dredge spoil islands and on higher elevation sand beaches (Herman and Bulger 1981, Brennan et al. 1985). Some species also roost in fields or other grassy areas near intertidal foraging sites (Brennan et al. 1985, Butler 1994); shorebirds may forage at these or other roost sites if suitable prey are present. Shorebirds occasionally roost on pilings, log rafts, floating docks, and other floating structures when natural roost sites are limited (Buchanan 1988; Wahl 1995; J. Buchanan, unpublished data).

Shorebirds will fly considerable distances between foraging and roosting locations where roost sites are limited (Page et al. 1979). Distances >16 km (10 mi) have been documented (Symonds et al. 1984, Buchanan et al. 1986). On rare occasions, some species (i.e., dunlins) will engage in continuous flight during the high tide period, even though suitable roosting habitat is available (Prater 1981, Brennan et al. 1985). The reason for this behavior is not understood. In addition, shorebirds will also fly for extended periods when disturbed at a roost site. The energetic costs associated with extensive flights at or among roosting and foraging locations are not well understood.

Other habitats used by shorebirds in this region include pasture and agricultural land. Thousands of shorebirds roost (and occasionally forage) in pastures near Raymond and Bay Center on Willapa Bay during winter and spring migration (Buchanan and Evenson 1997). Large concentrations of roosting birds have been observed on fallow fields at Nisqually delta, Skagit Bay, Samish Bay, Lummi Bay, and adjacent to other large estuaries in northern Puget Sound and the Fraser River Valley (Brennan et al. 1985, Butler 1994, Wahl 1995, Evenson and Buchanan 1997). This type of habitat use has been documented in other areas (Townshend 1981; Colwell and Dodd 1995, 1997; Rottenborn 1996).

Use of artificial wetlands by shorebirds has not been documented in Washington. However, many species of shorebirds, including at least 12 species that occur in western Washington, used managed coastal wetlands in South Carolina (Weber and Haig 1996) indicating that such habitats, if suitable, would likely be used in this state. Salt marsh created at the Jay Dow Sr. wetlands in northeastern California provides important habitat for shorebirds migrating through and breeding in that region (Robinson and Warnock 1996). Similarly, salt evaporation ponds are an important habitat used by over-wintering and spring migrant western sandpipers in San Francisco Bay (Warnock and Takekawa 1995) and by shorebirds in other parts of the world (Davidson and Evans 1986, Martin and Randall

1987, Sampath and Krishnamurthy 1988, Velasquez and Hockey 1992). Shorebirds also forage, usually in comparatively small numbers, in sewage lagoons associated with waste treatment facilities.

Shorebirds are generally site-faithful to specific wintering areas (Townshend 1985, Myers et al. 1986) although some individuals may move considerable distances among sites (Warnock et al. 1995, Warnock 1996). This fidelity to particular sites has important ramifications for conservation management and mitigation. For example, because shorebirds do not settle in their winter quarters in a random manner, but rather return to areas used in previous years, mitigation efforts must recognize that habitat loss will most likely result in density dependent competition (e.g., greater competition for the same level of resources due to a greater density of birds at a given site) at other sites in the region (see the "Habitat Loss" section below).

Freshwater Environments

Most shorebirds that forage in freshwater areas require ponds and pools that have exposed shorelines or that are shallow enough to allow foraging by wading birds. As with estuarine sites, the availability of appropriate prey (e.g. various invertebrates) and roost sites are important habitat requirements.

Locally nesting species have specific nest site requirements. Killdeer and spotted sandpiper both nest on gravel/cobble substrates, however they often occupy vastly different environments (Paulson 1993). Killdeers nest in habitats including dry lake beds, short-grass fields, and unpaved margins of roadways. In contrast, spotted sandpipers typically nest where there is herbaceous cover in sandy or rocky substrates along creeks, rivers and lakes in both forested and arid environments (Oring et al. 1997). American avocets, black-necked stilts, common snipes, and Wilson's phalaropes also nest in Washington, primarily in the eastern part of the state. Avocets and stilts nest in rather open areas in or near marshes or other bodies of water, while phalaropes and snipes nest in wet meadows and marshes (Paulson 1993). Other habitats used by shorebirds include marshes, pastures, flooded fields, reservoirs, impoundment drawdowns, sewage treatment ponds, stormwater wetlands, and other artificial wetlands (Rundle and Fredrickson 1981, Perkins and Lawrence 1985, Duffield 1986, Paulson 1993). Habitat associations of interior species are summarized in Table 1.

LIMITING FACTORS

Habitat Loss

Effects of Habitat Loss or Degradation During the Nonbreeding Season - During the past century the amount of coastal estuarine wetlands in North America has been severely reduced (Dahl 1990). In Washington, approximately 66% of the coastal wetlands were destroyed over this period (Boule et al. 1983). Most of Washington's wintering and migrant shorebird species are dependent on these estuarine areas for essential foraging and roosting requirements. The most typical form of habitat loss occurs when wetlands or intertidal areas, including roost sites (Burton et al. 1996), are filled for development purposes (Page and Gill 1994).

Activities that degrade rather than destroy habitat also have the potential to impact shorebirds. Temporary or permanent reductions of habitat quality may reduce foraging efficiency and increase shorebird energetic requirements and/or mortality rates. Mineral extraction activities such as removal of sand from coastal beaches (Phipps 1990) or gravel from river beds, may degrade or destroy foraging, roosting and nesting habitat used by shorebirds.

For some shorebird populations, the loss of nonbreeding habitats, including roosting sites (Burton et al. 1996), results in increased density-dependent mortality (Sutherland and Goss-Custard 1991). This increased mortality occurs when shorebirds are forced to leave degraded or destroyed sites and settle elsewhere. Such movement to other sites increases the density of birds at remaining sites and results in greater competition for limited resources (Goss-Custard 1977, Evans et al. 1979, Goss-Custard 1979, Schneider and Harrington 1981, Goss- Custard 1985, Moser 1988, Lambeck et al. 1989) because of higher rates of prey depletion and increased rates of competitive interference (Goss-Custard and Durell 1990, Sutherland and Goss-Custard 1991, Evans 1991). It is likely that these movements force some birds to occupy lower-quality sites where competition for marginal resources is more intense

(Evans 1976, Sutherland and Goss-Custard 1991). These movements may have a greater impact on juvenile shorebirds (Goss-Custard and Durell 1987) and may therefore considerably influence population structure; this may have occurred in a wintering population of dunlins in Europe (Sutherland and Goss-Custard 1991).

For shorebird species that forage on invertebrates associated with kelp windthrow, the health of offshore kelp forests may be important for maintaining stable populations in this region. In coastal California, linear densities of spotted sandpiper, wandering tattler, whimbrel, black turnstone, and ruddy turnstone were higher on the Palos Verdes Peninsula in 1985-86, after offshore kelp forests had been restored, than in 1969-73 when kelp was absent (Bradley and Bradley 1993). Although these relationships were highly significant, the authors cautioned against generalizing their results to other regions because other factors may have partially contributed to the observed population changes.

Effects of Habitat Loss or Degradation on Reproductive Capability - The loss or degradation of habitat at migratory stop-over sites may influence survival rates and annual productivity of shorebirds on their Subarctic/Arctic breeding grounds. The timing of arrival at the breeding grounds sometimes occurs during periods of adverse weather or depleted prey availability. Survival at this time is more likely if the birds have accumulated sufficient fat and protein reserves at temperate staging sites (Morrison and Davidson 1989). Some shorebirds carry more fat than is needed to make flights between staging areas and the breeding range (Davidson and Evans 1989, Evans and Davidson 1990) and it is thought that these reserves provide insurance in the event of adverse conditions during migration or upon arrival at the breeding grounds. When shorebirds are delayed at staging areas or are otherwise unable to adequately accumulate these body reserves before or during migration, they are more likely to experience nest failure due to late arrival or poor physiological condition at the breeding grounds (Davidson and Evans 1989, Evans and Davidson 1990). Consequently, marginal environmental conditions at wintering or migratory staging areas in Washington may influence shorebird productivity at breeding areas thousands of miles away.

Bivalve Management - A number of economically important bivalve species are produced and harvested in Washington's sheltered marine waters, but there have been no studies on the relationship between their presence or harvest and shorebird behavior or abundance. The geoduck clam (*Panopea abrupta*) is generally harvested in waters ≥ 6 m deep at mean low low-water or ≥ 200 m from shore and its management therefore does not appear to have a direct bearing on shorebirds. Other bivalve species, however, are managed in intertidal areas that are also used by shorebirds. These areas are either privately owned or leased from the Washington Department of Natural Resources.

Bivalve management, when conducted on silt or silt-sand tide flats, clearly alters substrate conditions (Simenstad et al. 1991). These substrate alterations influence the quality of sites and in some cases may render a site less suitable or unsuitable for shorebird species associated with fine-silt substrates. The only study to address shorebird response to aquiculture activities, conducted in Tomales Bay, California, found far lower densities of dunlins and western sandpipers in aquiculture plots than in adjacent control plots (Kelly et al. 1996). The significance of substrate alteration and the resulting changes in suitability of foraging habitat to local shorebird populations is unknown. It should be noted that some shorebirds may benefit from bivalve management. The density of willets, an uncommon species in Washington, was greater in aquiculture plots than in control plots at Tomales Bay, California (Kelly et al. 1996). Shorebirds in Washington, particularly greater yellowlegs, occasionally forage in tidal pools associated with aquiculture operations (J. Buchanan, unpublished data). The significance of this potential association is also unknown.

Water Diversion - Habitat loss in interior regions of Washington occurs primarily when wetland areas are drained and used for agricultural or development purposes. It is possible that changes in the water table resulting from irrigation demands on local drainages has reduced or eliminated some areas of wetland or moist habitats (Hallock and Hallock 1993, Neel and Henry 1996). Such habitat losses may increase density-dependent effects on shorebirds in the manner described above.

Water Salinization - Changes in water chemistry, manifested through salinization, may adversely effect shorebirds or their habitats in the Columbia Basin. Although a natural phenomenon in the intermountain west (defined as the portion of western North America that lies between the Cascade and Rocky Mountain ranges), water salinization increases as greater demands are placed on limited water resources (American Society of Civil Engineers 1990). Water salinization occurs when water is diverted for other uses. Diversion of water typically results in less water delivered to wetlands and other water bodies. As a result, wetlands and ponds become shallower and more saline

through evaporative concentration (Rubega and Robinson 1996). The extent to which water salinization has occurred in interior Washington is unknown. In addition, it is not clear how to best manage saline wetlands for shorebirds or other wildlife (Rubega and Robinson 1996).

Salinization may directly effect shorebirds in a number of ways. First, salinization interferes with their ability to regulate water balance through excretion of excess salt (Rubega and Robinson 1996). Although some birds have well developed salt glands that enable them to excrete excess salt (Schmidt-Nielson 1960), it is not clear that all shorebirds have this capability (Rubega and Robinson 1996). An inability to maintain water balance results in dehydration and death (Rubega and Robinson 1996).

Second, water salinization may influence shorebird behavior. Shorebirds in highly saline areas often concentrate near freshwater sources such as springs (Rubega and Robinson 1996; J. Buchanan, personal observation). If these freshwater sources are scarce it is likely that energetic costs will be increased for birds that travel to these sites. Like all birds, shorebirds bathe regularly. It is thought that salinization may increase feather wetting, which in turn may increase thermoregulatory demands (Rubega and Robinson 1996). Water balance and thermoregulatory considerations may be particularly significant to fledglings (Rubega and Robinson 1996).
Water salinization may also result in changes in emergent vegetation as well as in the composition of the invertebrate community (Wolheim and Lovvorn 1995). These changes may influence the composition of shorebirds using particular sites by reducing the species richness of potential prey species (Rubega and Robinson 1996). Research is clearly needed to investigate the relationship between increasing water salinization and the health and behavior of shorebirds that migrate through or nest in the Columbia Basin.

Effects of Livestock Grazing - A number of research projects indicate that livestock grazing has a variety of positive and negative effects on shorebirds and their habitats in the interior portion of western North America (Powers and Glimp 1996). The direct effects, including trampling and disturbance, are negative, whereas the indirect effects are either positive or negative and include habitat changes and factors related to foraging and predation (Powers and Glimp 1996). The potential significance of these effects are thought to be related to the species of grazer and the timing and distribution of grazing (Powers and Glimp 1996).

The effects of trampling by livestock include destruction of eggs or nests (Rohwer et al. 1979, Guldemond et al. 1993), abandonment of disturbed nests (Delehanty and Oring 1993), and increased time adult birds spend away from their nests (Graul 1975), which likely results in increased exposure of eggs. Although each of these effects has been noted in shorebirds (Powers and Glimp 1996), research on these topics is lacking from the intermountain west.

Livestock may also impact shorebird habitats by altering attributes of the environment. For example, livestock grazing can alter vegetation composition, compact soil, and increase erosion (Kadlec and Smith 1989, Powers and Glimp 1996). These changes have been demonstrated to result in reduced populations of invertebrates (Mono Basin Ecosystem Study Committee 1987), reduced use of habitats by shorebirds (Bowen and Kruse 1993), and increased egg depredation and predation upon chicks and adults (Redmond and Jenni 1986, Bowen and Kruse 1993).

Conversely, livestock grazing has certain demonstrated or potential benefits to shorebird habitats, depending on the timing and intensity of grazing. Grazing was thought to control the growth of vegetation that would otherwise have been too tall or dense to allow use by shorebirds (Crouch 1982, Kohler and Rauer 1991, Nilsson 1997). In addition, several studies in non-arid regions indicate that grazed lands supported greater populations of invertebrate prey species and that shorebird foraging and body condition was enhanced at those sites (Galbraith 1987, Granval et al. 1993). It is unknown whether these potential benefits of livestock grazing would occur in the intermountain west.

Effects of Exotic Plants - Three exotic species of cordgrass (*Spartina* spp.) have invaded the intertidal areas of Washington (Frenkel and Kunze 1984). Although *Spartina alterniflora* was introduced to Willapa Bay in 1894, and was recognized as a potential problem in 1942, its spread has increased dramatically in the past decade (Mumford et al. 1991). Cordgrass grows in dense stands that effectively trap sediments; this process leads to changes in substrate elevation that may substantially degrade the original salt marsh environment (Sayce 1988, Landin 1991). Research in Europe indicates that tideflat areas with *Spartina* growth have lower densities of the invertebrate prey of shorebirds (Millard and Evans 1984, Atkinson 1992). Moreover, an association between the spread of *Spartina* and a decline in shorebird abundance was reported in Great Britain (Goss-Custard and Moser 1988). Observations near the mouth of the Willapa River in Willapa Bay in spring 1998 indicate that extensive areas used by red knots and

western sandpipers in the early 1980s are now covered by cordgrass and no longer appear to be used by these shore-birds (Chris Chappell, personal communication). Consequently, although the information for North America is rather limited, it appears that the colonization and alteration of tideflats by cordgrass has the potential to influence the availability of shorebird foraging and roosting habitats in Washington.

Another exotic species, purple loosestrife (*Lythrum salicaria*), has invaded the Columbia Basin (Engilis and Reid 1996). Loosestrife is a dense, woody plant that can grow to over two meters in height along the margins of ponds, lakes and wetlands. This fast-growing plant can render invaded shoreline areas unsuitable for shorebirds. Additional exotic species that may cause habitat degradation, although likely at a lesser scale, include *phragmites* which grows along salt marsh margins, and reed canarygrass (*Phalaris arundinacea*), which grows along margins of freshwater wetlands and flooded fields that might be used by shorebirds.

Effects of Exotic Vertebrates and Invertebrates - Numerous exotic vertebrate and invertebrate species have been introduced to coastal and interior wetlands (Carlton and Geller 1993). The common carp (*Cyprinus carpio*) was introduced to many wetland areas in the intermountain west and appears to be degrading wetland habitats (Engilis and Reid 1996). The foraging behavior of this exotic species disturbs aquatic plant beds which increases turbidity and reduces photosynthetic activity by submerged plants (Robel 1961). The likely consequence is a change in wetland vegetation composition and a reduction in invertebrate populations.

A number of exotic marine invertebrates, transported and introduced via ballast water introduction (Cordell 1998), have the potential to impact shorebird prey populations in Washington's estuaries. The Asian clam (*Potamocorbula amurensis*) has recently become established in San Francisco Bay, California (Carlton et al. 1990). The invasion of this clam was very rapid and in some areas of San Francisco Bay it now dominates the macrobenthic fauna (Nichols et al. 1990). We have no evidence to suggest that this species has colonized estuarine sites in Washington. The European green crab (*Carcinus maenas*) was documented in coastal estuaries of Washington in 1998. It too has the capability to dramatically alter the macrofaunal community of marine estuaries. Such changes would be potentially deleterious to shorebird and other wildlife populations associated with marine estuaries.

Similarly, various Asian copepods have recently been introduced via ballast waters to coastal estuaries in the Pacific Northwest (Cordell 1998, Cordell and Morrison 1996). Although the outcome of these invasions is not clear, potentially significant deleterious effects similar to those associated with other invasions of this type are likely to occur (Carlton et al. 1990, Nichols et al. 1990, Cordell 1998).

Utility Lines - Collisions with utility lines have been documented for a wide variety of bird species including shorebirds (Kitchin 1949, Bevanger 1994, Brown and Drewien 1995, Janss and Ferrer 1998). Placement of utility lines adjacent to intertidal areas may degrade habitat quality by increasing the likelihood of in-flight collisions (Scott et al. 1972, Lee 1978). Fatal injuries to shorebirds following collisions with utility lines have occurred where utility lines were situated adjacent to intertidal foraging areas in western Washington and at the Fraser River estuary in British Columbia (Kitchin 1949; J. Buchanan, unpublished data; R. Butler, personal communication; S. Richardson, personal communication).

Wind Turbines - Mortality of shorebirds has been documented at wind turbine sites in the Netherlands (Musters et al. 1995, 1996) and in the United States (Erickson et al. 2001), although the rate of documented mortality was generally low. It is likely, however, that mortality would be greater at complexes of turbines situated along flight corridors used by large concentrations of shorebirds. Wind turbine sites in southeastern Washington occur near areas used by a relatively small flyway of migrating shorebirds, but the potential impact of the turbines on those shorebirds is currently unknown. There are relatively few wind turbine sites in Washington at present, but it is expected that many such sites will be established in the near future as the technology for managing this efficient source of energy is refined. The significance of wind turbines as a source of mortality will likely depend on the number and location of these complexes built in the coming years.

Other Potentially Hazardous Structures - One million or more birds are killed annually across North America in collisions with structures such as skyscrapers and communication towers (see www.towerkill.com [1998]). Because of their great height, these structures are a hazard to low-flying migrant birds. Even the illumination from safety lights is thought to confuse birds, causing circling behavior around the structure that increases the likelihood of collisions with support cables or the structure itself (Avery et al. 1976). As of November 1998, there were 241

towers exceeding 61 m (200 ft) in Washington, including 19 towers of at least 152 m (500 ft). Many of these towers are located in the Puget Trough; the presence of these towers may be a mortality factor for shorebirds that overwinter and/or migrate through this region. The potential magnitude of this factor has not been addressed (see www.towerkill.com [1998]). Shorebirds have also been documented colliding with coastal lighthouses; multiple incidents involving red-necked phalaropes occurred at the Destruction Island lighthouse in 1916 (Bowles 1918). Such occurrences are poorly documented, but this is likely related to limited access and search efforts at such sites.

Pollution

Chemicals and Heavy Metals - Research from other temperate coastal regions indicates that rather high levels of organochlorine contaminants (White et al. 1980, White et al. 1983) and heavy metals (Goede 1985, Goede and de Voogt 1985, Blomqvist et al. 1987, Ferns and Anderson 1994) occur in shorebird tissues. Although the effects of these contaminants on shorebirds are not known, physiological and behavioral abnormalities associated with high contaminant levels have been reported for other temperate marine bird species (Gilbertson et al. 1976, Gilbertson and Fox 1977, Sileo et al. 1977, Fox et al. 1978).

Contaminant levels have been reported in black-bellied plovers, dunlins, and western sandpipers wintering in western Washington (Schick et al. 1987, Custer and Myers 1990). Both studies found levels of organochlorine contaminants below those known to affect the survival or reproduction of shorebirds. However, some spring migrants from Grays Harbor carried very high DDE residues (Schick et al. 1987). Black-bellied plovers from two Puget Sound sites carried low levels of mercury and elevated levels of selenium (Custer and Myers 1990). In addition, dunlins occasionally ingest lead shot (Kaiser et al. 1980, J. Buchanan, unpublished data), but residue levels of lead in shorebirds are unreported for this area. Given the lack of current data on concentrations of organochlorine and heavy metal contaminants in shorebirds in this area (Schick et al. 1987, Custer and Myers 1990), it is difficult to assess the potential current effects related to these contaminants. Other contaminants, such as organophosphorus insecticides, also occur in the environment; there is no information on the presence or effects of these contaminants on shorebirds in this region (Morrison 1991).

Contaminants known or suspected to have originated from upland agricultural areas have been documented in shorebirds (White et al. 1980, Zinkl et al. 1981, DeWeese et al. 1983, White et al. 1983, Schick et al. 1987, Custer and Mitchell 1991). The discovery of contaminants (i.e., selenium) in waterfowl and wading birds that use freshwater marshes (Ohlendorf et al. 1986, Saiki and Lowe 1987, DuBowy 1989, Williams et al. 1989) suggests that common snipe, American avocet, black-necked stilt, and Wilson's phalarope may be vulnerable to exposure to a similar variety of contaminants. Two incidents of dunlins killed after exposure to agricultural chemicals have been reported from northern Puget Sound (Lora Leshner, personal communication). In California, killdeers and dunlins died after ingesting grain poisoned by strychnine (Warnock and Schwarzbach 1995); the likelihood of such an event occurring in Washington is unknown.

Heavy metals and other contaminants are present in naturally-occurring and dredged sediments in estuaries, and accumulate in fish, birds, mammals, and invertebrates (Goerke et al. 1979, Seelye et al. 1982, Duinker et al. 1984). Contaminants can also be released from sediments by bait digging in the intertidal zone (Howell 1985). Intake of these contaminants occurs when shorebirds forage in intertidal areas. Other sources of pollutants include waste discharge, which has been associated with the disappearance of invertebrate prey species of shorebirds in the Netherlands (Esselink et al. 1989, van Impe 1985). The significance of waste discharge on shorebird abundance or physical condition in this region is unknown.

Oil Pollution - In a summary report on the potential effects of oil spill contamination in northern Puget Sound and the Strait of Juan de Fuca, 10 shoreline habitat types were identified in the order of their sensitivity to oil contamination (Kopenski and Long 1981). Three of the four most sensitive habitat types - sheltered marshes, sheltered tidal shores, and exposed tidal flats - are primary foraging and roosting habitats for numerous shorebird species. The most abundant wintering shorebird species to use these habitats, the dunlin, is considered highly sensitive to oil spill pollution (Vermeer and Vermeer 1975). Other species, such as the sanderling, are likely sensitive as well (Chapman 1984). Certain species that use rocky shoreline habitats may be less vulnerable to some impacts from oil spills (Smith and Bleakney 1969), since oil would have a shorter "residence time" on rocky shorelines exposed to high wind and wave energy. This reduces the time period during which birds would be exposed to oil, although short-term impacts to these species can still be substantial (Andres 1997).

Spill-related avian impacts can be manifested in at least 5 ways. First, direct mortality occurs due to a number of factors related to plumage fouling or toxicity (Leighton 1990). Second, reduced invertebrate food supplies caused by oil pollution (Bellamy et al. 1967, Grassle et al. 1980, Maccarone and Brzorad 1995) may result in reduced survival rates if birds are forced to relocate to densely-occupied or less productive areas (Sutherland and Goss-Custard 1991). This is especially true during winter, when foraging efficiency may be constrained by adverse weather, particularly if body-fat reserves are too low to fuel significant emigrations. Third, the activity associated with the actual cleanup of the spill may disturb shorebirds to such an extent that foraging and roosting patterns are disrupted (Burger 1997). Fourth, research indicates that oiled shorebirds spend more time preening and less time foraging after a spill (Burger 1997). Burger (1997) concluded that this was a potentially negative influence on the condition of the birds upon their departure for migration (and also on their arrival at the breeding grounds; see above), and added that the detrimental effects were magnified by the presence of people (see section on human disturbance). Finally, oiled birds may be more vulnerable to predation, particularly if 1) plumage fouling or thermal stress make them less efficient at avoiding predators, or 2) their marked plumage or altered behavior make them more conspicuous to predators (Curio 1976).
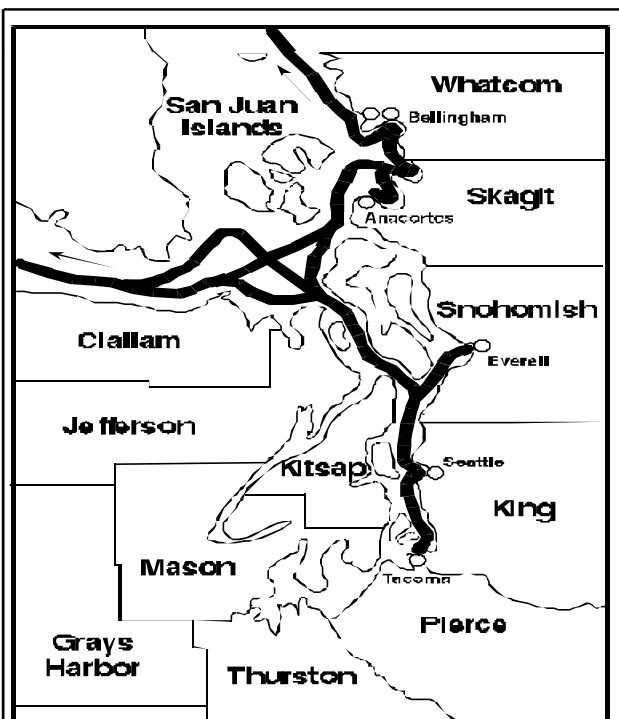

Figure 2: Major shipping lanes in the Puget Sound and the Strait of Juan De Fuca. These lanes extend northwards through the Strait of Georgia, and along Washington's outer coast into the Columbia River.

Recent experience indicates that oil pollution is a significant potential threat to shorebirds in this region. Larsen and Richardson (1990) found that 3,574 of 11,708 shorebirds (mostly dunlins) were still oiled 5 days following the *Nestucca* oil spill off Grays Harbor in December, 1988. This proportion of oiled birds declined over the next 3 weeks, and it was unclear whether the decline was related to self-cleaning, emigration, or mortality. The beaches fouled by this spill support very high overwintering concentrations of sanderlings and roosting dunlins (Buchanan 1992). It is noteworthy that the largest Puget Sound populations of shorebirds in winter, spring, and fall occur at estuaries in close proximity to major shipping lanes and/or oil refineries (Evenson and Buchanan 1995, 1997; Figure 2).

Other Sources of Pollution - Plastic-particle pollution has been documented in most marine waters (Coe and Rogers 1997) and occurs when plastic debris (e.g., packaging material) enters the marine environment from land (Liffmann and Boogaerts 1997, Redford et al. 1997) or at-sea sources (Coe and Rogers 1997). The variety of plastic waste present in the marine environment is quite high and differs from one site to the next (Ribic et al. 1997). Debris surveys conducted at the ports of Seattle and Tacoma and on the beach at Olympic National Park reported high amounts of plastic debris; the park survey in 1992 found an average quarterly accumulation of 1729 pieces of plastic debris/km (Ribic et al. 1997). Plastics digestible by wildlife comprised between 44-74% of the debris found in surveys along the west coast of North America (Ribic et al. 1997).

Plastic pollution in marine environments is potentially detrimental to shorebirds and other wildlife after it is intentionally or accidentally ingested. Small particles are ingested by surface feeding marine birds (Baltz and Morejohn 1976, Day et al. 1985) and have been associated with reduced fat deposits (Connors and Smith 1982, Ryan 1988) and perhaps intestinal blockage and ulcerations in other species (Day et al. 1985). Among shorebirds, the red phalarope appears most vulnerable to this type of contamination in Washington (Bond 1971, Connors and Smith 1982, Day et al. 1985), although other shorebird species have been known to ingest plastic particles (i.e., bar-tailed godwit [*Limosa lapponica*] and red-necked phalarope; Robards et al. 1997).

Human Disturbance

Human disturbance has the potential to influence shorebirds in at least 3 ways (Fox and Madsen 1997). First, substantial disturbances force birds to alter their normal activity patterns resulting in an increase in energetic costs. Second, shorebirds forced to leave an area due to human disturbance may settle in lower-quality alternate habitats. Third, increased energetic costs and use of lower-quality habitats may expose shorebirds to greater risks of predation. The occurrence and potential significance of these patterns is only now beginning to be investigated and understood in North America.

Many human disturbances are related to recreation. Sources of disturbances include beachwalkers, wandering dogs, birdwatchers, hunters, windsurfers, horseback riders, cyclists, vehicles, boats, kayaks, personal water craft (e.g., jet skis), helicopters, and airplanes (Kirby et al. 1993, Goss-Custard and Verboven 1993, Koolhaas et al. 1993, Smit and Visser 1993). In Washington, these types of activities are responsible for both inadvertent and intentional disruption of foraging and roosting behavior (J. Buchanan, unpublished data). Most disturbances from recreational sources are temporary (e.g., birds relocate to a new site following a disturbance). However, cumulative effects of repeated disturbances, particularly during periods of peak human activity (Kirby et al. 1993), or during periods of peak shorebird abundance (e.g., migration; Burger 1986) may be significant (Klein et al. 1995), although this has not been well assessed (Goss-Custard and Verboven 1993). Human disturbance may be most significant in areas where roost sites are limited (Warnock et al. 1995) because the birds do not have alternate sites they can use when disturbed.

Pedestrian and Vehicular Recreational Activities - Perhaps the most common type of human disturbance is recreational walking or other travel on beaches. Pedestrian or vehicle traffic on beaches or other areas used by shorebirds negatively affects shorebird distribution, abundance, foraging efficiency, and behavior (Burger and Gochfeld 1991, Pfister et al. 1992, Goss-Custard and Verboven 1993, Kirby et al. 1993). In fact, local population declines of sanderling, semipalmated sandpiper, short-billed dowitcher, and red knot along the Atlantic coast of North America may be related to site disturbance from moderate levels of vehicle traffic (Pfister et al. 1992). Klein et al. (1995) found that several shorebird species were more common in areas further from roads and trails (or dikes) on a wildlife refuge than in similar habitats near roads and trails. Some species (i.e., black-bellied plover, willet) were particularly sensitive to higher levels of vehicle traffic and responded by moving further from roads (Klein et al. 1995). Limited information suggests that black oystercatchers will abandon areas with regular human activity (Ainley and Lewis 1974, Nysewander 1977, Andres 1998); this may be particularly critical in nesting areas.

Human disturbance occasionally escalates to a point where shorebirds are killed. At North Beach, Washington, a beach open to vehicle traffic, roosting flocks of western sandpipers, dunlins, sanderlings, and dowitchers have been intentionally targeted by speeding motorists; at least 480 birds were killed in 2 separate incidents on this beach (R. Schuver, personal communication; M. Cenci, personal communication). Harassment by motorists of roosting shorebirds is not uncommon on Washington beaches (J. Buchanan, personal observation).

Water-related Recreational Activities - Shorebirds are also disturbed by recreational activities on water (Weston 1997). Smit and Visser (1993) reported that kayakers represent a potentially important source of disturbance to roosting birds because the small daft of a kayak allows close approach to roost sites in intertidal areas. Disturbance by personal motorized water craft (e.g., jet skis) has been documented at a large roost site in Grays Harbor (L. Vicencio, personal communication). These types of disturbances may occur throughout marine areas of Washington.

Waterfowl Hunting - A common human disturbance activity is waterfowl hunting. The noise associated with shotgun blasts disturbs foraging and roosting black-bellied plovers, greater yellowlegs, dunlins, and western sandpipers in Washington and can cause birds to temporarily leave an area (J. Buchanan, unpublished data). In a review of the effects of hunting disturbance on waterbirds (including shorebirds), Madsen and Fox (1995) reported that hunting disturbances can result in temporary disruption of daily activities (foraging, roosting, preening) and displace birds from preferred foraging areas. These responses to hunting disturbance result in greater energetic costs due to under-exploitation of preferred foraging areas. Given that populations of many species may be limited during the winter period the potential significance of the disturbance is clear, though it is unknown whether the level of disturbance from hunting reduces the physical condition or survival of shorebirds in Washington.

Although many shorebird species were hunted formerly (Bent 1927, Page and Gill 1994), the common snipe is the only shorebird game species in Washington. Other species, including dunlin, long-billed dowitcher, and greater yellowlegs, are occasionally shot by hunters who mistake them for snipes (Hainline 1974, J. Buchanan, unpublished data; R. Butler, personal communication; J. Hidy, personal communication). In a small sample of snipe wings submitted anonymously by hunters, 18% of the wings were actually from long-billed dowitchers (Buchanan and Kraege 1998). It is currently unclear whether this source of mortality is as substantive as these preliminary data suggest.

Intentional killing of non-game shorebirds by waterfowl hunters has also been documented at several sites in western Washington, including Samish Bay, Totten Inlet, and Willapa Bay (J. Hidy, personal communication; R. Woods, personal communication, J. Buchanan, unpublished data). The Willapa National Wildlife Refuge is closed to snipe hunting to reduce the likelihood that nontarget species will be shot (J. Hidy, personal communication).

Aircraft - Aircraft traffic and military activities can also disturb shorebirds (Smit et al. 1987, Koolhaas et al. 1993, Smit and Visser 1993). In a review of shorebird disturbance factors in Europe, Smit and Visser (1993) found that the distance at which shorebirds flushed varied among sites, suggesting that shorebirds were less habituated to aircraft disturbances at certain sites. Nonetheless, they reported that shorebirds were usually disturbed (e.g., they flushed from foraging or roosting sites) by aircraft flying at <300 m (990 ft). Similarly, shorebirds were more restless on days with jet activity than on days without (Koolhaas et al. 1993). Helicopters disturbed shorebirds at greater distances than other aircraft, although one study showed no disturbance from helicopters flying at 100-300 m (330-990 ft) 2-3 times per hour, suggesting, perhaps, that habituation had occurred to the regular flights (Smit and Visser 1993). Small and slow flying aircraft were one of the most disturbing phenomena in the Wadden Sea area (Smit and Visser 1993). Additionally, ultralight aircraft may cause impacts because of low flights and associated noise, although there are no data on shorebird responses to this potential source of disturbance (Smit and Visser 1993).

Environmental Conditions, Predation, and Disease

The effects of adverse weather, predation, and disease on the physical condition of shorebirds is important from a management perspective. Although these factors (i.e., general storm patterns, predation) typically operate at a level beyond human influence, their significance may be far greater if coupled with the effects of subsequent human activities (e.g. habitat loss, pollution, disturbance). Consequently, a general understanding of these factors is necessary for effective management.

Adverse Weather Conditions - Reduced body mass, emigration, depleted invertebrate food sources, reduced availability of adequate nesting and foraging areas, and outright mortality are known to occur during winter storms or prolonged periods of flooding or drought. The impact of winter storms may be more severe in regions with normally mild weather conditions because shorebirds maintain fat levels and muscle mass (i.e., protein reserves) adequate for survival under the prevailing environmental regime (Davidson 1981, Davidson and Evans 1982, Davidson et al. 1986a, b; Dugan et al. 1981). Unusual storm events therefore have the potential to catch the birds "off guard".

Flood and drought conditions are known to influence habitat use by shorebirds. Drought in interior areas may result in reduced availability of foraging or nesting habitats, particularly for species that use wetlands (Alberico 1993). Significant flooding in estuarine or interior habitats may inundate foraging, roosting or nesting locations for extended periods, and in estuarine areas may deplete invertebrate populations through erosion or scouring of fine intertidal sediments (Ferns 1983). These conditions are unsuitable for certain species and can result in reduced body condition or site abandonment (Strauch 1966, Rundle and Fredrickson 1981, Hands et al. 1991, Warnock et al. 1995). Extensive winter movements (up to 160 km [100 mi]) in response to adverse weather have been documented in California (Warnock et al. 1995) and appear to occur in Washington (Evenson and Buchanan 1995, 1997).

On the other hand, changes in water levels, particularly at interior sites, may create more suitable conditions for certain shorebird species (Rundle and Fredrickson 1981, Hands et al. 1991, Smith et al. 1991, Taylor et al. 1993). Sites that generally lack adequate foraging areas due to extremely high or low water levels will be used by shorebirds when foraging opportunities are created by changing water levels.

Global Warming - There is currently considerable debate regarding the ecological significance of global warming. A change in global temperature would likely have both predictable and unforeseen impacts on shorebirds. Changes in sea level will likely alter the distribution and extent of estuarine areas, and may reduce the area of intertidal and saltmarsh habitats available to shorebirds (Lester and Myers 1989-90). Other potential responses to global warming include changes in migration timing, migration routes, extent and quality of breeding habitats, and the availability of prey.

Other changes related to climatic conditions are occurring along the Pacific coast of North America. Recent research indicates that significant warming has occurred in waters of the California Current. This warming has been linked to declines in zooplankton and seabird populations (Roemmich and McGowan 1995, Veit et al. 1996). Changing conditions in offshore waters may influence the distribution and abundance of phalaropes migrating through the region. In addition, rock sandpiper numbers have declined substantially in the southern portion of their wintering range during this period of oceanic warming (Buchanan 1999).

Predation - Predation is a potentially significant limiting factor because it is a substantial source of mortality among shorebirds. The overall mortality rate of most shorebird species is very high (Martin-Löf 1961, Boyd 1962, Soikkeli 1967, Gromadzka 1983; see Warnock et al. 1997). The presence of predators in an area typically results in heightened levels of vigilance by shorebirds (Metcalfe 1984). This enhanced vigilance, in combination with other sources of disturbance, can have a potentially significant effect on shorebird activity schedules and physical condition (Burger 1997). Perhaps the most significant predators of shorebirds in Washington are the peregrine falcon (*Falco peregrinus*) and merlin (*F. columbarius*), both recognized as priority species in Washington. An estimated 21% of a wintering population of dunlins in California were taken by falcons (Page and Whitacre 1975). In some situations predation by raptors may influence the latitudinal distribution of wintering shorebirds (Whitfield et al. 1988) as well as population structure (Townshend 1984). Some studies show that juvenile shorebirds are preferentially selected by raptors, or that they are more vulnerable to predation because they roost in atypical habitats (Kus et al. 1984, Townshend 1984). Shorebirds also respond to the presence of mammalian predators such as rats; this may be most significant at nocturnal roosts (Burton et al. 1996).

Disease - The significance of disease for most shorebird species is unknown. However, outbreaks of avian cholera and botulism Type C are capable of killing thousands of birds, including shorebirds (Kadlec and Smith 1989).

Political and Management Constraints

Shorebirds as a group are characterized by annual, round-trip flights of enormous distances between wintering and breeding areas. This life history attribute alone makes it difficult for management agencies to identify species of concern and facilitate meaningful protection strategies. Factors that influence the health of shorebird populations may operate on the breeding grounds, the wintering grounds and/or along flyways. Consequently, managing shorebirds, particularly the highly migratory species, requires that these factors be addressed wherever they occur.

Current methods of identifying and protecting species of concern across broad geographical areas are somewhat limited in their utility (unless the species is listed by federal governments). For example, a species listed as threatened or endangered at the state or province level generally has no special standing elsewhere (except for basic protections under the Migratory Bird Treaty Act). This creates potential difficulties for management of a state-listed species if a limiting factor exerts significant influence during migration through a state or province where the species (does not breed and) is not listed. States tend to list only those species that have breeding populations within state boundaries and generally focus on determining a species' status within the state. In short, it is currently difficult, if not impossible, for states (and likely provinces) to effectively enact legal protection for species for which there is local or regional, but not federal, concern.

MANAGEMENT RECOMMENDATIONS

These management recommendations are based on a combination of locally and regionally important conservation issues. The following sections contain a spectrum of management recommendations that land owners, resource managers, and others can use to reduce impacts to shorebirds or to improve shorebird habitats. These recommendations address regional or large scale conservation issues, as well as site-specific actions that may be

meaningful to local sub-populations. Some of these recommendations can be implemented by landowners and local governments, while others are more policy oriented, and need to be addressed by state and federal agencies, and conservation organizations. Because of the broad range of shorebird distributions and their dynamic life history characteristics, it is important to understand these management issues at various spatial and temporal scales.

Habitat Identification and Preservation

Identify important local and regional sites - One of the first tasks required to protect shorebird habitat is to identify important local and regional sites. British workers have developed a system to evaluate site populations by comparing them to national, international and flyway populations (Prater 1981). Field work to identify locally and regionally important sites is ongoing in much of western North America (Page and Gill 1994; G. Page, personal communication), and many important sites in western Washington have been identified (Buchanan and Evenson 1997, Evenson and Buchanan 1997). Additional work is needed for the migration periods in eastern Washington, the fall migration period in western Washington, and for the group of rocky shoreline species along the Washington coast.

Wetland habitats of all sizes support shorebird populations in Washington. In North America, standards set forth by the Western Hemisphere Shorebird Reserve Network specify that sites which support at least 20,000 shorebirds or at least 5% of the flyway population are of regional importance (Myers et al. 1987a; Harrington and Perry 1995; I. Davidson, personal communication). This strategy appears to effectively identify several of the major estuarine sites in Washington. However, recent research in Puget Sound indicates that numerous sites support populations of <5,000 shorebirds, and that cumulatively these sites may account for as much as 20-50% of the Puget Sound shorebird population (Evenson and Buchanan 1995, 1997), indicating a need to recognize the importance of assemblages of smaller sites. This may also be particularly important for some shorebirds that migrate through the Columbia Basin (Robinson and Warnock 1996, Skagen 1997).

Preserve remaining wetland habitat - Preservation of remaining wetland habitat should be a priority for shorebird conservation programs. Locally and regionally important sites should be purchased to reduce the loss or degradation of habitat important for shorebirds and other wildlife. Following an assessment of water needs and a determination of salinization significance, efforts should be made to insure the availability of high-quality water for important wetlands and wetland complexes in the Columbia Basin. In a review of coastal wetland conservation strategies, Bildstein et al. (1991) recommended the development of new protective and regulatory legislation, and more effective enforcement of existing laws concerning wetland use.

Land Use Assessment

Assess livestock grazing in habitats used by shorebirds for potential impacts - Research indicates a number of direct and indirect impacts on shorebirds or their habitats due to grazing livestock (Powers and Glimp 1996). Negative impacts described elsewhere include the destruction of eggs or nests (Rohwer et al. 1979, Guldemond et al. 1993), abandonment of disturbed nests (Delehanty and Oring 1993), and adult birds spending an increased time away from their nests (Graul 1975), which likely results in increased exposure of eggs.

Assess commercial sand and gravel extraction from beach and riverine areas for potential impacts to shorebirds - Certain beach and riverine areas are important foraging, roosting, or nesting areas for shorebirds (Buchanan 1992, Paulson 1993). The development of a review process for these activities would help ensure that shorebirds are considered as part of the permitting process.

Utility Lines and Wind Turbines

Assess impacts associated with placement of new utility towers and lines - New towers and utility lines should not be placed in known or suspected flight corridors or near wetland areas used by shorebirds. New lines should be placed below ground if possible. In areas where placement of towers and lines have been proposed, an effort should be made to determine whether flight corridors or wetlands occur nearby so that more appropriate alternate strategies may be developed and implemented.

Mark existing utility lines to make them more visible - Where possible, existing utility lines should be marked or treated to make them more detectable by birds in areas where collisions involving shorebirds have occurred or are likely to occur. Techniques include: coating or painting wires, marking wires with mobile (i.e., non-stationary) spirals or strips of fiberglass or plastic, warning lights, and placement of predator silhouettes or acoustical devices to scare birds (Bevanger 1994). Recent research indicates that static wire-marking may effectively reduce the number of collisions birds have with power lines (Janss and Ferrer 1998); the wire markings used in that study included white spirals (30 cm diameter x 100 cm length) looped around the static wire and black crossed bands (two 35 cm bands attached side-by-side at their mid point) on conductors. Similarly, collision mortality (of cranes and waterfowl) was reduced in sections of transmission and distribution lines marked with dampers (112-125 cm [1.27 cm diameter] polyvinyl chloride plastic lengths twisted around the transmission lines and placed at 3.3 m intervals on the uppermost static wire) or plates (30.5 x 30.5 cm yellow fibreglass squares with a contrasting black diagonal stripe 5 cm in width and placed at 23-32 m intervals on static wires or center conductors) (Brown and Drewien 1995). Also, yellow marking devices may be more visible to birds and should be used in areas characterized by dark or cloudy conditions, whereas a combination of colors (red markers may be best in bright sunlight) would suffice for variable conditions (Raevel and Tombal 1991, Brown and Drewien 1995).

Some strategies may be more effective for certain species groups than others due to species differences in sound or color perception. Research should be conducted to evaluate the effectiveness of these and other techniques designed to reduce collisions (Bevanger 1994, English 1996). Evaluations of potential techniques should consider the type of behavior that places birds at risk. For example, the first 3 approaches listed above may be less effective in areas where shorebirds make significant nocturnal flights between foraging and roosting locations.

Other strategies to reduce the incidence of bird collisions with utility lines involve line configuration. Grouping multiple lines might make them more visible to birds, and the lines will occupy a smaller area of flight space, thus reducing the likelihood of collisions Bevanger (1994). In addition, the lines should be arranged side by side rather than in a vertical stacked formation (Bevanger 1994).

Assess impacts associated with placement of wind turbines - Wind turbines should not be placed in known or suspected flight corridors, near known concentrations of birds, or near wetland areas used by shorebirds. In areas where wind turbine placement has been proposed, an effort should be made to determine whether flight corridors, important wetlands, or other habitats occur nearby so that alternate strategies may be used.

Oil Spills

In the event of an oil spill, limit public access to beach or estuarine spill sites - Oiled birds typically spend a considerable amount of time attempting to clean their plumage and spend less time foraging (Burger 1997). This results in an increase in energetic costs. Consequently, the impacts of an oil spill can be exacerbated by disturbances caused by human recreation (e.g., beach walking), except in some circumstances where intentional disturbance is used to exclude shorebirds and other wildlife from oiled beaches. For this reason, public access to the vicinity of spill sites or areas where oiled birds occur should be limited as much as necessary or possible until shorebird roosting, foraging, and preening behavior returns to a baseline level.

Assess and enhance navigational assistance procedures for commercial marine vessels - An assessment of the causes of oil spills should be conducted to determine how navigational aids might reduce the incidence of these events. Although determining the specific enhancements is beyond the scope of this document, they might include better navigational charts or training, and increased tug boat availability to assist larger vessels that enter Strait of Juan de Fuca and Puget Sound waters.

Continue the development and refinement of oil trajectory models - A number of oil trajectory models have been developed for spill response management. These models typically incorporate factors such as characteristics of the oil; wave action and other physical processes; and oceanographic and meteorological factors such as tidal cycle, currents and weather (ASCE Task Committee 1996, Galt 1994, Galt et al. 1996). These models are used to respond to actual spills and to identify high risk sites (Begg et al. 1997). Because of the complex functioning of currents and tides within the Puget Sound region, however, researchers are attempting to develop new models to improve site protection and spill response. These important efforts should be continued and supported (Begg et al. 1997).

Develop baseline information needed to assess impacts of oil spills - Baseline information on shorebird abundance and habitat use is lacking for a number of species and should be updated periodically for all potentially vulnerable species. This information will be important for efforts to: 1) assess impacts of oil spills (Parsons 1996), 2) develop appropriate remediation for spill damages (Parsons 1996), and 3) improve protection and response strategies (Begg et al. 1997).

Plastics in the Marine Environment

Develop procedures for controlling spills of plastics into the marine environment - Small plastic particles injure surface feeding marine birds that intentionally or inadvertently ingest them. A strategy to control the amount of plastic that enters the marine environment will be complex because plastic waste originates from land and at-sea sources, it is virtually impossible to identify the origin of most debris (Ribic et al. 1997), and compliance is difficult to enforce (offenders are rarely caught; Laska 1997, Sutinen 1997). Local waste management programs are generally ineffective because the mobility of plastic makes this form of pollution a global management issue (Ninaber 1997).

Much of the land-based plastic pollution appears to enter the marine environment from storm water runoff. Moreover, plastic pellets are transported to marine waters from locations at any sector of the plastics industry (Redford et al. 1997), indicating that better containment is needed in all phases of pellet manufacture, packaging, transport, and use. Strategies to limit land-based sources of marine debris should involve development and implementation of regulatory and administrative measures, use of education to identify problems and solutions, creation of solid waste management infrastructure, use of new technologies, political commitment, and assessment and monitoring programs (Redford et al. 1997).

Support changes to marine pollution regulations that result in global control of marine plastic pollution. Annex V of the International Convention for the Protection of Pollution from Ships, known as MARPOL (73/78), was enacted in 1988 to reduce at-sea marine pollution. MARPOL is a product of the International Maritime Organization. Some authorities believe the provisions of MARPOL must be enhanced to be truly effective (Ninaber 1997). Improvements to MARPOL and other marine pollution regulations are needed and should consist of the following elements at the very least: 1) technological innovations that reduce the amount of plastic materials used on ships or that allow for at-sea processing, 2) organizational and operational changes within the shipping and marine recreation industries to facilitate policy development that addresses waste management, 3) educational communication that is designed to promote an environmental ethic and which targets specific marine 'user' groups, 4) government and private regulation and enforcement efforts that require development of waste management plans for ocean-going vessels and that extend authority to state or municipal authorities to levy fines for illegal dumping, and 5) creation of economic incentives by promoting development and use of recyclable products and development of on-board waste-processing equipment (Laska 1997). Finally, because waste management in the marine environment is a global issue, a standardized approach that facilitates participation by vessels and ports world-wide is needed. Incompatible vessel and port waste management programs (e.g. removal and handling of recyclable waste) will result in failure to control marine plastic pollution. For additional recommendations regarding plastic particle pollution, see Koss (1997), Laska (1997), Liffmann et al. (1997), Ninaber (1997), Sutinen (1997), and Wallace (1997).

Pesticides and Other Chemicals

Use extreme caution when applying chemicals near habitats used by shorebirds - Some pesticides (including insecticides, fungicides, rodenticides, herbicides) and fertilizers (including animal waste) can directly kill fish and wildlife and indirectly affect habitat quality when used inappropriately. Because information on the toxicity and effects of specific chemical treatments to fish and wildlife is scarce or lacking for many chemical compounds, a conservative approach to chemical treatments is recommended and alternatives to chemical use are encouraged (Odum 1987). Appendix A (of this volume) lists contacts useful in assessing pesticides, herbicides, and their alternatives.

Use current information to establish buffer zones when applying chemicals - Buffer zones should be implemented around shorebird and waterfowl nesting habitat in agricultural landscapes to minimize the impacts of spray drift (e.g., Payne et al. 1988), particularly when the effects of drift are negative or unknown. These buffer zones should be specific to the types of chemicals used and their methods of application. Creation of adequate buffer zones

requires up-to-date information about the potentially adverse effects of various compounds on estuarine and wetland ecosystems and the wildlife that use these habitats.

Promote public education about chemical use and wetland functions through natural-resource agencies, local governments, conservation groups, and others - There is a need for a general understanding by the public that actions near or within wetlands affect the proper functioning of the ecosystem (Grue et al. 1986). Efforts to provide important information to the public will likely require elements of research, monitoring, and education. Implementation of an integrated training and certification program for landowners and commercial pesticide applicators has been recommended as a means to provide pesticide users with important biological information and training (Grue et al. 1989).

Human Disturbance

Control public access and human activities in areas important to shorebirds - This may consist of directing foot traffic away from roosting or foraging sites that should not be disturbed by human visitors. Similar efforts to control areas open to the public at Grays Harbor during spring migration appear to have been successful although an ecological assessment of human disturbance on shorebirds there has not been done. Similarly, Pfister et al. (1992) recommended identifying important beach areas and establishing vehicle restriction zones during critical roosting periods to reduce disturbance to shorebirds.

Develop site-specific strategies to manage human disturbance - Important wintering and migratory staging sites should be identified so that site-specific strategies can be developed, as necessary, to manage human disturbance. Potential strategies include developing informational signs that identify or describe important foraging or roosting areas. Groups of volunteers ("beach patrols") at the Dee estuary in Europe have successfully educated the public about shorebird ecology by distributing leaflets and leading organized birdwatching trips to roost sites (Kirby et al. 1993). It may be possible to coordinate similar groups of volunteers in Washington if future site disturbance warrants such action.

Post informational signs to reduce human disturbance - Informing the public about the sensitivity of large concentrations of roosting or foraging birds may reduce disturbance at such sites. One means to accomplish this would be to post informational signs at beach access points, public boat launches, or other marine access points.

Address the effects of disturbance in refuge management plans - Management plans for existing or proposed refuge or wildlife management areas should address the potential impacts of hunting and other human disturbances. Fox and Madsen (1997) assert that many refuge/wildlife management areas are linear in shape and as a consequence have few disturbance-free areas. They propose that refuges should be designed to provide disturbance-free areas and adequate buffer zones, and that refuge design must take into account the ecology of the species expected to use the area. For shorebirds, this means identifying important foraging and roosting areas and accounting for typical spatial and temporal patterns of use. For example, it would be important to determine whether shorebirds exhibited differential use of diurnal and nocturnal roost sites, and whether there was age-, sex- or species-related segregation in habitat use (Meltofte et al. 1994). In addition, it has been recommended that complexes of disturbance-free roosting sites should be situated such that the distance among roosts is equal to normal intra-roost flight distances of the species that typically move the shortest distances within a single estuary (Rehfisch et al. 1996). Obviously, a substantial amount of information is need to examine the issue of disturbance and to develop scientifically-based management guidelines as needed (Hill et al. 1997).

Assess the level of unintentional shorebird mortality due to hunting - The level of unintentional mortality of shorebirds due to hunting is likely very low. An evaluation of this source of mortality would provide an indication as to whether a new identification/information guide for shorebirds should be developed for inclusion in a waterfowl hunting pamphlet. Such an assessment may allow for more effective refuge design or area access considerations.

Implement educational programs that inform the public about the ecology and behavior of shorebirds through natural-resource agencies, local governments, conservation groups, and others - This may reduce harassment of shorebirds in areas of high use by humans (Kirby et al. 1993). In addition, public education programs should emphasize the international scope of shorebird conservation (Bucher 1995, Finney 1995); such an effort should greatly improve conservation efforts throughout the western hemisphere (Castro 1993). Finally, resource

management agencies and wildlife interest groups must work together to improve regional involvement in international conservation efforts. Such efforts require improved information on the basic ecology of flyway species, identification of significant threats or potential impacts, and development of real conservation measures (Davidson et al. 1995).

Control of Exotic Species

Continue efforts to control the establishment and growth of cordgrass, purple loosestrife, and other noxious weeds- A substantial effort is underway to implement an integrated weed management program in Puget Sound and Willapa Bay following guidelines set forth in an environmental impact statement on noxious emergent plant control (Washington Department of Agriculture et al. 1993). Potential methods to eradicate noxious weeds include biological control, repeated mowing, hand pulling of seedlings, and chemical treatment (Washington Department of Agriculture et al. 1993). Some of these methods are currently being used (Kilbride et al. 1995, Washington Department of Fish and Wildlife 1995c). A monitoring and assessment strategy is essential to determine the efficacy of the methods and to safeguard against unanticipated impacts (e.g., those resulting from chemical application). Appendix A lists useful contacts for assessing pesticides, herbicides, and their alternatives.

Develop guidelines or regulations to control the transport of exotic invertebrates in marine waters - A large number of exotic invertebrate species are transported in ship ballast and discharged in estuarine or portside waters around the world (Carlton 1985). Ballast occasionally is discharged in 'technically restricted places" if it is felt that petroleum products are not contained in the ballast (Carlton 1985), making current controls on ballast uptake and discharge limited or ineffective. Due to the potentially deleterious effects of exotic marine invertebrates on native marine assemblages and the apparent lack of meaningful controls on ballast management, policy makers and resource management agencies should work with marine transport organizations to develop meaningful procedures for uptake and discharge of ballast.

Restoration/Creation of Habitat

The restoration or creation of tidal and nontidal areas for overwintering shorebirds is a possible means to mitigate environmental impacts. There is potential risk associated with this approach, however, because shorebirds do not settle in their winter quarters in a random manner, but rather return to areas used in previous years. Little information is available to assess the potential effectiveness of such restoration efforts (Wilcox 1986, Rehfisch 1994), and it is stressed that restoration is not an adequate substitute for safeguarding existing wetlands. Mitigation efforts at wintering grounds must recognize that habitat loss will most likely result in density-dependent competition at other sites in the region (see below).

Restoration of habitats used during breeding and migration seasons is also an important consideration. Substantial efforts are currently underway in the intermountain west to manage and restore wetland habitats (Inter-mountain West Joint Venture; Ratti and Kadlec 1992). These efforts should be supported.

There are many risks, often unforeseen, associated with restoration/creation projects. For example, restoration projects that reduce shore width typically result in the covering of adjacent high-level sandy tide flats with fine silt (Hill and Randerson 1986); the resulting change in substrate may not support species that formerly used the site (Burton et al. 1996).

Develop site-specific strategies for restoration projects - Information on local water, soil, and vegetation conditions and requirements (freshwater environments; Hammer 1997) or tidal, wind pattern, sea swell, and substrate conditions (marine environments; see below) needs to be incorporated.

Create new sites at least five years prior to modification of natural habitat - Artificially created sites should provide for all displaced birds and should address this need at least 5 years prior to the modification of natural habitat to allow an assessment of its success (Davidson and Evans 1987). Specifically, this 5-year period is needed to: 1) identify suitable sites; 2) acquire, design, and construct the mitigation features at sites; 3) allow settlement and stabilization of suitable sediments; and 4) allow colonization of sufficient densities of invertebrate prey species (Davidson and Evans 1987).

Address population dynamics at long-term and regional scales through mitigation - Mitigation studies should model population dynamics in a variety of local habitats over wide spatial (e.g. coastal, Puget Sound, and interior) and temporal (e.g., at least 5 years) scales. This is important because 1) shorebirds may use a variety of habitats (e.g., intertidal mudflats, beach, salt marsh) in an area (Burger et al. 1997); 2) changes in shorebird populations at a site during the nonbreeding season may also reflect responses to factors at other sites within the estuary, at other estuaries, or even at breeding areas (Goss-Custard and Durell 1990, Goss-Custard and Yates 1992); and 3) impacts to a site may influence shorebird populations at other sites.

Evaluate shorebird use of artificial impoundments - Artificially created sites may be very important to shorebirds, particularly in the Columbia Basin. Artificial drawdown sites may provide more nesting opportunities for certain species depending on the type of shoreline or the availability of nesting substrate (Paton and Bachman 1996). Care must be taken, however, to determine whether the spatial extent of the shoreline area created by the drawdown concentrates predator search effort and leads to high predation rates (Rönkä and Koivula 1997). In addition, efforts to modify such sites should be evaluated in the same manner as undisturbed sites (Warnock and Takekawa 1995).

Create adequate roost sites - Roost sites are an important habitat resource used by shorebirds during the nonbreeding season. Although most shorebirds appear to prefer salt marshes and beaches as roost sites, they also use dredge-spoil islands and other human-created areas. Shorebirds will likely use artificial sites if they are properly designed. A primary consideration in creating a roost site is that it must be designed to address the needs of the species that will use the site. Island roosts should provide shelter from strong winds or sea swell if these are significant environmental conditions in the particular area (Burton et al. 1996). In addition, Burton et al. (1996) recommended that island roosts should be open, with flat tops and gently sloping sides so that the birds can effectively scan for predators (Metcalfe 1984).

Manage artificial (freshwater) sites for breeding season use - Shorebirds will nest in artificial wetlands and impoundment drawdowns when certain conditions are met (Green 1988, Paton and Bachman 1996). The first consideration required when managing habitats for breeding birds is to determine the focal species that will use the site. Nesting requirements are quite different for species like the killdeer and American avocet. Other considerations include the depth of water in impoundments and the availability of invertebrate prey (see sections below).

Manage artificial (freshwater) sites during fall migration - During fall migration, shorebirds are attracted to drawdowns in reservoirs and other artificial impoundments, flooded agricultural lands, and artificial fish ponds (Rundle and Fredrickson 1981, Hands et al. 1991, Smith et al. 1991). Gradual draw-downs in impoundments are recommended because this more effectively facilitates the extended-use period of shorebirds during fall migration and assures availability of resource alternatives as local conditions change (Rundle and Fredrickson 1981, Skagen and Knopf 1994). Rundle and Fredrickson (1981) further recommended that shallow [0-5 cm (0-2 in) deep] flood pools be interspersed with exposed saturated soils to enhance shorebird use; shorebirds also used areas disked prior to flooding. It is important to maintain drawdown and flooded lands habitat for the duration of fall migration to provide habitat conditions favorable for late-season movements of juveniles (Morrison 1984, Hands et al. 1991). Shorebirds are attracted to these artificially created areas during spring migration, but seem to use them less than during fall (Rundle and Fredrickson 1981, Hands et al. 1991), although data from sites in the Pacific Northwest are lacking.

Maximize invertebrate production at artificial (freshwater) sites - Artificial impoundments will be most effective if the site contains features that maximize invertebrate production and foraging efficiency by shorebirds (Rehfisch 1994). The enhancement or creation of artificial sites will require local knowledge of the potential for a specific site to support desired populations of invertebrates. Some recommendations for the management of artificial impoundments are provided in Table 2.

Table 2. Features of pastures, fields, and artificial impoundments that maximize benefits for nesting or migrating shorebirds.

Site feature	Recommended condition or action	References
Water depth	• Less than 5 cm (2 in) for sandpipers. • Less than 10-15 cm (4-6 in) for larger species (e.g., yellowlegs, avocets). Areas of slightly deeper water may be suitable for phalaropes. • Particularly at sites with a permanent or long-term management emphasis, areas of deeper water [>30 cm (12 in)] should be maintained in the center of impoundments to minimize winter mortality of invertebrates. Also, the deeper area(s) should not be allowed to dry out and would thus act as a source from which invertebrates might colonize areas flooded during migration periods.	Hands et al. (1991), and Rundle and Fredrickson (1981) Rehfisch (1994)
Seasonal availability	• Impoundments and managed drawdowns may be most important during autumn migration. Where possible, maintain a number of units (e.g., 6) during peak periods of anticipated use to ensure the availability of suitable conditions; the most important period in eastern Washington is probably August-September. • Gradual drawdowns create suitable conditions over a longer time period.	Hands et al. (1991), Rundle and Fredrickson (1981)
Vegetation	• In impoundments generated by spring precipitation or runoff, greater water depths may be needed to inhibit growth of undesirable aquatic vegetation. Short drying periods may also be required to control invasive plant species. • Dense shoreline vegetation may impede use by shorebirds. • Use of pastures by small and medium-sized shorebirds increases when vegetation is <20 cm (8 in) tall; shorebirds appear to prefer sites with vegetation <10 cm (4 in) tall.	Rundle and Fredrickson (1981) and Rehfisch (1994) Rundle and Fredrickson (1981) Colwell and Dodd (1997)
Special methods of site preparation	• Disking prior to flooding may improve site conditions.	Rundle and Fredrickson (1981)
Arrangement of units	• Where possible, maintain a number of sites (e.g., 6) during peak periods of anticipated use to ensure the availability of suitable conditions. • Create mosaic of shallow water areas interspersed with areas of exposed, saturated soil.	Hands et al. (1991) and Reid et al. (1983) Rundle and Fredrickson (1981)

Maintain agricultural areas and pasturelands near sites used by shorebirds - Colwell and Dodd (1995, 1997) recommended that a mosaic of pasture lands with various vegetation heights and flooding conditions be maintained in coastal areas near estuaries. They felt that it might be possible to manage for appropriate vegetation height through cattle grazing. They added, however, that the information needed to make specific recommendations about grazing intensity and timing was not currently available. Similarly, Rottenborn (1996) stated that the greatest use by shorebirds of agricultural lands in Virginia was in areas of flooded, bare (plowed) earth. He believed that the potential value of staging areas might be enhanced by managing adjacent pasture and agricultural lands for the open conditions most often used by shorebirds. Prescribed fire may be a potential method to create or enhance shorebird habitat in certain upland areas (Stone 1994).

Effectively manage artificial sites - There are several additional practical issues that should be addressed by those interested in creating or maintaining artificial habitats (Engilis and Reid 1996). First, in areas where flooding or erosion are important issues, it will be necessary to design and use spillways properly to prevent damage. Second, exotic species such as carp and purple loosestrife must be controlled and their potential reinvasion routes managed to prevent the reestablishment of these species. Third, in areas with a controlled water source it is important to maintain water flow, provide adequate draining, and use adequate spacing between inflow and outflow points to minimize stagnant water and reduce the likelihood of outbreaks of avian cholera and botulism Type C (Kadlec and Smith 1989). Fourth, an assessment of soil conditions is necessary to determine whether the site will effectively hold water (e.g., prevention of drainage to the water table, or seepage through dikes). The capacity of a site to contain water may be accomplished with as little as 10% clay content although 30% clay content is more desirable

(Engilis and Reid 1996). Finally, artificially constructed islands designed as shorebird nest sites must have a gently sloping shoreline (a minimum 5:1 ratio to a height 30-60 cm above water level is recommended; Engilis and Reid 1996) and be large enough to enable shorebirds to effectively use predator avoidance behavior to protect eggs or fledglings. Resource managers should consult Engilis and Reid (1996) and Hammer (1997) for more details about wetland habitats and restoration.

Consider other recommendations - Evans (1991) made a number of additional recommendations that should be considered in any restoration or mitigation project. These recommendations are based on shorebird ecological studies and do not reflect results of actual mitigation assessments, which are largely lacking. First, many wintering shorebirds forage in protected areas during periods of strong winds. In areas where strong winds are known to occur, it may be important to provide sheltered, yet open feeding areas. This might be accomplished by excavating channels through mitigation tideflats. Second, it may be possible to increase the availability of invertebrate prey at wintering sites by discharging clean cooling water from industrial processes. Evans (1991) suggests that increases in prey availability may occur if such discharges increase water and mud temperatures. However, it is recommended that such action be done experimentally and evaluated for its potential impacts to plankton and invertebrate communities prior to more widespread use. Finally, creation of adjacent wetlands may be beneficial in some situations where reclamation eliminates habitat and effectively reduces the amount of time that shorebirds can spend foraging at a site. This may be particularly important for smaller shorebirds that face a competitive disadvantage to larger species for spatially or temporally limited resources (Davidson and Evans 1986). [Shorbird conservation planning documents were prepared after this PHS document was completed; see Brown et al. (2000) and Drut and Buchanan (2000)].

Conservation Planning

Develop a comprehensive planning process within state and federal natural resource agencies - Managing for shorebird populations in Washington requires development of comprehensive conservation objectives for the various shorebird species and the habitats they use. This must be done in the context of a landscape scale that incorporates the full range of species occurrences and community interactions in the habitats involved (Skagen 1997). Accomplishing this will likely facilitate more effective implementation of the recommendations described above and will likely provide greater opportunities to address the conservation needs of other species associated with the habitats used by shorebirds (Dickson and McKeating 1993, Laubhan and Fredrickson 1993, Streeter et al. 1993, Fredrickson and Laubhan 1994) [Shorbird conservation planning documents were prepared after this PHS document was completed; see Brown et al. (2000) and Drut and Buchanan (2000)].

Broaden the geopolitical scale of conservation planning - Due to the migratory status of most shorebirds and the potential difficulties associated with their management as described above, there is a need for comprehensive conservation planning at the flyway level. Strong partnerships and governmental commitments developed at this geopolitical scale may result in:

1) better understanding of limiting factors and population health of various species, 2) more effective management of refuges and other important areas used by shorebirds, and 3) opportunities to efficiently protect shorebirds and a large number of other species through the development of regional or flyway-level plans that emphasize specific needs and solutions. The current effort to develop a National Shorebird Conservation Plan may address these issues and should be supported. In addition, as part of a comprehensive planning and coordination process, cooperative agreements should be established whereby listing a species as threatened or endangered in a flyway state or province would prompt other flyway states or provinces to evaluate that species' status. The evaluation would determine 1) whether factors in the other states or provinces may have influenced the initial listing or are significant for recovery planning, and 2) whether the species should be listed in other states or on a flyway basis. This second concept requires that regional or flyway standards for listing be developed.

RESEARCH NEEDS

Many authors have commented on the importance of research for conserving wildlife resources (Bildstein et al. 1991, Morrison 1991). Essential research should investigate shorebird distribution, population trends, and annual survival or mortality estimates, as well as energetic and eco-physiological relationships. In addition, shorebird ecology and habitat relationships in Washington need to be studied, including threats to shorebird habitats and their

Table 3. Summary of research and information gaps relating to shorebird species in Washington that are addressed in this document. An asterisks (*) represents areas of information developed from Washington, pound sign (#) represents areas of information from elsewhere within the species range that is pertinent to Washington.

Species	Important sites identified[a]	Population trends monitor[d]	Food habits[b]	Physiolog/ mortality factors	Recent contaminant studies[c]	Effects of disturbance[d]	Effects of habitat degradation	References[e]
Black-bellied plover	*				*	#	#	7,8,9, 15,16
American golden-plover	*							14
Pacific golden-plover	*							14
Semipalmated plover	*					#		14
Killdeer	*					#		9,14
Black oyster-catcher	*		*			#		11,13, 17
Black-necked stilt	*					#		14
American avocet	*							14
Greater yellowlegs	*					#		3,7,9
Lesser yellowlegs						#		
Solitary sandpiper								
Wandering tattler							#	1
Spotted sandpiper							#	1
Whimbrel							#	1
Marbled godwit	*							14
Ruddy turnstone							#	1
Black turnstone							#	1
Surfbird								
Red knot	*					#		14
Sanderling	*				*	#		4,15
Western sandpiper	*				*	#		7,9, 15
Least sandpiper						#		
Baird's sandpiper								
Pectoral sandpiper	*							5
Rock sandpiper		*						6,14
Dunlin	*		*		*	#		2,4, 9,15
Short-billed dowitcher	*					#		7,10, 14
Long-billed dowitcher	*							7,10,14

Species	Important sites identified[a]	Popula-tion trends monitor[d]	Food habits[b]	Physiolog/ mortality factors	Recent contami-nant studies[c]	Effects of disturb-ance[d]	Effects of habitat degradation	Refer-ences[e]
Common snipe	*							14
Wilson's phalarope	*							14
Red-necked phalarope	*		*					12,14
Red phalarope	*							14

[a]Various species that migrate through eastern Washington use habitats whose availability is seasonally or annually unpredictable due to changes in water levels; important habitats for many species (for example, lesser yellowlegs, solitary sandpiper, spotted sandpiper, and least sandpiper) can likely be predicted seasonally or annually based on availability of suitable conditions; [b]Only the food habits studies conducted in Washington, Oregon, or southern British Columbia are included because of substantial regional differences in energetic demands, prey availability, and prey use; [c]Includes chemical, industrial, heavy metal, plastic, and oil pollution; [d]See table 4 for details and references; [e]References are as follows: 1 = Bradley and Bradley 1993, 2 = Brennan et al. 1990, 3 = Buchanan 1988, 4 = Buchanan 1992, 5 = Buchanan (in prep - a), 6 = Buchanan (in prep - b), 7 = Buchanan and Evenson 1997, 8 = Custer and Myers 1990, 9 = Evenson and Buchanan 1995, 10 = Evenson and Buchanan 1997, 11 = Frank 1982, 12 = Jehl 1986, 13 = Nysewander 1977, 14 = Paulson 1993, 15 = Schick et al. 1987, 16 = Sutherland and Goss-Custard 1991, 17 = Vermeer et al. 1989.

use of artificial wetlands. Research on environmental contaminants and shorebird toxicology is needed in Washington (Morrison 1991). Additional research needs are presented below. Many of these and other research topics have not been addressed for shorebird species in Washington (Table 3).

Evaluate the potential impacts of commercial shellfish management may have on shorebird populations - There is currently a dearth of information on the response of shorebirds to management of bivalves in intertidal areas in the Pacific Northwest. Due to this lack of information, research should be conducted to evaluate whether various aspects of commercial bivalve production influence site quality for shorebirds.

Determine the relationship between livestock grazing and shorebird habitat quality - Information on the effects livestock trampling may have on shorebirds is needed for the intermountain west. Negative effects noted elsewhere include eggs or nest destruction (Rohwer et al. 1979, Guldemond et al. 1993), nest abandonment (Delehanty and Oring 1993), and adult birds spending an increased time away from their nests (Graul 1975), which likely results in increased exposure of eggs. Vegetation control is one potential positive effect. An effort is needed to identify these relationships, particularly in the Columbia Basin, and determine the conditions under which grazing activities and shorebird habitat management might be compatible.

Develop a better understanding of the ecology and population status of the common snipe - The common snipe is a state game species. The effects of hunting mortality on common snipe populations need to be investigated to ensure appropriate management.

Evaluate the effects of various types of human disturbance on shorebirds - Studies have shown that many types of human activities disturb shorebirds. Research on disturbance effects should focus on 1) vehicle and pedestrian traffic on beaches, 2) watercraft disturbance on lakes and bays, and 3) tourist/birdwatcher disturbance at migratory stopover sites.

Determine the effects of water salinization on shorebirds and other wildlife - The relationship between increasing water salinization within the Columbia Basin and the shorebirds that migrate through or nest in that region needs to be investigated. Understanding this relationship will be required to better control the potentially harmful effects of increasing salinization on shorebirds and other wildlife, and for effective management of vegetation.

Use new technology to improve our understanding of shorebird ecology - Satellite imagery has been used to assess habitat suitability and availability (Yates et al. 1993a,b), as well as to predict presence or abundance of birds (Lavers and Haines-Young 1997). Development of this and other tools, including Geographic Information Systems, should greatly increase our ability to address management issues of concern.

Table 4. Summary of responses by shorebirds to human disturbances.

Species	Response behavior and type of disturbance	Reference
Killdeer	• Moved to areas beyond 60 m (197 ft) from trail[1] when visitation level exceeded 301-450 visitors/4 hr time period. Did not appear to be as sensitive to vehicle traffic.	Klein et al. (1995)
Black-bellied plover	• Generally found far [81-100 m (266-328 ft)] from roads, and moved to areas beyond 100 m (328 ft) when traffic level exceeded 601-750 vehicles/4 hr time period.	Klein et al. (1995),
	• In northern Europe, mean flush distance in response to people walking on tidal flats was 124 m (407 ft).	Smit and Visser (1993)
Semipalmated plover	• Generally found far [61-80 m (200-262 ft)] from roads, and moved to areas beyond 80 m (262 ft) when traffic level exceeded 451-600 vehicles/4 hr time period.	Klein et al. (1995),
	• In northern Europe, the mean flush distance in response to people walking on tide flats by the closely related ringed plover (*Charadrius semipalmatus*) was 121 m (397 ft).	Smit and Visser (1993)
Willet	• Generally found far [61-80 m (200-262 ft)] from roads, and moved to areas beyond 80 m (262 ft) when traffic level exceeded 451-600 vehicles/4 hr time period. Moved to areas beyond 40 m (131 ft) from trail when visitation level exceeded 151-300 visitors/4 hr time period.	Klein et al. (1995)
Sanderling	• Generally found far [61-80 m (200-262 ft)] from roads, and moved to areas beyond 80 m (262 ft) when traffic level exceeded 451-600 vehicles/4 hr time period. Moved to areas beyond 60 m (197 ft) from trail when visitation level exceeded 301-451 visitors/4 hr time period.	Klein et al. (1995),
	• Median flush response distance on a New England beach was 12 m (39 ft).	Roberts and Evans (1993)
	• More sensitive to disturbance (humans, dogs, etc.) on beaches at dusk [flush response distance = 8.3 m (27.2 ft)] than during day [flush response distance = 5.0 m (16.4)].	Burger and Gochfeld (1991)
	• Concentrated on sections of beach with fewer people.	
	• At high disturbance levels (vehicle count >100/day), used back beach much more than front beach, compared to periods of lower disturbance (vehicle count <20/day).	Pfister et al. (1992)
Dunlin	• Generally found far [81-100 m (266-328 ft)] from roads, and moved to areas beyond 100 m (328 ft) when traffic level exceeded 301-450 vehicles/4 hr time period.	Klein et al. (1995),
	• In northern Europe, mean flush distance in response to people walking on tidal flats was 71-163 m (233-535 ft).	Smit and Visser (1993)
Western/least sandpiper	• Generally found far [61-80 m (200-262 ft)] from roads, and moved to areas beyond 80 m (262 ft) when traffic level exceeded 451-600 vehicles/4 hr time period.	Klein et al. (1995)

Species	Response behavior and type of disturbance	Reference
Greater yellowlegs	• Did not respond to differing levels of road traffic, but foraging areas were located further from road than expected based on distribution of habitat. Most greater yellowlegs used areas >20 m (66 ft) from the road.	Klein et al. (1995)
Lesser yellowlegs	• Did not respond to differing levels of road traffic, but foraging areas were located further from road than expected based on distribution of habitat. Most lesser yellowlegs used areas >20 m (66 ft) from the road.	Klein et al. (1995)
Red Knot	• Did not respond to differing levels of road traffic, but foraging areas were located further from road than expected based on distribution of habitat. Most red knots used areas >90 m (295 ft) from the road. • In northern Europe, mean flight distance in response to person in kayak was about 250 m (820 ft) • Mean flight distance in response to wind surfer was about 200 m (656 ft). • In northern Europe, birds less approachable on days with aircraft activity. Incidence of restlessness greater on days with aircraft activity.	Klein et al. (1995) Smit and Visser (1993), Koolhaas et al. (1993)
Short-billed dowitcher	• Did not respond to differing levels of road traffic, but foraging areas were located further from road than expected based on distribution of habitat. Dowitchers were more common at >90 m (295 ft) than at any distances closer to road. • Abundance on front beach declined sharply when level of disturbance exceeded 10-40 vehicles/day.	Klein et al. (1995) Pfister et al. (1992)
Black-necked stilt	• Avoided habitats within 20 m (66 ft) of road.	Klein et al. (1995)
Eurasian oystercatcher (*Haematopus ostralegus*)	• In northern Europe, took to flight when walking person within 250 m (820 ft) 57% of time. In northern Africa, flocks were flushed by a walking person at 400-500 m (1,312-1,640 ft). Mean flight distance in response to walking person ranged from 85-138 m (279-453 ft). • Mean flight distance in response to person in kayak was about 40 m (131 ft). • Mean flight distance in response to wind surfer was about 125 m (410 ft).	Smit and Visser (1993)
Redshank *Tringa totanus*	• Mean flight distance in response to person in kayak was about 195 m (640 ft). • Mean flight distance in response to wind surfer was about 285 m (935 ft).	Smit and Visser (1993)

Species	Response behavior and type of disturbance	Reference
Bar-tailed godwit	• Mean flight distance in response to person in kayak was about 200 m (656 ft). • Mean flight distance in response to wind surfer was about 240 m (787 ft). • Mean flight distance in response to walking person ranged from 101-219 m (331-718 ft). • At least 20% of birds in flock flushed when jet flew within 400-500 m (1,312-1,640 ft). • At least 55% of birds in flock flushed when helicopter flew within 900-1,000 m (2,953-3,281 ft).	Smit and Visser (1993)
Eurasian Curlew *Numenius arquata*	• Mean flight distance in response to person in kayak was about 230 m (755 ft). • Mean flight distance in response to wind surfer was about 400 m (1,312 ft). • Mean flight distance in response to walking person ranged from 101-339 m (331-1,112 ft).	Smit and Visser (1993)
Black turnstone	• In northern Europe, mean flush distance in response to people walking on tidal flats was 47 m (154 ft).	Smit and Visser (1993)
Primarily 8 species, including: semipalmated sandpiper, ruddy turnstone, sanderling, both dowitchers, red knot, dunlin, and greater yellowlegs	• In two New Jersey bays, factors influencing whether shorebirds flew but returned as a result of disturbances included duration of disturbance (short disturbances causes more flights), number of disturbances, distance between birds and source of disturbance, number of children at the site, number of people walking, and number of dogs. Factors influencing whether shorebirds flew away and did not return included duration of disturbance, the number of boats, and the number of children at the site.	Burger (1986)

[1]Trail or road traffic in various studies refers to responses of shorebirds to pedestrian or vehicular activity on trails or roads adjacent to intertidal areas within a refuge, unless otherwise noted.

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KEY POINTS

Habitat Requirements

Coastal Environments
- The primary habitat requirements of migrant or winter resident shorebirds relate to the availability of adequate foraging and roosting areas.
- Most species in western Washington are associated with silt or silt/sand intertidal areas and adjacent beaches or salt marshes. Pastures and agricultural land are also used by roosting and foraging shorebirds in western Washington.
- Shorebirds are adapted to forage in a narrow range of microhabitat conditions, from exposed tide flats or beaches to shallow water, salt marshes, and even open water.
- The foraging requirements of many shorebirds are met primarily in estuarine ecosystems, where tidal mud flats provide foraging substrates. Black-bellied plover, dunlin, western sandpiper, and dowitchers forage on mud flats with high levels of silt, whereas semipalmated plovers and sanderlings forage in sandy or silt/sand areas. Other species, such as rock sandpiper, surfbird, and wandering tattler are found almost exclusively along rocky intertidal shores.
- Shorebirds often roost in salt marshes adjacent to intertidal feeding areas, but will use a variety of habitats. Shorebirds at Grays Harbor and Willapa Bay often roost in large flocks on Pacific beaches, occasionally concentrating near the mouths of small creeks. In some areas, shorebirds roost on naturally-occurring and dredge-spoil islands and on higher elevation sand beaches. Some species may also roost in fields near intertidal foraging areas; foraging occurs at these or other roost sites if suitable prey are present. Shorebirds occasionally roost on log rafts, floating docks, and other floating structures when natural roost sites are limited.

- Use of artificial wetlands by shorebirds has not been documented in Washington. However, many species of shorebirds, including at least 12 species that occur in western Washington, use artificial or managed coastal wetlands in other parts of the United States and the world. Artificial wetlands could potentially provide important shorebird habitat in Washington.
- Shorebirds are generally site-faithful to specific wintering areas. This fidelity to particular sites has important ramifications for conservation management and mitigation.

Freshwater Environments
- Many species in eastern Washington use wet meadows, flooded fields and other areas of shallow water.
- Most shorebirds that forage in freshwater areas require ponds and pools that have exposed shorelines or that are shallow enough to allow foraging by wading birds. As with estuarine sites, the availability of appropriate invertebrate prey and roost sites are important habitat requirements.
- Habitats used by shorebirds in nonestuarine regions include marshes, pastures, flooded fields, reservoirs, impoundment drawdowns, stormwater wetlands, and other artificial wetlands.

Management Recommendations

Habitat Protection
- Identify and preserve wetland habitats important to shorebirds. Assemblages of smaller sites, as well as major estuaries provide critical habitat to shorebirds in Washington.
- Where livestock grazing occurs in pastures used by shorebirds, assess for potential trampling or disturbance of nesting birds.
- Assess commercial sand and gravel extraction from beach and riverine areas for potential impacts to shorebirds. The development of a review process for these activities would help ensure that shorebirds are considered as part of the permitting process.
- Avoid placement of new utility towers and lines in flight corridors or near wetland areas used by shorebirds. New lines should be placed below ground if possible.
- Where possible, treat existing utility lines to make them more detectable by birds in areas where collisions with shorebirds have occurred or are likely to occur. Techniques include coating or painting wires, marking of wires with mobile spirals or strips of fiberglass or plastic, placement of predator silhouettes, warning lights, and acoustical devices to scare birds. Static wire-marking may effectively reduce the number of collisions with power lines. Grouping multiple lines may make them more visible to birds and will occupy a smaller area of flight space. In addition, it is suggested that the lines be arranged side by side rather than in a vertical stacked formation.
- Address shorebirds and their flight corridors in wind turbine and cellular tower proposals.
- In the event of an oil spill, limit public access to beach or estuarine spill sites. The impacts of an oil spill can be exacerbated by disturbances caused by human recreation (e.g., beach walking).
- Control the entry of plastic litter into the marine environment. Small plastic particles injure surface feeding marine birds that inadvertently ingest them.
- Continue efforts to control the establishment and growth of cordgrass, purple loosestrife, and other noxious weeds. Potential methods to eradicate noxious weeds include biological control, repeated mowing, hand pulling of seedlings, and chemical treatment.
- Use extreme caution when applying chemicals near habitats used by shorebirds. Encourage alternatives to chemical use. Appendix A (of this volume) lists contacts useful in assessing pesticides, herbicides, and their alternatives.
- Use current information to establish buffer zones when applying chemicals. Implement buffer zones around shorebird and waterfowl nesting habitat in agricultural landscapes to minimize the impacts of spray drift.
- Assess whether or not public access and human activities should be controlled at areas important to shorebirds. If needed, potential solutions may include erecting cordons to restrict foot traffic from roosting or foraging sites, and establishing vehicle restriction zones during critical roosting periods.

Restoration/Creation of Habitat
- Develop a site-specific strategy for any restoration project affecting shorebirds. Information on local water, soil, and vegetation conditions and requirements (freshwater environments) or tidal, wind pattern, sea swell, and substrate conditions (marine environments) needs to be incorporated.
- Create new sites at least five years prior to modification of natural habitat. Artificially created sites should provide for all displaced birds and should address this need at least 5 years prior to the modification of natural habitat to allow an assessment of its success. This 5-year period is needed to 1) identify suitable sites; 2) acquire, design, and construct the mitigation features at sites; 3) allow settlement and stabilization of suitable sediments; and 4) allow colonization of sufficient densities of invertebrate prey species.
- When conducting mitigation studies, model population dynamics in a variety of local habitats over wide spatial (e.g. coastal, Puget Sound, and interior) and temporal (e.g., at least 5 years) scales.
- Evaluate shorebird use of artificial impoundments. Artificially-created sites may be very important to shorebirds, particularly in the Columbia Basin. Artificial drawdown sites may provide more nesting opportunities for certain species depending on the type of shoreline or the availability of nesting substrate. In addition, efforts to modify such sites should be evaluated in the same manner as undisturbed sites.
- Create adequate roost sites. A primary consideration in creating a roost site is that it must be designed to address the needs of the species that will use the site. Island roosts should provide shelter from strong winds or sea swell if these are significant environmental conditions in the particular area. Island roosts should also be open, with flat tops and gently sloping sides so that the birds can effectively scan for predators.
- Manage artificial (freshwater) sites for breeding season use as well as fall migration.
- Maximize invertebrate production at artificial (freshwater) sites.
- Maintain agricultural areas and pasturelands near sites used by shorebirds.
- Practical considerations regarding management of artificial sites include:

  - proper design and use of spillways in areas prone to flooding and erosion,
  - control of exotic species such as carp and purple loosestrife,
  - water flow maintenance that minimizes stagnant water and reduces the likelihood of outbreaks of avian cholera and botulism Type C,
  - an assessment of soil conditions to determine whether a site will effectively hold water (e.g., prevention of drainage to the water table, or seepage through dikes).

Policy needs and considerations for government agencies and conservation organizations
- Initiate and design conservation planning efforts to address the following:
  - comprehensive, multi-species, landscape-level or ecosystem plans that address many species, habitats, as well as factors such as community dynamics.
  - flyway-level biological and policy coordination among states and provinces to improve regional management and enhance opportunities to protect shorebird populations.
- Identify important local and regional sites.
- Preserve remaining wetland habitat. Locally or regionally important sites should be purchased to reduce the risk of loss or degradation of habitat important for shorebirds and other wildlife. New protective and regulatory legislation needs development, and existing laws concerning wetland use need more effective enforcement.
- Promote public education about chemical use and wetland functions. Implementation of an integrated training and certification program for landowners and commercial pesticide applicators has been recommended as a means to provide pesticide users with important biological information and training.
- Continue the development and refinement of oil trajectory models.
- Develop site-specific strategies to manage human disturbance. Potential strategies include developing informational signs that identify or describe important foraging or roosting areas and organizing groups of volunteers ("beach patrols") to educate the public about shorebird ecology.
- Post informational signs at boat docks, moorage areas, and beach access points to explain the impacts of disturbances caused by boats, personal watercraft, unleashed dogs, and other human activities.

- Address the effects of human disturbance in refuge management plans. Refuges should be designed to provide disturbance-free areas and should take into account the ecology of the species expected to use the area.
- Assess the level of unintentional mortality due to hunting. An evaluation of this source of mortality would provide an indication as to whether a new identification/information guide for shorebirds should be developed for inclusion in a waterfowl hunting pamphlet.
- Implement educational programs to inform the public about the ecology and behavior of shorebirds. Public education programs should emphasize the regional and international scope of shorebird conservation. Such efforts require improved information on the basic ecology of flyway species, identification of significant threats or potential impacts, and development of real conservation measures.
- Undertake comprehensive efforts to control the spread of exotic invertebrates in marine waters.
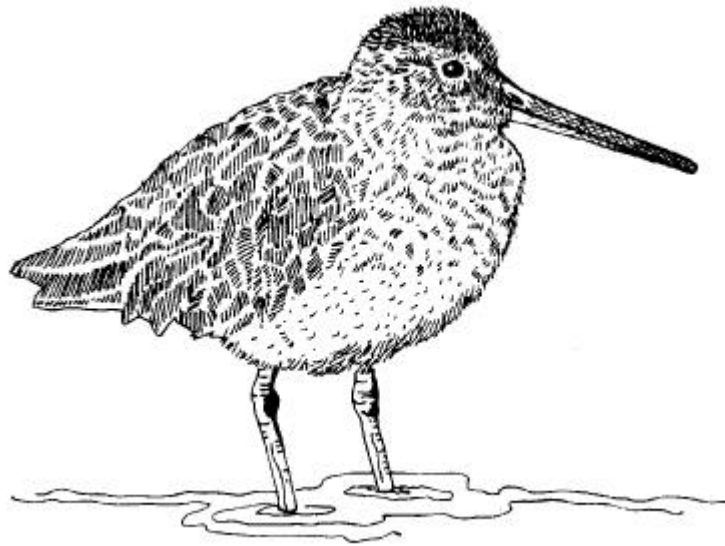
Common Murre
Uria aalge

Last updated: 2003

Written by Kenneth I. Warheit and Christopher Thompson

GENERAL RANGE AND WASHINGTON DISTRIBUTION

The common murre is a gregarious, colonially nesting, and circumpolar seabird with a boreal, low Arctic, and northern temperate distribution (American Ornithologists' Union 1983, Nettleship and Evans 1985, Gaston and Jones 1998, Ainley et al. 2002). Based mostly on morphological differences, there have been up to eight subspecies or races described for the common murre (Storer 1952, Tuck 1961, Bédard 1985, Gaston and Jones 1998, Ainley et al. 2002), with three to six occurring in the Atlantic Ocean and two in the Pacific Ocean (*Uria aalge inornata*, *U. a. californica*).

Figure 1. The breeding distribution of common murres, *Uria aalge,* in Washington is restricted to locations between Tatoosh Island and Greenville Arch (Speich and Wahl 1989, Carter et al. 2001).

In the Atlantic Ocean there are roughly 2,000,000 (Nettleship and Evans 1985) to as many as 9,000,000 (Gaston and Jones 1998) adult common murres breeding from the Labrador and Newfoundland coast in Canada, north to southern Greenland, Iceland, northern Norway and Spitsbergen, and south to Great Britain and the coast of Europe to Portugal (Harrison 1983, Gaston and Jones 1998, Ainley et al. 2002). In the Pacific and Arctic Oceans, common murres range from Cape Lisburne, Chukchi Sea, Siberian and Alaskan coasts of the Bering Sea, and south along the eastern and western north Pacific to Hokkaido, Japan, and Hurricane Point, central California, respectively (Sowls et al. 1978, American Ornithologists' Union 1983, Harrison 1983, Gaston and Jones 1998, Ainley et al. 2002). In the northern parts of the Pacific Ocean and throughout the Arctic Ocean, the common murre and the closely related thick-billed murre (*Uria lomvia*) may nest together in mixed colonies, making it difficult to estimate the total population of either species (Gaston and Jones 1998). Based on the work of Carter et al. (2001), U.S. Fish and Wildlife Service [USFWS] (2001), and others (e.g., Takekawa et al. 1990, Lowe and Pitkin 1996), Ainley et al. (2002) recorded nearly 5,000,000 common murres and 4,500,000 unidentified murres from California through Alaska, and Gaston and Jones (1998) added an additional 2,700,000 common murres from the Siberian Bering Sea and Kuril Island in the western Pacific Ocean.

Although common murres move away from breeding colonies after the breeding season, their winter range is essentially the same as their breeding range, but extends further south where murres are regularly found in southern California in the Pacific and Maine in the Atlantic (American Ornithologists' Union 1983). Some populations of common murres may remain resident near breeding colonies throughout the year (e.g., common murres nesting in central California; Boekelheide et al. 1990, Sydeman 1993).
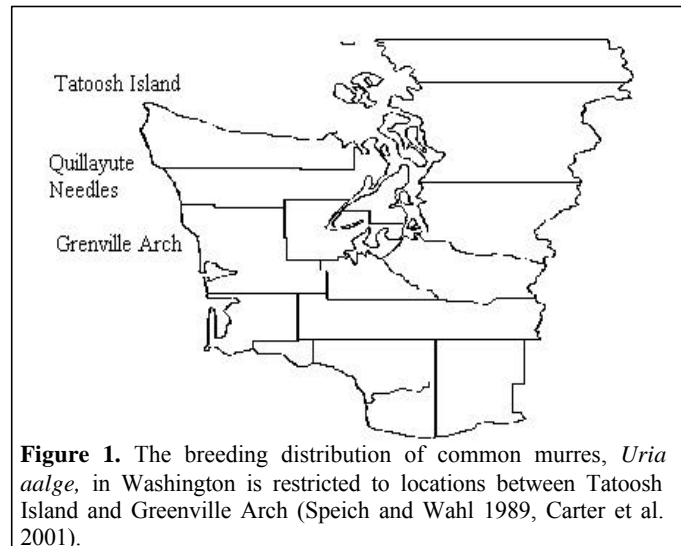
Washington Colony Distribution, Attendance, and Trends

Distribution: The breeding distribution for common murres in Washington State is restricted to the outer coast from Grenville Arch (47° 18′ N, 124° 17′ W) to Tatoosh Island (48° 24′ N, 124° 44′ W) and include at least five groups of colonies or "complexes": Point Grenville, Split-Willoughby, Quillayute Needles, Carroll-Jagged, and Tatoosh (see Figure 1; Speich and Wahl 1989, Carter et al. 2001). All colonies, except that on Tatoosh Island, are part of the USFWS National Wildlife Refuge (NWR) system (North to South: Flattery Rocks, Quillayute Needles, and Copalis NWRs) and have been aerially surveyed each year since 1979 (Wilson 1991, Carter et al. 2001). Tatoosh Island is owned by the Makah Tribe and regular ground and boat surveys of breeding common murres on the island began in 1990 (Parrish 1995), although some data on murre status were collected on the island in the 1980s (Paine et al. 1990).

Attendance[1]: Data on the attendance of common murres in Washington have been recorded continuously by USFWS since 1979, when more than 31,000 birds were recorded from 12 localities (Speich and Wahl 1989, Carter et al. 2001). USFWS surveys did not include Tatoosh Island until 1994 (Carter et al. 2001), although work by University of Washington researchers estimated attendance at Tatoosh Island in 1979 to be less than 500-1000 birds (Paine et al. 1990, Parrish et al. 2001). In 2002 there were between 5,785 and 5,925 common murres in attendance at 15 NWR colonies (Wilson 2003), plus an additional 4,466 murres at Tatoosh Island (Thompson et al. 2003), for a total of over 10,000 birds. The largest colony in the state is Tatoosh Island, followed by Cake Island (Wilson 2003), both of which are in the northern part of Washington's common murre range.

Trends: In order to better understand the population dynamics of murres in Washington through 2002, we added to the analyses of Wilson (1991) and Carter et al. (2001), and included additional data for the refuge islands (Wilson 1996, 1999, 2002, and 2003) and for Tatoosh Island (Paine et al. 1990, Thompson et al. 2003). This new dataset provides nearly continuous data for common murres in Washington from 1979 through 2002, with the following exceptions: (1) refuge colony-specific data for 1999 and 2000 were not available, although total counts were obtained from Figure 1 in Wilson (2003); and (2) continuous attendance data from Tatoosh Island were only available from 1991 through 2002 (Thompson et al. 2003), although Paine et al. (1990) plotted murre attendance for 1978, 1979, 1986, and 1988). In order to fill in the gaps, we used the plotted attendance figures for these years and extrapolated from these figures using linear regression to obtain attendance estimates at Tatoosh Island for 1987 and 1989-1990 (Figures 2, 3). Our analysis is similar to that of Wilson (2003), except we include data for Tatoosh Island, and we do not focus attention on a time period dictated by the *Tenyo Maru* oil spill. When multiple aerial surveys were conducted in a given year, we chose the median values in our analysis. Our results indicate that the common murre population in Washington appears stable over the past decade.
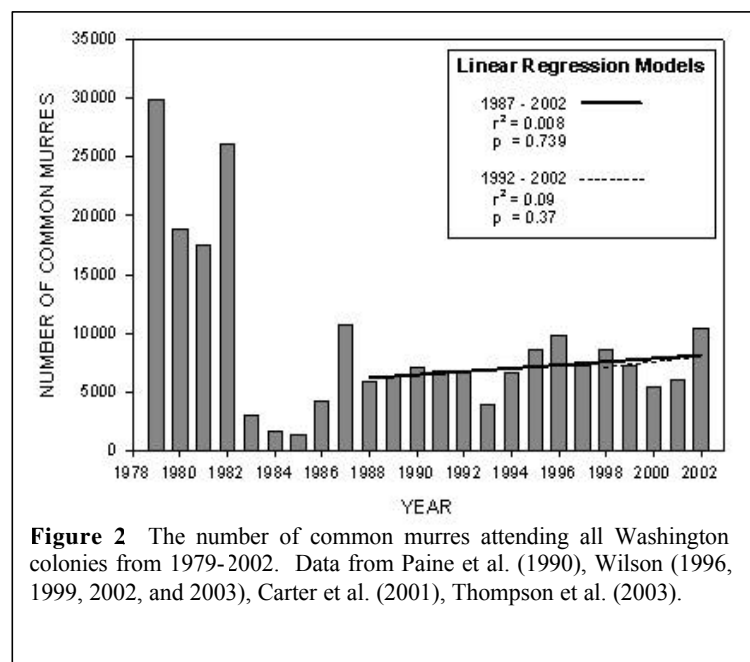

Figure 2 The number of common murres attending all Washington colonies from 1979-2002. Data from Paine et al. (1990), Wilson (1996, 1999, 2002, and 2003), Carter et al. (2001), Thompson et al. (2003).

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[1] Attendance is the number of individuals counted during a colony census, and represents breeding and non-breeding birds. At the time of these censuses, the breeding population at the colony was composed of breeding birds (i.e., adults) that were at the colony and were therefore counted. Adult birds (generally the mates of the birds present at the colony) that were at-sea were not counted. The total population was composed of all juvenile, subadult, and adult birds that would or potentially would breed at the colony.

Figure 2 shows the total attendance at murre colonies from 1979 through 2002. The dramatic decline in murre attendance in 1983, as initially documented by Wilson (1991), is clearly evident. Murre numbers stayed low from 1983-1985 and began to increase through 1987. After 1987, murre numbers remained stable through 2002. If murres in Washington are at "carrying capacity[2]" (Wilson 2003:2), this capacity is remarkably lower than that in the late 1970s and early 1980s (see below, and Parrish and Zador 2003 for discussion of common murre carrying capacity in Washington).

Carter et al. (2001) divided the murre colonies into a southern (Gray's Harbor County, including Point Grenville and Split-Willoughby Complexes) and a northern component (Jefferson and Clallam Counties, including the Quillayute Needles, Carroll-Jagged, and Tatoosh Complexes). From 1979 through 1982, common murres attending Washington colonies in the southern areas averaged 92% of the total Washington population (Figure 3). In 1988, the dominance of the southern areas ended and by the mid 1990s the Washington murre population had shifted to the northern colonies (Figure 3). In 2002, 81% of common murres in Washington were nesting in the northern areas, with 44% at Tatoosh Island and 35% at the Quillayute Needles Complex.
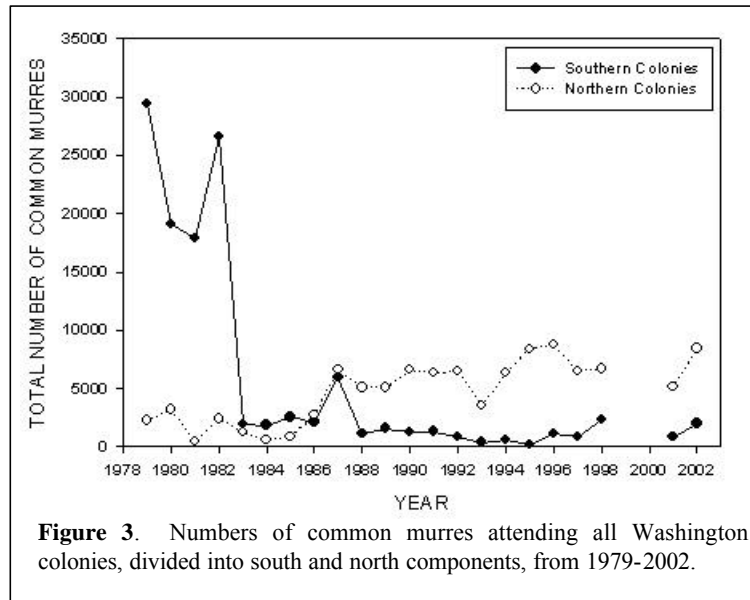

Figure 3. Numbers of common murres attending all Washington colonies, divided into south and north components, from 1979-2002.

Although murre attendance summed across all colonies (as presented in Figure 2) has been relatively stable for 15 years, attendance at individual rocks has varied (Carter et al. 2001). This is especially true at the Quillayute Needles and Carroll-Jagged Complexes, in particular Cake Rock and Carroll, Huntington, and Petrel Islands (Figure 4; see also Carter et al. 2001:Figure 2.11). In the early 1980s, Petrel Island was the predominant murre colony in the area, followed by Huntington Island from the mid 1980s through the early 1990s. The murre population at Carroll Island increased dramatically following the 1994 breeding season, but has been replaced by Cake Rock (Figure 4) as the main murre colony in the area.

Understanding trends in common murre colony attendance in Washington over the past two decades is confounded by at least two basic issues. First, as discussed above, there does not appear to be a uniform trend in colony attendance among colonies from the Quillayute Needles and Carroll-Jagged Complexes. The fact that all Washington murre colonies are within a range of 127 km (79 mi) makes these data even more perplexing. Second, counts at particular colonies generally have not been replicated in any given year, and census methods used by different researchers may differ and may not be directly comparable. Counts at common murre refuge colonies have been conducted only once per year from 1979 through 1993 (Carter et al. 2001), and single yearly counts can result in poor estimates of breeding attendance (Hatch and Hatch 1989). Censuses by other researchers often resulted in different population estimates. For example, Wilson (in Carter et al. 2001:Appendix F) estimated that only 50 common murres were in attendance on Grenville Arch during an aerial survey on June 26, 1985. However, Speich et al. (1987) provided a maximum count of 8,000 common murres on Grenville Arch for the week that included June 26, 1985, based on a combination of shore- and boat-based counts. Land, boat, and aerial surveys have the potential of sampling different parts of a colony, and therefore they may produce different results. In addition, there may be inherent hourly or daily variability in attendance at Washington colonies (Parrish 1996a, b), and censuses taken on two different days (or at two different times during the same day) may differ as a result of this variability.

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[2] The number of individuals that the resources of a habitat can support.

At-sea Distribution

Although common murre breeding in Washington is restricted to cliffs, rocks, and islands on the outer coast, murres are found throughout the year in all marine waters of the state, including Puget Sound (Wahl et al. 1981, Briggs et al. 1992, Thompson 1997, 1999, Nysewander et al. 2001, Thompson et al. 2002, 2003). In Puget Sound, murre densities are positively correlated with distance from the shore and water depth (D. Nysewander, personal communication; Wahl et al. 1981); however, this relationship does not exist along the outer coast and in the western portions of the Strait of Juan de Fuca (Thompson 1997, 1999). The temporal and spatial patterns for the abundance and distribution of common murres in Puget Sound are highly variable (Thompson 1997, 1999, Nysewander et al. 2001). For example, population indices for common murres in the Puget Sound in July were 48,423; 9,915; 5,271; and 30,660 for 1993 through 1996, respectively (D. Nysewander, personal communication). The reason for this variability is unclear, although the timing of post-breeding dispersal of adult murres from coastal colonies is most likely an important variable. The at-sea density of common murres is highest in the fall (i.e., post-breeding, beginning late July/early August) on the outer coast (Briggs et al. 1992, Thompson 1997, 1999, unpublished data) and in Puget Sound (D. Nysewander, personal communication). The increase of murres in Washington waters following the breeding season is, in part, a result of post-breeding dispersal from colonies in Oregon (Warheit 1996, Thompson 1997, 1999), possibly California, and to a lesser extent, British Columbia and Alaska. Although murre distribution and abundance also varies substantially in time and location on the outer coast, total at-sea population estimates of murres on the outer coast were consistent in 2001 and 2002 ([mean, 95% CI] 2001: 72,840; 48,816 – 91,124; 2002: 74,011; 35,803 – 103,048; Thompson, unpublished data).

RATIONALE

The common murre is a State Candidate species. Carter et al. (2001) concluded that the common murre population dropped dramatically from approximately 26,000 in 1982 to 3,000 in 1983, coinciding with a severe El Niño-Southern Oscillation (ENSO) (Wilson 1991). This decline was mirrored at common murre colonies in California (Boekelheide et al. 1990) and Oregon (Hodder and Graybill 1985). However, unlike colonies in California and Oregon total attendance at Washington refuge colonies has not recovered to pre-1983 ENSO levels and has not exceeded 11,000 since that event. Wilson (1991) and Carter et al. (2001) suggested that the lack of recovery to pre-1983 numbers and low attendance within the NWRs may be the result of a combination of ENSOs, oil spills, gillnet mortality, and Naval disturbances at breeding colonies.
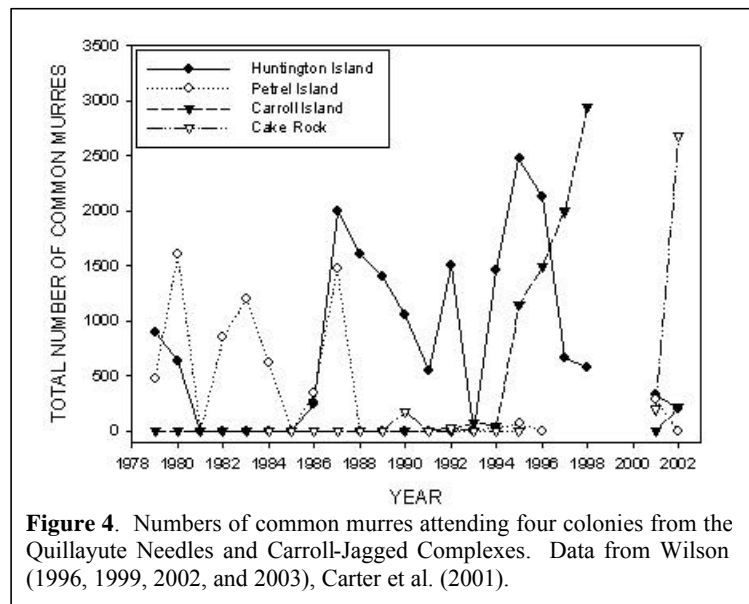

Figure 4. Numbers of common murres attending four colonies from the Quillayute Needles and Carroll-Jagged Complexes. Data from Wilson (1996, 1999, 2002, and 2003), Carter et al. (2001).

HABITAT REQUIREMENTS

Common murres require coastal cliff ledges or elevated marine terraces on islands or rocky headlands for breeding (Ainley et al. 2002). The habitat must be above the splash zone, inaccessible to terrestrial predators or pests (such as cats, rats, foxes, or raccoons), sufficiently windswept or elevated to permit takeoff and landing (Tuck 1961), and in "full ocean view" (Ainley et al. 2002:5). Common murres do not build nests, and each pair lays a single egg directly on the substrate, usually on bare rock, although on Tatoosh Island a subcolony of murres nested on soil near vegetation (salmonberry [*Rubus spectabilis*]; Parrish 1995, Parrish and Paine 1996). Common murres also require marine habitats with relatively abundant prey. Prey include Pacific herring (*Clupea harengus*), Pacific sandlance (*Ammodytes hexapterus*), northern anchovy (*Engraulis mordax*), rockfish (*Sebastes* spp.), salmon (*Oncorhynchus*

spp.), squid, and euphasids (Vermeer et al. 1987, Boekelheide et al. 1990, Ainley et al. 2002). Common murres require that breeding habitat be sufficiently close to productive foraging areas (e.g., oceanographic fronts, tidal sheers, upwelling plumes, shelf-break fronts, and runoff plumes; Ainley et al. 2002) so that repeated trips between the colony and prey sources can be made within a single day (foraging radius for common murres is approximately 60 km [37 mi]; see Ainley et al. 1991). Following the breeding season, common murres require only suitable marine habitat for foraging and resting, although murres may return to colony rocks prior to the breeding season. During this time murres are frequently seen close to shore (Ainley et al. 2002).

Diet

There have been only two detailed studies of the diet of common murres in Washington. The first study is based on the contents of the gastrointestinal tracts of common murres collected from salmon drift gill nets in the late summer and fall from 1993 through 1996 (Wilson 1998, Wilson and Thompson 1998, Lance and Thompson, in press). In this geographically limited study, common murres fed on Pacific herring (74.2 % frequency of occurrence), Pacific sandlance (45.8%), and salmonid species (21.9%). The proportion of these prey species in the diet of murres did not differ significantly between murre age classes (adult vs. subadult), gender, or among years. The mean lengths of Pacific herring and Pacific sandlance were not significantly different in the murre diet. Diet diversity within individual murres was low with most gastrointestinal tracts containing only one or two prey species. Based on the time of day in which Pacific herring and Pacific sandlance were present in murre esophagi and/or proventriculi, Wilson and Thompson (1998) and Lance and Thompson (in press) determined that murres fed most frequently on these two species at dusk (2100-2259 PST).

The second study included only the diet of chicks fed by adults at nest sites on Tatoosh Island (Parrish 1996 a, b, Parrish and Zador 2003, Thompson et al. 2003). The primary prey items fed to chicks were surf smelt (*Hypomesus pretiosus*), Pacific herring, Pacific sandlance, and eulachon (*Thaleichthys pacificus*) (Parrish and Zador 2003, Thompson et al. 2003).

LIMITING FACTORS

A variety of natural and human-induced factors can affect common murre populations. Colony attendance and reproductive success for murre populations along the west coast of North America have been affected by ENSO events (Hodder and Graybill 1985, Ainley and Boekelheide 1990, Wilson 1991). Additional natural factors that may affect murre abundance, distribution, and reproductive success include food availability, predation pressure, and the distribution of specific marine habitats (Briggs et al. 1987, 1992; Speich et al. 1987; Ainley and Boekelheide 1990; Allen 1994; Ainley et al. 1995; Parrish 1996a; Parrish and Paine 1996; Thompson 1997). Disturbance caused by aerial predators such as the bald eagle (*Haliaeetus leucocephalus*) can also negatively affect the reproductive success of breeding murres (Speich et al. 1987, Parrish 1995, 1996a, b; Parrish et al. 2001, Thompson et al. 2003; R. Lowe, personal communications).

Common murres are also vulnerable to drowning in fish-nets or becoming oiled during spills because they are gregarious on land and at sea (Burger and Fry 1993, DeGange et al. 1993, Warheit et al. 1997). In the last 10-20 years, there have been several oil spills in California, Oregon, and Washington, with two major spills in Washington resulting in substantial mortality to common murres. Murres were the most numerous seabirds affected in the *Tenyo Maru* and *Nestucca* oil spills off the coast of Washington (Ford et al. 1991, Momot 1995, *Tenyo Maru* Oil Spill Natural Resources Trustees 2000). Seabird mortality associated with gillnets in Washington and central California have shown a bias toward common murres (Takekawa et al. 1990, Erstad et al. 1994, Pierce et al. 1994, Thompson et al. 1998). Overall, in Washington, it is estimated that thousands of common murres have been killed in salmon gillnets and by oil spills (Ford et al. 1991, Momot 1995; Melvin and Conquest 1996; Warheit 1996; Melvin et al. 1997). Recreational fishing does not appear to be a threat to common murres in Washington (C. MacDonald and W. Beeghley, unpublished data); however, more research is necessary before any conclusions can be reached. The degree to which these factors affect the long-term stability of the population(s) of common murres in Washington is unknown.

Population Regulation

Population responses of a common murre colony to natural or human-induced environmental changes may depend on how that colony is reproductively linked to other colonies and how the overall population is geographically structured. There have been three studies particularly relevant to the geographic structure of common murres occurring from British Columbia south to California. First, Warheit (1996) estimated that 55–58% of common murres killed during the *Tenyo Maru* oil spill were from Washington (the remaining birds were from Oregon). These results indicate that at certain times of the year the Washington "population" of common murres is simply an association of birds from different geographic areas, and not necessarily an integrated breeding nexus. Second, Warheit (1999) stated that based on preliminary genetic analysis, there is little to no geographic structure to common murre populations from British Columbia to California, although there is a slight north-south gradient in allelic frequencies. These tentative conclusions also indicate that there is no evidence for a distinct Washington "population." Finally, Drovetski et al. (submitted) found a lack of geographic structure to mitochondrial DNA variation among common murres from Japan, Russia, Alaska, and California, and that the history of common murres in the Pacific is highlighted by local population declines and recovery through high migration and gene flow.

The results from the two genetic analyses suggest that common murres in Washington are part of a large and integrated metapopulation that includes, at a minimum, birds from Oregon and British Columbia. However, because both studies limited the Washington samples from one locality (near Tatoosh Island), neither contributes to our understanding of the geographic structure and demographics of common murres within Washington.

There are few data available to help determine what factors (natural or human-induced) are actually "regulating" common murre populations in Washington. Common murre abundance and distribution may be determined by factors such as migration from outside Washington (as the genetic data suggests), food distribution, or bald eagle predation or disturbance. Wilson (2003) has suggested that common murres in Washington are at their carrying capacity and that growth of this population is being limited by food. Parrish and Zador (2003) looked for correlations between a series of mechanisms and several measures of murre demographics and foraging behaviors. They concluded that although a central Oregon colony of murres (Yaquina Head) may be near carrying capacity, Washington colonies "probably exist well below carrying capacity," and at Tatoosh Island eagle predatory pressure is affecting several demographic parameters (Parrish and Zador 2003:1054). Without additional data on potential regulating factors, it is impossible to predict how a particular colony or population will be affected by events such as gillnet or oil spill mortality. In addition, without more inclusive data on common murre demographic parameters throughout Washington (such as survival, reproductive success, or dispersal from colonies in addition to Tatoosh Island) or information about common murre food habits and potential effects of climate change on prey distribution and abundance, it is difficult to design a comprehensive management or restoration plan for common murres in Washington.

MANAGEMENT RECOMMENDATIONS

To successfully manage the population(s) of common murres in Washington, additional baseline data are needed. Therefore, the following management recommendations consist of two parts. First, we will outline the priority research recommendations. Second, we list direct management activities that should be or have been implemented for the conservation of the breeding and at-sea populations of common murres in Washington.

Research and Monitoring Recommendations

1) *Breeding distribution and phenology, and reproductive success*: Tatoosh Island, and to a lesser extent Point Grenville (Thompson et al. 2003) are the only areas in Washington where definitive data have been collected on the basic reproductive parameters of common murres. Therefore, there are no extensive data on breeding phenology, reproductive success, or factors affecting reproductive success (e.g., food availability) available from murre colonies south of Tatoosh Island. This information is important to understanding the demographics of common murres in Washington and for implementing effective management programs.

2) *Geographic structure of population*: There are at least two aspects of the geographic structure of common murre populations in Washington that are important in designing management plans.

    a) <u>Dispersal</u>: The connectivity among colonies is based on the degree to which birds hatched in an area disperse to another area. If the dispersal rate among several areas is high, these areas function as one population, and natural recovery following a disturbance may be relatively quick due to the influx of immigrants. In these cases, management activities need to be directed at the population, rather than an individual colony. However, if a colony or area is isolated and few or no birds disperse to or from the colony, management activities need to be directed at the colony or area because recovery following disturbance must be through local recruitment and natal philopatry (i.e., birds that hatch at a colony and return to that colony to breed). Data on dispersal can be collected directly through the observation of banded birds and indirectly through genetic analyses of individuals from colonies throughout a particular geographic range. At this time our entire knowledge of the genetic structure of common murres from British Columbia to California is based on only four colonies.

    b) <u>Identification of origin of birds</u>: If common murres are geographically structured either within Washington or between Washington and other regions along the west coast, particular morphological or genetic markers may exist that can identify a bird from a specific colony or region. If such markers exist, it may be possible to identify the areas of origin (e.g., Washington versus Oregon) for common murres killed in oil spills or fishing nets in Washington marine waters (e.g., Warheit 1996, Edwards et al. 2001).

3) *Survival rates*: Adult and juvenile survival are important parameters in understanding the demographics of common murre populations (Nur et al. 1994). Although there are data on the survival rates for common murres from both the Atlantic and Pacific oceans (Hudson 1985, Harris and Wanless 1988, 1995; Sydeman 1993), no data are currently available from any Washington colony. Obtaining data on survival rates requires banding individual birds.

4) *Sources of mortality:* Researchers (Parrish 1996a, b; Parrish and Paine 1996; Parrish et al. 2001) studied the effects of eagle disturbance on survival and reproductive success of common murres on Tatoosh Island. This type of study should be conducted at other murre colonies in Washington, as was attempted at Point Grenville (Thompson et al. 2003). To better understand the effects of fishing bycatch mortality and oil spills on common murres in Washington, more data are needed on the number of individuals killed each year in all types of fishing gear (including recreational fishing) and in oil spills (including small-scale but chronic spills). Systematic and wide-ranging beach bird surveys are essential to document baseline mortality rates for marine birds in Washington. The Coastal Observation and Seabird Survey Team initiated such a comprehensive coastwide program in 1999 (Hass and Parrish 2000).

5) *Fisheries bycatch mortality*: More research is required to further reduce the number of birds killed in all kinds of fishing gear.

    a) <u>Pingers</u>: Melvin et al. (1997) conducted experiments on the use of audio devices (i.e., pingers) attached to gillnets as a method to reduce the rate by which seabirds become entangled. We recommend that new experiments be conducted on the use of pingers on 20 mesh nets.

    b) <u>Recreational fishery activities</u>: Based on one year of data, it appears that bycatch of common murres in recreational fishing lines are minimal (C. MacDonald and W.Beeghley, personal communications). Nevertheless, a more comprehensive, multi-year, and systematic study needs to be implemented to effectively evaluate this potential problem.

    c) <u>Monitoring</u>: Comprehensive monitoring of the at-sea distribution of common murres in Puget Sound, Strait of Juan de Fuca, the outer coast, and along the Oregon coast needs to be implemented and maintained; monitoring and surveying have been or are currently being conducted on Tatoosh Island (Paine et al. 1990, Parrish 1995) and on all colonies managed by USFWS (Speich et al. 1987, Wilson 1991, Briggs et al. 1992, Carter et al. 2001). These data should be used to determine seasonal murre abundance that might influence the regulation of a particular gillnet fishery. This information will also help determine potential injury from oil spills occurring in particular places at specific times of the year.

6) *Food habits*: Short- and long-term changes in food resources for common murres can result from factors such as ENSO events, Pacific Decadal Oscillation (Mantua et al. 1997, Minobe 1999), overfishing, and global climate change. Food shortages resulting from ENSO events have been documented to be associated with large die-offs of common murres in Washington (Good et al. 1999). Management plans must be designed that

incorporate this information. Detailed analysis of food habits for common murres in Washington is limited for most sites. Comprehensive studies of common murre food habits and foraging ecology are needed and should combine information gathered both at sea and at breeding colonies. These studies need to be long-term, multiyear endeavors, and should include analyses on diet, adult foraging rates, chick diet at nest sites, and information about the marine food web (in particular, the abundance, distribution, and life history of the primary prey species, and how these prey species might be affected by climate change). This type of comprehensive analysis was initiated in 2001 (Thompson et al. 2003), but the *Tenyo Maru* Oil Spill Trustee Committee terminated funding for this project after two years.

7) *Spatial factors affecting murre distribution*: As described in the Trends Section above, common murres have shifted their Washington distribution to the north (Figure 3), and have experienced irregular attendance at the Quillayute Needles and Carroll-Jagged Complexes (Figure 4). These spatial patterns are unmistakable and may relate to differences in local terrestrial and marine environments. Differences in factors such as food availability, human and eagle disturbance, and rates of predation need to be examined.

Direct Management Actions and Recommendations

1) *Reduce bycatch of common murres in Washington drift gillnets*: A considerable amount of research has been conducted in Washington to determine the degree to which seabirds, in particular common murres, are caught in non-treaty salmon drift gillnets (Erstad et al. 1994, 1996; Pierce et al. 1994; Thompson et al. 1998). In addition, researchers (Melvin and Conquest 1996, Melvin et al. 1997) have developed procedures to reduce seabird bycatch in drift gillnets. Because thousands of murres are potentially killed by gillnets each year (Thompson et al. 1998), specific management activities to reduce this mortality are warranted. The Washington Fish and Wildlife Commission adopted procedures and commercial fishing regulations designed to reduce the bycatch of seabirds, particularly common murres and rhinoceros auklets, in gillnets (Washington Department of Fish and Wildlife 1997). These regulations set the following gillnet design standards and timing restrictions to reduce mortality associated with gillnets:
   a) Net design: The monofilament line in the first 20 meshes below the corkline of nets must be replaced with #12 white twine which is more visible to diving birds. Melvin et al. (1997) showed that the 20 mesh nets (but with thicker #18 white twine) significantly reduced seabird bycatch without significantly reducing fishing efficiency.
   b) Length of season: The Department of Fish and Wildlife was authorized to end the 1997 sockeye and pink salmon gillnet fisheries in northern Puget Sound (Areas 7/7a) when the number of seabirds in the fishing area became abundant in order to eliminate common murre bycatch. This authority should be extended to future years.
   c) Fishing hours: The Commission eliminated early morning (change-of-light period) and most night fishing to reduce the time in which fishers would be unable to see and thereby avoid flocks of birds; the designated open fishery was from 1.5 hours after sunrise to midnight.
   d) Educational programs: Although the Commission's new regulations did not require the implementation of educational programs, the Commission's goals may be best met through programs designed to instruct the commercial fishing fleet in Washington on how best to avoid encountering seabirds.

2) *Reduce effects from oil spills*: Oil spills are usually accidents and as such are difficult to plan and manage. Nevertheless, activities can be employed to reduce the probability and negative effects of an oil spill. The Washington Departments of Ecology and Fish and Wildlife are addressing the following:
   a) Spill prevention through vessel and facility inspections
   b) Coordinated spill response and injury assessment
   c) Restoration planning and implementation
   d) Oiled wildlife rescue capabilities
   e) Industry and coast guard drills and geographic response plans to enhance spill response activities

3) *Reduce human disturbance at breeding colonies*: Human disturbance through activities such as kayaking, boating, or aircraft overflights can disturb nesting common murres and affect local recruitment and productivity (Speich et al. 1987, Parrish 1996b, Warheit et al. 1997). As provided in the *Nestucca* oil spill restoration plan (Momot 1995), the USFWS will inform citizens about the sensitivities of seabird breeding colonies at NWR sites in Washington through brochures and signs/posters displayed prominently at commercial, private, and

public boat launches and marinas, and in refuges and parks. These brochures and signs will also inform the public that it is illegal to harass seabirds and to enter onto a NWR island without proper authorization. The *Tenyo Maru* Oil Spill Trustee Committee has implemented a similar program in Oregon and the Cape Flattery – Tatoosh Island area in Washington (*Tenyo Maru* Oil Spill Natural Resources Trustees 2000). Finally, although the use of brochures and signs promises to reduce disturbance at specific colonies, other factors such as aircraft ceiling violations over specific common murre colonies (e.g., Tatoosh Island; Parrish 1996b) need to be addressed through a combination of educational programs and enforcement of existing laws and regulations.

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KEY POINTS

Habitat Requirements

- Requires for breeding coastal cliff ledges or elevated marine terraces on islands or rocky headlands that are inaccessible to terrestrial predators.
- Lays a single egg directly on the substrate, usually on bare rock.
- Requires breeding habitat to be sufficiently close to productive foraging areas.
- In the eastern Pacific, preys upon Pacific herring, Pacific sandlance, northern anchovy, rockfish, salmon, squid, and euphasids.
- In Washington, chicks are fed surf smelt, Pacific herring, Pacific sandlance, and eulachon by adults at the nest site.
- Dietary diversity of individual murres tends to be low.
- Requires only suitable marine habitat for foraging and resting following the breeding season. However, murres may return to colony rocks prior to the breeding season.

Management Recommendations

Research and Monitoring Recommendations
- Collect data on breeding phenology, reproductive success, and factors affecting reproductive success in Washington to support the implementation of more effective management programs.
- Gather comprehensive data to determine the rate of dispersal among colonies to better focus management efforts. Identification of genetic markers to track the origin of individual murres is also important.
- Collect survival data to more accurately understand murre demographics in Washington.
- Conduct comprehensive surveys to better understand the effects of various sources of mortality (e.g., natural mortality, bycatch, oil spills).
- Carry out additional research and monitoring efforts that will help identify ways to further reduce the number of birds killed in fishing gear.
- Develop and conduct comprehensive studies of murre food habits and foraging ecology. These studies should combine information gathered both at-sea and at breeding colonies.
- Examine spatial factors affecting murre distribution. Differences in factors such as food availability, human and eagle disturbance, and rates of predation need to be examined.

Direct Management Actions and Recommendations
- Replace the monofilament line in the first 20 meshes below the corkline of nets with #12 white twine which is more visible to diving birds. 20 mesh nets (but with thicker #18 white twine) significantly reduced seabird bycatch without significantly reducing fishing efficiency.
- Extend the Fish and Wildlife Commission's authority to end certain fishing seasons when the number of seabirds in a fishing area becomes abundant.
- Design programs to instruct commercial fishing fleets on how to best avoid seabird bycatch.
- Resource agencies should continuously improve their capabilities to reduce the effect of oil spills through various means (e.g., vessel and facility inspections, coordinated spill response and injury assessments, restoration, wildlife rescue).
- Reduce human disturbance at breeding colonies caused by activates such as kayaking, boating, or aircraft overflights.
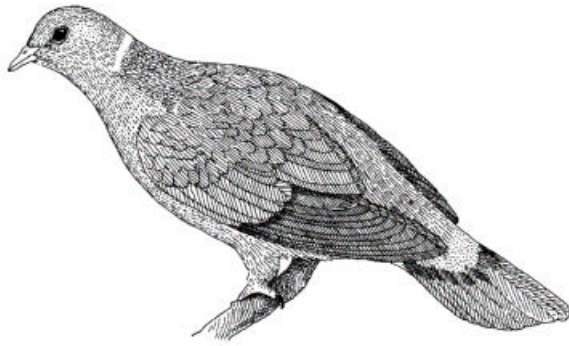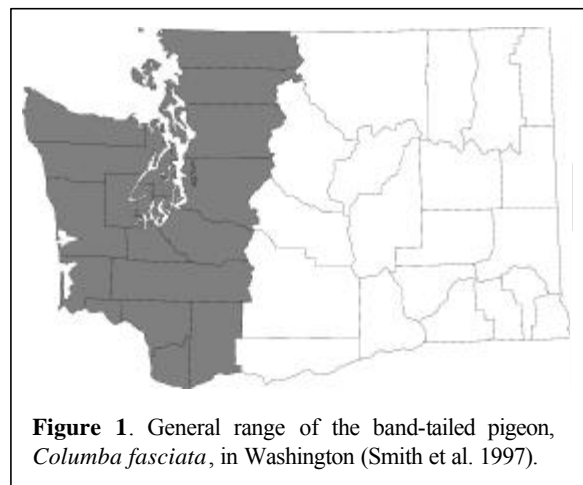
Band-tailed Pigeon
Columba fasciata

Last updated: 2003

Written by Jeffrey C. Lewis, Michelle Tirhi, and Don Kraege

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Band-tailed pigeons are primarily restricted to coniferous forest zones in mountainous areas of western North America (Jarvis and Passmore 1992). Braun (1994) recognized two races of band-tailed pigeons in North America. The interior race (*Columba fasciata fasciata*) breeds primarily in the Rocky Mountains south of Wyoming, whereas the Pacific Coast race (*Columba fasciata monilis*) breeds west of the Cascade and Sierra Nevada crests [up to 4,200 m (13,800 ft) elevation; Pacific Flyway Council 1983] from British Columbia and southeastern Alaska south to Baja California, Mexico.

Figure 1. General range of the band-tailed pigeon, *Columba fasciata*, in Washington (Smith et al. 1997).

The bulk of Pacific Coast population of band-tailed pigeons winters from south of Redding, California through Mexico (Schroeder and Braun 1993); however, year-round residents occur in the Pacific Northwest (Jarvis and Passmore 1992). Schroeder and Braun (1993) found that some interchange occurs between the Pacific coast and interior races.

Band-tailed pigeons reside mainly in western Washington (see Figure 1) and are typically located around mineral springs and seeps (Keppie and Braun 2000). The highest densities occur on the Olympic Peninsula and on Washington=s southern coast (Grays Harbor, Pacific, and Wahkiakum counties). During the breeding season (April - September), most of the population is found below 305 m (1,000 ft) elevation (Jeffrey 1989). In late summer, band-tailed pigeons may move to higher elevations. By late September, most band-tailed pigeons leave Washington and migrate to their wintering grounds. However, year-round residents are known to occur in the Puget Sound as far north as Seattle (B. Tweit, personal communication).

RATIONALE

Band-tailed pigeons are listed as a State and Federal Game species. The hunting season in Washington underwent an emergency closure in 1991 due to a rapid decline in the population as determined from pigeon surveys (Braun 1994). Breeding Bird Survey data indicated the population of band-tailed pigeons in Washington declined significantly from 1968 to 1993 (Braun 1994, Keppie and Braun 2000). However, more recent data showed increases in population that allowed the reinstatement of a limited hunting season in 2002, after a 10-year restriction on hunting (Washington Department of Fish and Wildlife 2001, 2002).

Band-tailed pigeons require mineral springs close to a food source during the breeding and brood-rearing season (Jarvis and Passmore 1992). A scarcity of mineral sites combined with the alteration of available nesting habitat jeopardizes band-tailed

pigeon populations (Braun 1994). Intensive hunting pressure in the past has also been held responsible for declines in the population (Jarvis and Passmore 1992).

HABITAT REQUIREMENTS

In Washington, band-tailed pigeons are associated with Douglas-fir (*Pseudotsuga menziesii*), red alder (*Alnus rubra*), western hemlock (*Tsuga heterophylla*), red cedar (*Thuja plicata*), bigleaf maple (*Acer macrophyllum*), sitka spruce (*Picea sitchensis*), willow (*Salix* spp.), pine (*Pinus* spp.), cottonwood (*Populus* spp.), and Garry oak (*Quercus garryana*) (Jeffrey 1989, Braun 1994). Berry- and nut-producing trees and shrubs are also common in their range (Keppie and Braun 2000).

Breeding Season

During the breeding season (April - September), band-tailed pigeons are found in mixed conifer and hardwood forests interspersed with younger wooded areas or small fields (Jeffrey 1977, 1989). Abundant food and mineral sources are necessary during this time (Jarvis and Passmore 1992). Nesting habitat in western Oregon is dominated by closed-canopy, conifer forests (mostly Douglas-fir) in sapling-pole forest development stages (Leonard 1998). Nests are placed in conifers or broad-leafed trees, typically 4.5-12.0 m (15-40 ft) above the ground. Nests may be distributed in small groups or well-dispersed (Jeffrey 1977, Curtis and Braun 1983). In Oregon, average home range size during the nesting season was 11,121 ha. (Leonard, 1998).

Band-tailed pigeons seek sources of mineral salts (especially calcium) necessary for egg production and the production of "crop milk" for feeding young (March and Sadleir 1975, Jarvis and Passmore 1992, Braun 1994). Mineral salts are found in mineral springs and marine shorelines, and occasionally livestock salt blocks are used (Jeffrey 1977). Pigeons have been documented returning to mineral springs in subsequent years (Jarvis and Passmore 1977, 1992).

Food

During spring migration, this herbivorous bird feeds on acorns, buds, blossoms, young leaves and needles, fruits, and berries (Jeffrey 1977). Primary food sources include Cascara buckthorn (*Rhamnus purshiana*), elderberry (*Sambucus* spp.), wild cherry (*Prunus* spp.), huckleberry (*Gaylussacia* spp.), madrone (*Arbutus menziesii*), dogwood (*Cornus* spp.), and oak (*Quercus* spp.) in late spring and summer (Jeffrey 1977). Pacific red elderberry (*Sambucus callicarpa*), blue elderberry (*Sambucus cerulea*), and cascara buckthorn were determined to be important food items in the Northwest because of their high caloric, calcium and protein content (Jarvis and Passmore 1992, Keppie and Braun 2000, Sanders 2000). During the spring and summer, newly planted fields or stubble containing grains from the fall harvest are also preferred food sources (Jarvis and Passmore 1992, Braun 1994, Keppie and Braun 2000).

During fall and winter, band-tailed pigeons feed on acorns, nuts, berries, grains and fruits (Fry and Vaughn 1977, Jeffrey 1989). Pigeons often move to high elevation meadows in the fall prior to migration (Jeffrey 1989). In the Oregon coastal range, primary feeding sites for radio-marked band-tailed pigeons were located in riparian or moist bottomlands (Leonard 1998). Nestlings feed on "crop milk" which is later supplemented by other regurgitated crop contents from either parent (Keppie and Braun 2000).

LIMITING FACTORS

Land development and forest practices that degrade or destroy mineral springs and nesting habitat limit band-tailed pigeon populations (Pacific Flyway Council 1983). Although undocumented mineral sites likely occur, only a limited number of mineral sites actively used by pigeons are known to exist in western Washington (Gillum 1993). A lack of berry/mast-producing plants may also limit use of areas by band-tailed pigeons (D. Kraege, personal communication).

Band-tailed pigeons lay a single egg 1 to 3 times per year (Leonard 1998); thus, their productivity is considered low. Intensive hunting of band-tailed pigeons can be detrimental (Neff 1947; D. Kraege, personal communication), especially at mineral sites where breeding adults are more abundant than juveniles during the hunting season (Jarvis and Passmore 1992).

Outbreaks of the protozoan disease Trichomoniasis are suspected in periodic large-scale mortalities of band-tailed pigeons (Keppie and Braun 2000). Trichomoniasis is transmitted through contaminated feed at urban bird feeders and possibly through contaminated mineral springs (D. Kraege, personal communication).

MANAGEMENT RECOMMENDATIONS

To adequately conserve nesting habitat, mineral springs and other mineral sources used by band-tailed pigeons should be protected (Braun 1994). Trees surrounding mineral sites are important for perching (Pacific Flyway Council 2001), and their removal should be avoided. Mineral sources may be enhanced by removing dense vegetation that could limit bird access. Because mineral sites are uncommon, they should be a high priority for conservation-oriented acquisitions.

Large clearcuts should be discouraged in band-tailed pigeon habitat (Jeffrey 1977). Clearcuts should be replanted with a variety of species rather than a single tree species. Berry/mast- producing shrubs and trees are important food sources and should be maintained and enhanced, particularly those close to mineral sources and higher elevation areas used during migration (Braun 1994).

The use of herbicides that eliminate food producing shrubs and trees should be discouraged, particularly in stands containing the important food sources described by Jeffrey (1977). Modern silvicultural practices, including the use of herbicides to control deciduous shrubs and trees, have potentially reduced food-producing plants throughout the range of the band-tailed pigeon (Braun 1994). Landowners are encouraged to use integrated pest management strategies that target specific pests or weeds, use pest population thresholds to determine when to use pesticides or herbicides, and to use crop rotation/diversity and beneficial insects to control pests (Stinson and Bromley 1991). If pesticide or herbicide application is planned for areas used by band-tailed pigeons, refer to Appendix A for a list of contacts to consult when using and assessing pesticides, herbicides and their alternatives.

People maintaining bird feeders should regularly clean feeders and report all sick and dying band-tailed pigeons to the nearest Washington Department of Fish and Wildlife regional office, the U.S. Fish and Wildlife Service regional headquarters, or to the USGS Wildlife Health Research Center at (608) 271-4640 (D. Kraege, personal communication).

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KEY POINTS

Habitat Requirements

$ Band-tailed pigeons are associated with Sitka spruce, red cedar, western hemlock, red alder, bigleaf maple, Douglas-fir, willow, pine, cottonwood, Garry oak, and other berry- and nut-producing trees and shrubs.
$ Mixed conifers and hardwoods with a good interspersion of different forest development stages and openings, abundant food resources, and mineral springs are necessary during the breeding and brood-rearing seasons.
$ Band-tailed pigeons feed on grains, acorns, nuts, buds, blossoms, young leaves, needles, and the fruits and berries of several trees and shrubs.

Management Recommendations

$ Protected and/or enhance mineral springs and other mineral sources used by band-tailed pigeons. These areas should be a high priority for conservation-oriented acquisition.
$ Avoid removal of trees surrounding mineral sites.
$ Avoid large clearcuts in band-tailed pigeon habitat.
$ Replant clearcuts with multiple tree species. Maintain and enhance berry-, fruit-, and nut-producing shrubs and trees in band-tailed pigeon habitat.
$ Avoid using herbicides that eliminate local food producing trees and shrubs and use integrated pest management within band-tailed pigeon habitats when possible. If pesticide or herbicide use is being considered for areas used by band-tailed pigeons, refer to Appendix A for a list of contacts to consult to assess pesticides, herbicides and their alternatives.
$ Report sick and dying band-tailed pigeons (indicating Trichomoniasis disease) to the nearest Washington Department of Fish and Wildlife regional office, the U.S. Fish and Wildlife Service regional headquarters, or to the USGS Wildlife Health Research Center at (608) 271-4640.
$ Avoid maintaining bird feeders in urban areas where Trichomoniasis outbreaks have been documented and regularly clean feeders.

Burrowing Owl

Athene cunicularia

Last updated: 2003

Written by Noelle Nordstrom

GENERAL RANGE AND WASHINGTON DISTRIBUTION

The breeding range of the burrowing owl includes southern Canada from southern British Columbia eastward to south-central Manitoba, and extends as far south as Mexico (Haug et al. 1993). This species was extirpated from British Columbia but was reintroduced into the province in 1983. In Washington, burrowing owls typically occupy shrub-steppe habitat of the eastern part of the state during the breeding season (see Figure 1; Bryant 1990).

Burrowing owls winter mainly in the southern United States, central Mexico and Central America (Zarn 1974). Little information is available on the migration routes and times or wintering areas used by burrowing owls (Haug et al. 1993).

Figure 1. General range of the burrowing owl, *Athene cunicularia*, in Washington. Map derived from Washington Department of Fish and Wildlife data files and GAP Analysis of Washington.

Recent banding data have shown that some owls overwinter in eastern Washington (Conway et al. 2002). Additionally, a resident owl was recently found with eggs that were produced in late February (C. Conway, personal communication). Most burrowing owls from Canada and the northern United States are believed to migrate south in September and October. The northern migration to the breeding grounds is thought to occur from March through the first week of May (James and Ethier 1989, James 1992, Haug et al.1993).

RATIONALE

The burrowing owl is a State Candidate species and a Federal Species of Concern that was once widespread throughout steppe and prairie communities of North America. Currently, the burrowing owl is declining throughout much of its range in the western United States and Canada (Bent 1961, Holroyd and Wellicome 1997, Sheffield 1997). Breeding Bird Survey data for the Columbia Plateau indicate increasing populations, although this estimate is considered imprecise (Sauer et al. 2001).

HABITAT REQUIREMENTS

Burrowing owls inhabit open, dry areas in well-drained grasslands, shrub-steppe, prairies and deserts (Martin 1973). They also nest on agricultural lands and suburban areas (Haug et al. 1993). They use burrows for nesting, shelter, protection from predators and to reduce exposure to extreme temperatures (Zarn 1974, Winchell 1994). Although they are capable of digging, burrowing owls usually depend on abandoned burrows excavated by burrowing rodents such as prairie dogs (*Cynomys* spp.) and ground squirrels (*Citellus* spp.), or by larger mammals such as badgers (*Taxidea taxus*), foxes (*Vulpes* spp.) or coyotes (*Canis latrans*) (Mutafov 1992). In the Pacific Northwest, nesting burrowing owls often use unoccupied badger dens (Green and Anthony 1989).

The primary habitat characteristics preferred by burrowing owls include a complex of available burrows, short and/or sparse vegetation that provides good visibility, and adequate populations of prey species (Haug et al. 1993). Soil type affects the life and reusability of nesting burrows (Green and Anthony 1989, Holmes et al., in press). Specifically, the friable nature of sandy soils results in relatively high rates of burrow failure due to erosion and trampling by livestock. Silt-loam soils are more structurally stable and less likely to fail than are soils with a sand component.

Although badgers provide nesting sites for burrowing owls in Washington, they also are one of the owl's main predators (Haug et al. 1993). Burrowing owls line their nests with shredded livestock or ungulate dung, which may reduce nest predation by masking the owl's scent (Martin 1973, Zarn 1974, Green and Anthony 1989). However, several research teams have recently examined the use of dung by owls and found that this conclusion may not be true (C. Conway, personal communication).

Burrowing owls appear at breeding sites in February, and hatchlings emerge in May (C. Conway, personal communication). Recent observations suggest that resident owls initiate nesting earlier than migratory owls (C. Conway, personal communication). Incubation lasts approximately 28 days, and owlets emerge from the burrow about 2 weeks after hatching. At 2 to 3 weeks, the young begin to use other burrows near their nest burrow (C. Conway, personal observation). Paired owls will use up to 10 auxiliary burrows that are within 90 m (300 ft) of their primary nesting burrow (Climpson 1977). These auxiliary burrows are used to provide escape cover from predators, as secondary burrows for fledgling owlets and as alternates if the primary nest becomes heavily infested with parasites (Winchell 1994). Nests may also be located in natural cavities in small rock outcrops (Rich 1986). Nest burrows are often reused in successive years (Haug et al. 1993, Lutz and Plumpton 1999). There are no known records for a second brood during the breeding season in Washington (Haug et al. 1993).

The number of available burrows is not the only factor owls use to select a breeding site. They also look for areas that are open, with short and/or sparse vegetation and good horizontal visibility to see predators and locate prey (Green and Anthony 1989). In areas containing shrubs, they choose nesting burrows located near perches (Martin 1973, Green and Anthony 1989). Burrowing owls hunt by chasing prey items on foot or by catching them in the air (Haug et al. 1993). Their diet changes throughout the day, with insects most often caught during daylight and mammals preyed upon after dark (Martin 1973, Plumpton and Lutz 1993a).

Food availability and quality is likely to affect nesting densities of these owls for a given location (Desmond and Savidge 1996). Burrowing owls are opportunistic feeders, but they consume mostly insects and mammals (Green and Anthony 1989). Other prey species include birds, amphibians and reptiles (Zarn 1974, Gleason and Craig 1979, Mutafov 1992, Haug et al. 1993). Green and Anthony (1989) found a seasonal variation in diets, with rodents making up most of the owl's diet in the spring, and then shifting their diet almost exclusively to insects during the summer.

LIMITING FACTORS

Human activities that eliminate nesting and foraging habitat are likely the primary cause of this species decline (Haug et al. 1993, Sheffield 1997, Belthoff and King 2002). Intensive cultivation of shrub-steppe, grasslands and native prairies has long been recognized as a primary cause of the declining burrowing owl population (Haug et al. 1993). Agriculture and other development also expose owls to pesticides and increase their vulnerability to predation (Haug et al. 1993, Sheffield 1997). Although some burrowing owls take advantage of crop fields to exploit abundant food sources during the winter, intensive cultivation of native grasslands is a suggested cause of declines in populations of breeding owls (Haug et al. 1993). The burrowing owl is also limited

by the availability of mammal burrows. Additional mortality has been attributed to collisions with automobiles and shooting (Butts 1973, Haug et al. 1993).

Habitat Alteration

Although not all nesting burrowing owls use multiple burrows, some nests are associated with multiple burrows in close proximity to one another (Holmes et al., in press). The availability of burrows is reduced directly by destroying them (e.g., trampling of burrows by livestock and diking/tilling) and indirectly by eliminating or reducing the numbers of the animals that excavate the burrows (Haug et al. 1993). Burrow destruction by humans and dogs also occur. Thomsen (1971) estimated that 65% of the damaged burrows at her study site were caused by humans and 20% by domestic dogs. Large-scale efforts to control burrowing mammal populations can harm burrowing owls in areas where they rely on rodent burrows (Butts 1973, Holroyd et al. 2001).

Pesticides

Pesticides (specifically insecticides and rodenticides) can harm burrowing owls by causing direct mortality or sublethal effects such as decreased body weight and low reproductive success (Haug et al. 1993, Sheffield 1997, Holroyd et al. 2001). Indirect problems such as a decrease in available prey also occurs (James and Fox 1987). Burrowing owls are susceptible to secondary poisoning from insecticides and rodenticides because they feed on carcasses of poisoned prey species (Haug et al. 1993).

Direct exposure to carbofuran, a carbamate insecticide used to control grasshoppers, can significantly impact the survival and reproductive success of burrowing owls (James and Fox 1987, Mutafov 1992). When carbofuran (Furadan 480F) was applied over nest burrows, the number of young was reduced by 83% and nesting success was reduced by 82% (Mutafov 1992). In some instances, sprayed areas were less frequently occupied the following year by burrowing owls.

James et al. (1990) studied the control of ground squirrels with strychnine and its impacts on burrowing owls in southern Saskatchewan. They found, at least in the short term, no direct lethal effects on breeding burrowing owls. Adult survival, breeding success and chick weights were virtually the same in both treated and untreated areas. However, adult owls weighed significantly less in the treated versus the control sites, suggesting a sublethal effect on the species. Winchell (1994) states that nuisance rodent species can be baited or fumigated safely if care is taken not to treat burrows used by owls. However, even if burrowing owls escape inadvertent poisoning, their numbers will likely decrease because fewer burrowing mammals are creating new excavations for owl nesting and because of reduced available prey (C. Conway, personal communication).

Other Human Disturbances

Burrowing owls seem tolerant of human presence. However, Millsap and Bear (1988) found that reproductive success of burrowing owls in Florida was less at sites where home construction was taking place than at sites adjacent to construction, or where construction was absent.

Burrowing owls can also apparently become accustomed to vehicular traffic. However, nesting near roads may increase burrowing owl road kills. Plumpton and Lutz (1993b) found that vehicular traffic on roads near nesting sites did not create disturbance significant enough to influence the behavior of nesting owls. Unfortunately, owls frequently sit and hunt on roads at night, and collisions with vehicles occur frequently (Mutafov 1992).

Competition

Green and Anthony (1989) conducted a two-year study of 76 burrowing owl nests in the north-central Oregon and found nesting success to be only 57% the first year and 50% the second. Desertion was the primary reason for nest failure, which may have been related to the proximity of other nesting owls. Nestling mortality was greatest when pairs nested closer than 110 m (360 ft) apart. Green and Anthony (1989) suggested that in the Columbia Basin, nest sites were both clumped and scarce, forcing owls to nest too closely. If food sources are scarce, competition may then be strong enough to force some pairs to abandon their nests. Bryant (1990) found that competition might also limit the nesting success and return rates of burrowing owls reintroduced to areas

they historically occupied. Owls returning to their breeding grounds selected burrows as far away from neighboring owls as possible.

MANAGEMENT RECOMMENDATIONS

Protect Existing Habitat

Important ecological characteristics of areas used by burrowing owls should be maintained (Sheffield 1997). This includes preserving areas of native vegetation (e.g., shrub-steppe) and protecting burrowing mammal species (e.g., ground squirrels, badgers that create nesting habitat) for burrowing owls (Holroyd et al. 2001, Holmes et al., in press). Colonies of burrowing mammals should be preserved in areas where burrowing owls occur.

Nesting and satellite burrows should be protected from disturbance (Winchell 1994). Problems such as agricultural equipment collapsing burrow entrances and the inadvertent application of pesticides to occupied burrows can be reduced by placing markers near the burrows (Zarn 1974). Rangelands with sandy soils are especially prone to destruction of burrows by livestock (Holmes et al., in press). Where damage to burrows is likely or occurring, changes should be made in stocking rates, duration and/or season of grazing.

Activities such as oil and gas exploration and development, or other sources of human disturbance, should be restricted within 0.8 km (0.5 mi) of burrowing owl nests between 15 February and 25 September (T. Lloyd, personal communication; C. Conway personal communication). Direct destruction of burrows through chaining (dragging a heavy chain over an area to remove shrubs), cultivation, and urban, industrial, or agricultural development should be entirely avoided. Irrigation troughs should be regularly maintained because burrows often flood as a result of leaking irrigations systems (C. Conway, personal communication).

Local and regional government programs should be reviewed to ensure they address long-term conservation of burrowing owl habitat (Holroyd et al. 2001). Specifically, critical areas protection that fall under Washington's Growth Management Act could be a useful tool to conserve species, such as the burrowing owl, that are limited by loss of native habitat. Local development regulations could be designed to require mitigation and provide incentives to reduce potential impacts to this species resulting from proposed projects in owl habitat. Many resource agencies, including WDFW, have staff that can provide recommendations to assist in critical areas planning.

Pesticides

Insecticides and rodenticides are likely to harm burrowing owls directly through poisoning as well as indirectly by reducing populations of burrowing mammals (Holroyd et al. 2001). Therefore, it is recommended that alternatives should be researched thoroughly before resorting to their use. If pesticide use is planned for areas where burrowing owls occur, refer to Appendix A for contacts that can help evaluate pesticides and their alternatives.

Insecticides used in grasshopper control programs, especially carbofuran, have been shown to reduce reproductive productivity in burrowing owls. Carbofuran should not be applied within 250 m (820 ft) of active burrowing owl nests (Haug et al. 1993). Active burrowing owl nests should not be directly sprayed with any pesticide (James and Fox 1987, Lynch 1987).

Fumigation, treated bait or other means of poisoning nuisance animals should not be used in areas where burrowing owls occur. Burrowing owls are likely to scavenge the carcasses of poisoned rodents, making the owls potentially vulnerable to indirect poisoning (Sheffield 1997).

In cases where there are no alternatives to controlling burrowing mammals with poisoned bait or fumigation, thoroughly survey the area for burrowing owls during the nesting season (March through September) (Zarn 1974). Identify and mark nesting and satellite burrows by observing sentry owls, owl droppings and tracks, pellets, and dry, shredded animal dung. The use of treated grain to poison mammals should be restricted to the months of January and February (Butts 1973, Zarn 1974).

Mitigation

Artificial nest burrows are useful for expanding the capacity of existing nesting sites, and in transplant operations where burrowing owls are reintroduced into parts of their former range (Thomson 1988). Artificial burrows can also give researchers opportunities to study burrowing owl nesting ecology without destroying existing burrows (Bryant 1990, Olenick 1990, Haug et al. 1993). Dring (2000) and Green and Anthony (1997) have published papers that touch upon the design and use of artificial nesting burrows. State or federal wildlife agencies should be consulted for additional guidance prior to using artificial nesting burrows.

Artificial perches such as fence posts or stakes can be used in areas where vegetation is greater than 5 cm (2 in) tall (Green and Anthony 1989). Several perches scattered throughout the nesting area should benefit this species. Additionally, these and other mitigation measures could be incorporated into local critical areas ordinances where this species exists.

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KEY POINTS

Habitat Requirements

- Burrowing owls inhabit open, dry areas in well-drained grasslands, shrub-steppe, prairies and deserts. They also nest on agricultural lands and suburban areas.
- Preferred characteristics of burrowing owl habitat include a complex of available burrows, short and/or sparse vegetation that provides good visibility, and an adequate availability of prey.

Management Recommendations

- Preserve areas of native vegetation (e.g., shrub-steppe) used by the burrowing owl.
- Protect populations of badgers and other burrowing mammals that provide nesting habitat for burrowing owls.
- Direct local and regional government programs and policies (e.g., critical areas regulations) to ensure the survival of species, such as the burrowing owl, that are limited by loss of native habitat.
- Refer to Appendix A for contacts that should be used when evaluating pesticides and their alternatives. Insecticides and rodenticides have the potential to harm burrowing owls, and it is recommended that alternatives should be carefully considered before resorting to their use.
- Carbofuran should not be applied within 250 m (820 ft) of active burrowing owl nests. Active burrowing owl nests should not be directly sprayed with any pesticide.
- Fumigation, treated bait or other means of poisoning nuisance animals should not be used in areas where burrowing owls occur. Burrowing owls are likely to scavenge the carcasses of poisoned rodents and are potentially vulnerable to secondary poisoning.
- If there are no alternatives to controlling burrowing mammals with poisoned bait or fumigation, survey for burrowing owls during the nesting season (March through September). Identify and mark burrows used by owls by observing sentry owls, owl droppings and tracks, pellets, prey remains and burrows lined with dried animal feces.
- If all alternatives have been exhausted, poisoning of burrowing mammal colonies with treated grain should be restricted to January and February to minimize harmful effects to burrowing owls.
- Protect both nesting and auxiliary burrows from disturbance. Markers placed at burrows can direct earth moving and other heavy equipment away from burrowing areas and help prevent the collapse of underground passages. In addition, markers can help direct pesticide applications away from occupied burrows.
- Where damage to burrows from livestock trampling is likely or is occurring already, changes should be made in stocking rates, duration and/or season of grazing.
- Restrict activities such as oil and gas exploration and development or other sources of human disturbance within 0.8 km (0.5 mi) of burrowing owl nests between 15 February and 25 September. Direct destruction of burrows by urban, industrial or agricultural development should be avoided entirely.
- Artificial nest burrows can be used to expand the capacity of existing nesting sites and can aid in the reintroduction of owls into parts of their former range.
- Artificial perches, such as fence posts or stakes can be used in areas where vegetation is greater than 5 cm (2 in) tall. Several perches scattered throughout the nesting area might be required to benefit this species.

Flammulated Owl
Otus flammeolus

Last updated: 2003

Written by David W. Hays and Elizabeth A. Rodrick

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Flammulated owls are found in mountainous areas of western North America from Guatemala to Canada (American Ornithologists' Union 1983).

In Washington, they are breeding residents along the eastern slope of the Cascades, Okanogan Highlands and Blue Mountains. (see Figure 1; Smith et al. 1997).

RATIONALE

The flammulated owl is a State Candidate species. Limited research on the flammulated owl indicates that its demography and life history, coupled with narrow habitat requirements, make it vulnerable to habitat changes. The mature and older forest stands that are used as breeding habitat by the flammulated owl have changed during the past century due to fire management and timber harvest.
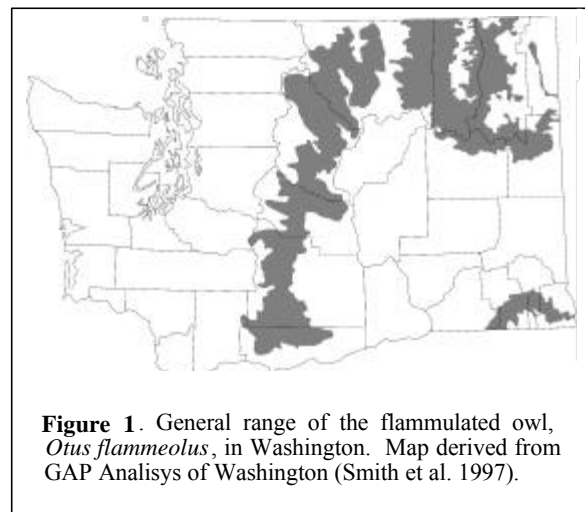
Figure 1. General range of the flammulated owl, *Otus flammeolus*, in Washington. Map derived from GAP Analisys of Washington (Smith et al. 1997).

HABITAT REQUIREMENTS

Flammulated owls are typically found in mid-elevation coniferous forests containing mature to old, open canopy yellow pine (ponderosa pine [*Pinus ponderosa*] and Jeffrey pine [*Pinus jeffreyi*]), Douglas fir (*Pseudotsuga menziesii*), and grand fir (*Abies grandis*) (Bull and Anderson 1978, Goggans 1986, Howie and Ritchie 1987, Reynolds and Linkhart 1992, Powers et al. 1996). In central Colorado, Linkhart and Reynolds (1997) reported that 60% of the habitat within the area defended by territorial males consisted of old (200-400 year) ponderosa pine/Douglas-fir forest. Territories most consistently occupied by breeding pairs (>12 years) contained the greatest (>75%) amount of old ponderosa pine/Douglas-fir forest. Marcot and Hill (1980) reported that California black oak (*Quercus kellogii*) and ponderosa pine occurred in 67% and 50%, respectively, of the flammulated owl nesting territories they studied in northern California. In northeastern Oregon, Bull and Anderson (1978) noted that

ponderosa pine was an overstory species in 73% of flammulated owl nest sites. Powers et al. (1996) reported that ponderosa pine was absent from their flammulated owl study site in Idaho and that Douglas-fir and quaking aspen (*Populus tremuloides*) accounted for all nest trees.

The owls nest primarily in cavities excavated by flickers (*Colates* spp.), hairy woodpeckers (*Picoides villosus*), pileated woodpeckers (*Dryocopus pileatus*), and sapsuckers (*Sphyrapicus* spp.) (Bull et al. 1990, Goggans 1986, McCallum 1994). Bull et al. (1990) found that flammulated owls used pileated woodpecker cavities with a greater frequency than would be expected based upon available woodpecker cavities. There are only a few reports of this owl using nest boxes (Bloom 1983). Reynolds and Linkhart (1987) reported occupancy in 2 of 17 nest boxes put out for flammulated owls.

In studies from northeastern Oregon and south central Idaho, nest sites were located 5-16 m (16-52 ft) high in dead wood of live trees, or in snags with an average diameter at breast height (dbh) of >50 cm (20 in) (Goggans 1986, Bull et al. 1990, Powers et al. 1996). Most nests were located in snags. Bull et al. (1990) found that stands containing trees greater than 50 cm (20 in) dbh were used more often than randomly selected stands. Reynolds and Linkhart (1987) suggested that stands with trees >50 cm (20 in) were preferred because they provided better habitat for foraging due to the open nature of the stands, allowing the birds access to the ground and tree crowns. Some stands containing larger trees also allow more light to the ground that produces ground vegetation, serving as food for insects preyed upon by owls (Bull et al. 1990).

Both slope position and slope aspect have been found to be important indicators of flammulated owl nest sites (Goggans 1986, Bull et al. 1990). In general, ridges and the upper third of slopes were used more than lower slopes and draws (Bull et al. 1990). It has been speculated that ridges and upper slopes may be preferred because they provide gentle slopes, minimizing energy expenditure for carrying prey to nests. Prey may also be more abundant or at least more active on higher slopes because these areas are warmer than lower ones (Bull et al. 1990).

Breeding occurs in mature to old coniferous forests from late April through early October. Nests typically are not found until June (Bull et al. 1990). The peak nesting period is from mid-June to mid-July (Bent 1961). Mean hatching and fledging dates in Idaho were 26 June and 18 July, respectively (Powers et al. 1996).

In Oregon, individual home ranges averaged about 10 ha (25 ac) (Goggans 1986). Territories are typically found in core areas of mature timber with two canopy layers present (Marcot and Hill 1980). The uppermost canopy layer is formed by trees at least 200 years old. Core areas are near, or adjacent to clearings of 10-80% brush cover (Bull and Anderson 1978, Marcot and Hill 1980). Linkhart and Reynolds (1997) found that flammulated owls occupying stands of dense forest were less successful that owls whose territories contain open, old pine/fir forests.

Day roosts are located in mature mixed conifer stands with dense, multi-layered canopies (Bull and Anderson 1978, Goggans 1986). Dense stands presumably provide cover from weather and predators, and they may form core areas of the owls' territories.

Flammulated owls are presumed to be migratory in the northern part of their range (Balda et al. 1975), and winter migrants may extend to neotropical areas in central America. In Oregon, they arrive at the breeding sites in early May and begin nesting in early June; young fledge in July and August (Goggans 1986; E. Bull, personal communication). In Colorado, owlets dispersed in late August and the adults in early October (Reynolds and Linkhart 1987).

Flammulated owls are entirely insectivores; nocturnal moths are especially important during spring and early summer (Reynolds and Linkhart 1987). As summer progresses and other prey become available, lepidopteran larvae, grasshoppers, spiders, crickets, and beetles are added to the diet (Johnson 1963, Goggans 1986). In Colorado, foraging occurred primarily in old ponderosa pine and Douglas-fir with an average tree age of approximately 200 years (Reynolds and Linkhart 1992). Old growth ponderosa pine were selected for foraging, and young Douglas-firs were avoided. Flammulated owls principally forage for prey on the needles and bark of large trees. They also forage in the air, on the ground, and along the edges of clearings (Goggans 1986; E. Bull, personal communication; R. Reynolds, personal communication). Grasslands in and adjacent to forest stands are thought to be important foraging sites (Goggans 1986). However, Reynolds (personal communication) suggests that ground

foraging is only important from the middle to late part of the breeding season, and its importance may vary annually depending upon the abundance of ground prey. Ponderosa pine and Douglas-fir were the only trees selected for territorial singing in male defended territories in Colorado (Reynolds and Linkhart 1992).

LIMITING FACTORS

Availability of suitable nest cavities and/or arthropod prey in ponderosa pine or mixed conifer forests are likely limiting. Reasons for the apparent narrow elevation range exhibited by flammulated owls are not known, but reasons are likely related to food and ecological tolerances (R. Reynolds, personal communication).

MANAGEMENT RECOMMENDATIONS

Creation of large areas of even-aged timber is likely detrimental to flammulated owls. Uneven stands of open mature and old timber located near brushy clearings provide good habitat for flammulated owls. The selection for mature to old-growth ponderosa pine/Douglas-fir forests in areas where owls have been studied throughout the west indicates that this habitat may also be important in Washington. Marcot and Hill (1980) noted the potential importance of old black oak trees to flammulated owls in California because of their numerous natural cavities. Washington's white oak/conifer forests should be surveyed for these owls.

All conifers and hardwoods having natural or excavated cavities in and adjacent to flammulated owl territories should be left undisturbed (Marcot and Hill 1980). Bull et al. (1990) suggests leaving large snags and trees (>50 cm [20 in] dbh and 6 m [20 ft] tall) along ridge-tops, and south and east facing slopes in ponderosa pine/Douglas-fir or grand fir forest types. Reynolds (personal communication) recommends leaving at least 5 snags/ha (2/ac) in ponderosa pine habitat.

Future nest snags should be recruited by continually retaining large, mature trees in or adjacent to suitable flammulated owl habitat (Marcot and Hill 1980). Where snags are lacking, large trees can be topped to promote woodpecker use and cavity formation. Fuelwood collection should be limited where flammulated owls occur because this practice eliminates nest snags.

Areas with brushy understory vegetation may provide insect prey and feeding cover when flammulated owls forage near the ground. Therefore, forest practices (e.g., application of herbicide) that remove brush from clearings adjacent to flammulated owl territories should be avoided. Application of insecticides that affect the owl's prey species should not occur within close proximity to flammulated owl home range areas, approximately 305 m (1,000 ft) from the nest. If insecticide or herbicide use is planned for areas where this species occurs, review Appendix A for contacts to assist in assessing the use of chemicals and their alternatives.

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KEY POINTS

Habitat Requirements

- Associated with mid-elevation coniferous forest.
- Nest and roost in mature and old, multi-storied stands.
- Nest in cavities.
- Insectivorous, forage in open areas.

Management Recommendations

- Maintain stands of open, mature timber near brushy clearings.
- Retain all trees with cavities in or adjacent to flammulated owl territories.
- Maintain at least 5 snags/ha (2/ac) >50 cm (20 in) dbh and >6 m (20 ft) tall in ponderosa pine forests.
- Ensure snag recruitment by retaining large, mature trees in or adjacent to flammulated owl habitat.
- Where snags are lacking, top large trees to promote woodpecker use and cavity formation.
- Limit fuelwood collection where flammulated owls occur.
- Leave brush in clearings near owl territories.
- Do not apply insecticides or herbicides in areas used by owls.

Vaux's Swift
Chaetura vauxi

Last updated: 2002

Written by Jeffrey C. Lewis, Morie Whalen, and Ruth L. Milner

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Vaux's swifts breed from southeastern Alaska, northwestern and southern British Columbia, western Montana, and northern Idaho south to central California and west to the Pacific Coast. They winter from northern Mexico south to Central America and Venezuela (Bull and Collins 1993, DeGraaf and Rappole 1995, Sibley 2000).

Vaux's swifts are summer residents throughout wooded areas of Washington (see Figure 1; Hoffman 1927, Jewett et al. 1953, Manuwal and Huff 1987, Lundquist and Mariani 1991). They usually arrive in Washington around early May and remain until September (Hoffman 1927). Breeding populations may occur in forested habitats throughout the state (Kitchin 1949, Jewett et al. 1953, Thomas et al. 1979, Brown 1985).
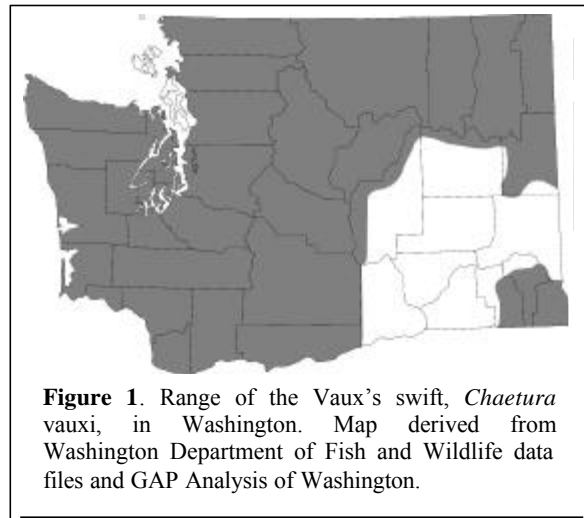
Figure 1. Range of the Vaux's swift, *Chaetura vauxi*, in Washington. Map derived from Washington Department of Fish and Wildlife data files and GAP Analysis of Washington.

RATIONALE

The Vaux's swift is a State Candidate species associated with old-growth and mature forests in the Cascade Range (Manuwal and Huff 1987, Lundquist and Mariani 1991), Olympic Peninsula (Kitchin 1949), and Blue Mountains (Jewett et al. 1953). Throughout their breeding range they are highly dependent on large hollow trees and snags for nesting and roosting (Baldwin and Zaczkowski 1963, Bull 1991, Bull and Cooper 1991). Loss of old-growth and mature forested habitat in Washington (Harris 1984, Thomas et al. 1990) threaten Vaux's swift populations (Bull 1991, Bull and Hohmann 1993).

HABITAT REQUIREMENTS

Vaux's swifts are strongly associated with old-growth forests (Manuwal and Huff 1987, Gilbert and Allwine 1991, Huff and Raley 1991, Lundquist and Mariani 1991, Manuwal 1991, Bull and Hohmann 1993), nesting primarily in old-growth coniferous forests (Baldwin and Zaczkowski 1963, Bull and Cooper 1991, Bull and Hohmann 1993). However, the characteristics of the stand as a whole (i.e., age, canopy layering, stem density) may not be as critical as the availability of suitable nesting or roosting structures (Bull and Hohmann 1993). The availability of suitable nesting or roosting structures is suspected to be the limiting factor for this species (Bull and Hohmann 1993). They

require hollow chambers in large snags or live trees with broken tops for nesting and night roosting. The height where swifts nest in hollow trees or snags may vary, ranging from near base level (Baldwin and Zaczkowski 1963) to an average of 12 m (39 ft) (Bull and Cooper 1991). Bull and Cooper (1991) found that nest trees averaged 25 m (82 ft) in height and 68 cm (27 in) in diameter at breast height (dbh). Many Vaux's swifts nest in hollow trees used by roosting pileated woodpeckers (*Dryocopus pileatus*). Swifts enter these trees through holes excavated by pileated woodpeckers. Without the aid of pileated woodpecker excavation, swifts would have no access to many hollow tree chambers (Bull and Collins 1993). Sterling and Paton (1996) suggested that Vaux's swifts may rely on pileated woodpeckers to create nesting habitat, potentially explaining the similar ranges of these two species in California.

Vaux's swifts have been frequently observed nesting or roosting in chimneys (Jewett et al. 1953, Huey 1960, Griffee 1961, Baldwin and Hunter 1963, Thompson 1977, Sterling and Paton 1996). Historical documentation indicates they prefer older construction, brick chimneys (Huey 1960, Baldwin and Hunter 1963, Baldwin and Zaczkowski 1963, Bull and Collins 1993). Vaux's swifts have been reported using chimneys at least 6.2 m (20 ft) in height, with openings ranging from 23 cm x 23 cm (9 in x 9 in) to 36 cm x 41 cm (14 in x 16 in), securing their nests in the chimney corners (Griffee 1961, Baldwin and Hunter 1963, Thompson 1977). Griffee (1961) observed up to 5 nesting pairs per chimney; however, 1 nest per chimney or tree is typical (Baldwin and Zaczkowski 1963, Thompson 1977, Bull and Collins 1993). Although chimneys are used by this species, hollow trees are favored by nesting and roosting swifts making them more vulnerable to the loss of old-growth forests as opposed to the loss of suitable artificial structures (Bull and Collins 1993).

Vaux's swifts feed exclusively while flying. Their diet consists primarily of flying insects and they forage mainly within a 0.40 km (0.25 mi) radius of the nest site when feeding their young (Bull and Beckwith 1993). Forests at various stages of development, grasslands and aquatic habitats are all used for foraging (Bull and Beckwith 1993).

LIMITING FACTORS

The strong connection of this species to old-growth forests suggest that availability of this type of forested habitat and its associated features (e.g., large, hollow snags and live trees) limit the swift's distribution and abundance during breeding season.

MANAGEMENT RECOMMENDATIONS

Vaux's swifts are found at their highest densities in old-growth forested habitat (Carey 1989, Carey et al. 1991, Gilbert and Allwine 1991, Huff and Raley 1991, Lundquist and Mariani 1991, Manuwal 1991, Bull and Hohmann 1993). The higher abundance of large, hollow snags and live trees appear to explain the greater density of swifts in old-growth versus younger forested stands (Bull and Collins 1993). Protection of existing old-growth should benefit Vaux's swifts, along with managing forest stands on long rotations (>200 years) and maintaining large hollow snags and live trees (Cline et al. 1980, Bull and Collins 1993, Bull and Blumton 1997). Large snags and live trees intended for future snag replacement should be retained and adequately distributed in harvest units (Bull and Collins 1993). Leave all hollow snags and live trees intact [preferably >50 cm (20 in) dbh]. Large defective trees, especially those showing signs of decay such as top rot, broken tops, fungal conks, dead branch stubs, or other defects, should be retained (Cline et al. 1980, Neitro et al. 1985).

Avoid disturbing chimneys that are occupied by nesting or roosting Vaux's swifts during the breeding season or during migration (early May - September). Chimneys are becoming less accessible because insulated pipe are replacing many old brick design, and others are covered with screen spark-arresters (Bull and Collins 1993). The retention of traditional chimney designs are preferred by nesting and roosting swifts. However, safe design should also be accounted for during chimney construction and modification.

Insecticides can greatly reduce Vaux's swift's primary food source and are a risk to swift populations (Brown 1985). All insecticide use should be avoided in or near nests and roosts. Organochlorine, organophosphate, and carbamate insecticides can be highly toxic to birds

(McEwen et al. 1972, Grue et al. 1983, Grue et al. 1986, Smith 1987). Synthetic pyrethroid insecticides (e.g., permethrin) may be an alternative to these compounds outside of snag-rich habitat, because these chemicals are not persistent in the environment or toxic to birds at recommended concentrations. However, synthetic pyrethroids are highly toxic to aquatic invertebrates and fish (Grue et al. 1983, Smith and Stratton 1986). Refer to Appendix A for contacts to assess pesticides, herbicides, and their alternatives.

Appropriate buffer widths for insecticide application near sensitive riparian and wetland areas range from 31-500 m (100-1,640 ft) (Kingsbury 1975, Payne et al. 1988, Terrell and Bytnar-Perfetti 1989). Buffer width calculations for insecticide application adjacent to snag-rich habitat should take into account the droplet size, volume of the compound and weather conditions that could influence wind drift (Kingsbury 1975, Brown 1978, Payne et al. 1988). Maintain a buffer of 500 m (1,640 ft) (Kingsbury 1975) from snag-rich areas when spraying insecticides (Brown 1978, Smith 1987).

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KEY POINTS

Habitat Requirements

- Vaux's swifts nest in hollow chambers created by decay within live or dead trees.
- Large hollow snags and live trees averaging 25 m (82 ft) tall, and 68 cm (27 in) dbh located in old-growth and mature forests are used for nesting. Many Vaux's swifts nest in hollow trees excavated by pileated woodpeckers.
- Overall stand characteristics (e.g., age, canopy layering, stem density) do not appear to be as important to Vaux's swifts as the availability of large, hollow snags and live trees.
- Vaux's swifts will nest/roost in unused brick chimneys with openings at least 23 cm x 23 cm (9 in x 9 in).

Management Recommendations

- Maintain existing old-growth as well as mature forest habitat. Manage stands on longer rotations (t >200 years).
- Retain all large, hollow large snags and large "defective" live trees, especially in younger, managed stands.
- Avoid disturbance of chimneys that are occupied by nesting and roosting Vaux's swifts during the breeding season (early May - September).
- Retain traditional chimney designs for use by nesting and roosting swifts. However, safe design should also be strongly considered for chimney construction and modification.
- Avoid using insecticides in areas inhabited by Vaux's swifts. Refer to Appendix A for contacts to assess pesticides, herbicides, and their alternatives.
- Substitute with synthetic pyrethroid insecticides (e.g., permethrin) or diflubenzuron (e.g., dimilin). Restrict the use of organophosphorous, organochlorine, and carbamate compounds to locations outside of snag-rich areas, away from swift nests and roosts.
- Maintain a 500 m (1,640 ft) buffer around snag-rich areas when spraying insecticide and apply during appropriate weather to avoid wind drift.

Lewis' Woodpecker

Melanerpes lewis

Last updated: 2002

Written by Jeffrey C. Lewis, Morie Whalen, and Elizabeth A. Rodrick

GENERAL RANGE AND WASHINGTON DISTRIBUTION

The Lewis' woodpecker breeds from British Columbia and southern Alberta, south to Utah and Colorado, and from South Dakota west to the Cascades. It is either a year-round resident or winters from Oregon south to Baja, California, and east to western Texas and Oklahoma (Tobalske 1997).

Historically, this woodpecker was known to breed throughout the Puget Trough, southwest Washington, and the Olympic Peninsula (Jewett et al. 1953, Jackman 1975, MacRoberts and MacRoberts 1976). Currently in Washington, Lewis' woodpeckers only breed east of the Cascades from the Columbia Gorge north, and east into the Okanogan highlands and northeast Washington (see Figure 1). Their present breeding range also includes the Blue Mountains (Tobalske 1997).
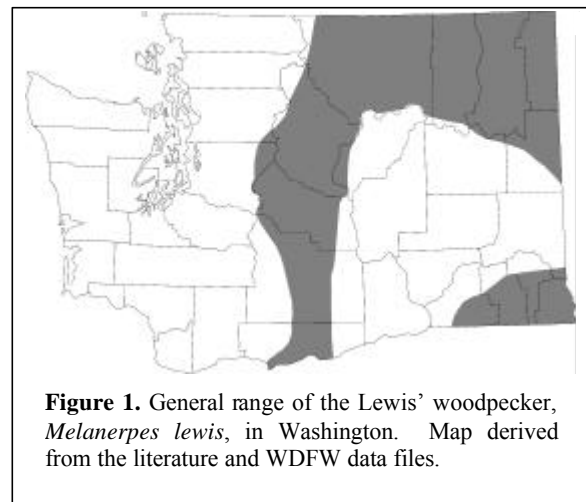
Figure 1. General range of the Lewis' woodpecker, *Melanerpes lewis*, in Washington. Map derived from the literature and WDFW data files.

RATIONALE

The Lewis' woodpecker is a State Candidate species. This species has shown a recent decline in the Western states, possibly due to competition for snags and nest cavities and loss of their historic riparian and ponderosa pine habitat (U.S. Fish and Wildlife Service 1985, Saab and Vierling 2001, Sauer et al. 2001). In Washington, the Lewis' woodpecker is only locally abundant as a breeding bird, and its range has contracted within the last half of this century to include only habitats east of the Cascade crest. This species is vulnerable to the loss of snag habitat, and to habitat loss as a result of fire suppression and brush control (Tobalske 1997, Saab and Vierling 2001).

HABITAT REQUIREMENTS

The Lewis' woodpecker prefers a forested habitat with an open canopy and a shrubby understory, with snags available for nest sites and hawking perches (Bock 1970). Bock (1970) states that the critical features of Lewis' woodpecker habitat are forest openness, understory composition, and availability of insect fauna. Additionally, optimum habitat for the Lewis' woodpecker has been defined by the following factors (Sousa 1983):

- total tree canopy closure $\leq$ 30%,
- total shrub crown cover $\geq$ 50%,
- crown cover of mast (nut) producing shrubs $\geq$ 70%,
- percent of total tree canopy closure comprised of hard mast trees $\geq$ 70%, and
- distance to potential mast storage sites $\leq$ 0.8 km (0.5 mi).

Breeding

Breeding populations of the Lewis' woodpecker in Washington are locally distributed, often in colonies, and occur frequently in burned forests (Jewett et al. 1953, Raphael and White 1984, Block and Brennan 1987, Tobalske 1997). Riparian areas dominated by cottonwoods (*Populus trichocarpa*), and oak (*Quercus garryana*) woodlands are major breeding habitats, as are open or park-like ponderosa pine (*Pinus ponderosa*) forests (Sousa 1983, Saab and Vierling 2001). Burned stands of Douglas-fir (*Pseudotsuga menziesii*) and mixed conifers are also used by this woodpecker as breeding habitat (Bock 1970, Raphael and White 1984). Openness is the characteristic common to all breeding habitats, and is related to this woodpecker's foraging methods of hawking and gleaning in brush (Bock 1970). Brushy undergrowth that supports insects on which Lewis' woodpeckers feed is an important component of their preferred breeding habitat (Tobalske 1997). In eastern Washington, undergrowth consisting of species such as sagebrush (*Artemisia* spp.), golden currant (*Ribes aureum*), bitterbrush (*Purshia tridentata*) and rabbitbrush (*Chrysothamnus* spp.) is typically present where this woodpecker breeds.

Lewis' woodpeckers will also use selectively logged or burned coniferous forests that are structurally similar to open ponderosa pine (Raphael and White 1984). In the normal cycle of reforestation, a burn may become suitable habitat for Lewis' woodpeckers between the 10th and 30th year of regeneration, when a shrub understory develops and insects are prevalent (Bock 1970, Jackman and Scott 1975). However, Saab and Dudley (1995) found Lewis' woodpeckers using a ponderosa pine stand two years after it burned. They reported Lewis' woodpeckers displacing hairy woodpeckers and western bluebirds from nest cavities that had been excavated in snags before the fire. This behavior had not been reported before in this species. Lewis' woodpecker nesting sites within salvaged stands of burned forests had an average of 59 snags/ha (24/ac) >23 cm (9 in) diameter at breast height (dbh) and 16 snags/ha (16.5/ac) >51 cm (20 in) dbh (Saab and Dudley 1997).

Riparian areas are also used as breeding habitat for Lewis' woodpeckers. Groves of cottonwood trees are especially suitable because they are open and usually have dead trees that offer nest and roost sites. Insects are abundant due to the lush vegetation within riparian areas (Bock 1970, Jackman and Scott 1975).

Lewis' woodpeckers have high nest site fidelity and often use the same cavity in consecutive years (Bock 1970). This woodpecker will excavate its own nest cavity, but it also uses natural cavities or holes excavated by other woodpeckers. Being a weak excavator, the Lewis' woodpecker prefers soft snags to live trees (Raphael and White 1984). Nest snags and trees in the Sierra Nevada averaged 11.4 m (37 ft) in height and 66.5 cm (26 in) dbh; mean nest height was 7.3 m (24 ft), and the mean diameter at nest-height was 52 cm (20 in) (Raphael and White 1984).

Feeding

The Lewis' woodpecker is an opportunistic feeder that breeds where insects are locally abundant, and it winters where hard nut producing trees are readily available (Bock 1970). Their diet during the spring and summer consists primarily of insects including ants, bees and wasps, beetles, grasshoppers and true bugs (Tobalske 1997). Fruits and berries were the most frequently eaten foods in late summer and fall, whereas winter foods consisted of acorns, commercial nuts, and corn. The feeding behavior of Lewis' woodpeckers is atypical among woodpeckers. Bock (1970) found that in summer they spent approximately 60% of their foraging time capturing insects in flight, 30% ground/brush foraging, and 10% gleaning insects from trees. Raphael and White (1984) reported that of Lewis' woodpeckers' foraging time, 76% was spent capturing insects in flight, 22% gleaning, and 2% drilling. During winter, Lewis' woodpeckers feed mostly on cached acorns and insects, and they spend some time flycatching and gleaning insects (Bock 1970). Although these woodpeckers protect only their immediate nest site during the breeding season, they defend a feeding area in winter (Bock 1970).

LIMITING FACTORS

The availability of snags, nest holes excavated by other woodpeckers, and abundant prey populations are the predominant factors that limit distribution and abundance of the Lewis' woodpecker (Jackman 1975). The selection of one specific area by this woodpecker probably depends on insect abundance. Certain timber management practices and heavy livestock grazing can impact an area's suitability for Lewis' woodpeckers (Jackman 1975, Jackman and Scott 1975). Fire suppression also has likely impacts on the availability of suitable habitat for this species (Saab and Dudley 1997, Tobalske 1997).

Certain habitats are only temporarily suitable, such as logged or burned forests prior to regeneration of second-growth stands. However, post-burn forests likely provide suitable habitat for longer periods within the dryer portions of Lewis' woodpecker range (e.g., eastern fringe of the Cascades) as a result of slower regrowth. Logged or burned coniferous forest is an important part of Lewis woodpecker habitat, but it is generally only suitable in the shrub stage. Unfortunately the brushy stage is undesirable for timber management, and efforts are made to eliminate it. Management practices that remove snags and damaged or diseased trees also limit the availability of nest sites. Additionally, livestock grazing can destroy native understory vegetation, which decreases insect abundance (Jackman and Scott 1975).

Frequent human disturbance at nest sites can also have a negative effect on this species. Lewis' woodpeckers become agitated by continued disturbance at the nest site and will occasionally desert their nest (Bock 1970).

MANAGEMENT RECOMMENDATIONS

In areas where the Lewis' woodpecker occurs, as many standing dead, insect infested, and damaged trees should be retained as possible during thinning and cutting operations (Jackman 1975, Saab and Dudley 1997). Large, soft snags that are suitable for Lewis' woodpecker nest sites are particularly valuable. In managed forests, retaining clusters of trees benefits this species over the retention of uniformly distributed trees for partially logged or salvaged units (Saab and Dudley 1997).

When replanting after a timber harvest, attempts should be made to duplicate natural tree species composition, rather than replanting with a single species (Jackman 1975). Sections of logged or burned forest should be left to regenerate naturally to brush (Jackman and Scott 1975). The brushy forest stage is important for maintaining a healthy insect populations and should not be suppressed (Jackman 1975).

Green forests that are either maintained for timber harvest or have a high risks of a stand-replacement fire should be managed in a way that snag numbers will replenish themselves over time (particularly by retaining broken-topped trees). This management practice will contribute to the continuous availability of easily excavated post-fire nesting trees. In burned forests, retain as many large (>50 cm (20 in) dbh) snags as possible (Saab and Dudley 1997).

Woodpeckers and other insectivores play an important role in naturally reducing insect populations. Management to increase woodpecker populations will likely have the secondary benefit of increasing other insectivorous birds (Takekawa et al. 1982). If pesticides or herbicide use is planned in areas inhabited by this species, refer to Appendix A which lists contacts useful when assessing pesticides, herbicides and their alternatives.

Livestock grazing should be limited where the Lewis' woodpecker occurs, so that native understory vegetation is not destroyed. However, more research is necessary to determine the specific threshold limits on grazing pressure to protect habitat for species. A brushy understory is necessary to provide an adequate insect prey base (Jackman 1975, Jackman and Scott 1975).

Frequent or prolonged human disturbance at nest sites of Lewis' woodpeckers should be avoided. Adult woodpeckers become agitated by continual disturbance at the nest site, and may desert the nest (Bock 1970).

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KEY POINTS

Habitat Requirements

- Critical features of Lewis' woodpecker include forested habitat with an open canopy, a shrubby understory composition, insect fauna and snags available for nest sites and hawking perches.
- Optimum habitat for the Lewis' woodpecker has been defined by the following factors:

  - total tree canopy closure $\leq$30%,
  - shrub crown cover $\geq$ 50%,
  - crown cover of mast (nut) producing shrubs $\geq$ 70%,
  - percent of total tree canopy closure comprised of hard mast trees $\geq$ 70%, and
  - distance to potential mast storage sites $\leq$ 0.8 km (0.5 mi).

- Mainly inhabits riparian stands dominated with cottonwoods, oak woodlands, and park-like ponderosa pine forests with brushy understory. They also use Douglas-fir, and mixed-conifer forests, and logged or burned areas up to 30 years old.
- Excavates cavities or uses available nest holes in snags.
- Feeds mainly on insects and hard nut crops and uses perches to scan for and catch insects in flight.

Management Recommendations

- Retain as many standing dead, insect infested, and damaged trees as possible during thinning and cutting operations. Large, soft snags are particularly valuable. In managed forests, retaining clusters of trees benefits this species over the retention of uniformly distributed trees for partially logged or salvaged units.
- Duplicate natural tree species composition when replanting after a timber harvest rather than replanting stands with a single species of tree. Sections of logged or burned forest should be left to regenerate naturally to brush. A brushy successional stage is important for healthy insect populations and should not be suppressed.
- Manage green forests that are either maintained for timber harvest or have a high risk of a stand-replacement fire in a way that snag numbers will replenish themselves over time (particularly by retaining broken-topped trees). This management practice will contribute to the continuous availability of easily excavated post-fire nesting trees. In burned forests, retain as many large (>50 cm (20 in) dbh) snags as possible.
- Refer to Appendix A that lists useful contacts for evaluating pesticides, herbicides and other alternatives if pesticide use is planned in areas where this woodpecker occurs.
- Limit livestock grazing where the Lewis' woodpecker occurs, so that native understory vegetation is not destroyed.
- Avoid frequent or prolonged human disturbance at nest sites of Lewis' woodpeckers.

Black-backed Woodpecker
Picoides arcticus

Last updated: 2003

Written by Jeffrey C. Lewis, Elizabeth A. Rodrick, and Jeffrey M. Azerrad

GENERAL RANGE AND WASHINGTON DISTRIBUTION

The black-backed woodpecker inhabits the boreal forests of North America, including the Cascade Mountains, the northern portions of the Sierra Nevada and Rocky Mountains, much of Canada, southeastern Alaska, northern New England, and the upper Midwest

In Washington, this woodpecker is found on the eastern slopes of the Cascade Mountains and in the coniferous forests of the Okanogan Highland, Selkirk and the Blue Mountains (see Figure 1; Smith et al. 1997).
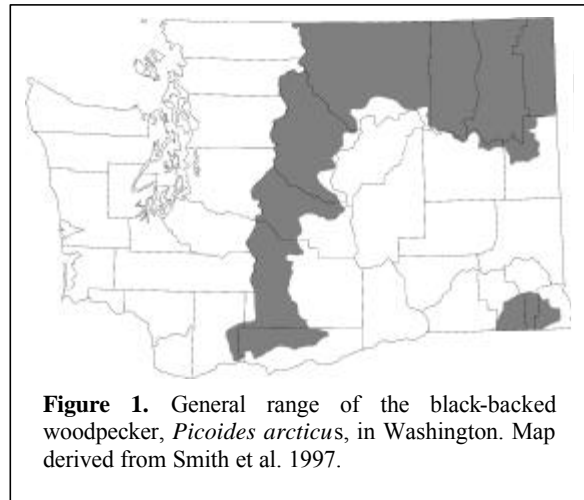
Figure 1. General range of the black-backed woodpecker, *Picoides arcticus*, in Washington. Map derived from Smith et al. 1997.

RATIONALE

The black-backed woodpecker is a State Candidate species and is in danger of population decline through loss of breeding and foraging habitat.

HABITAT REQUIREMENTS

Black-backed woodpeckers primarily inhabit standing dead lodgepole pine (*Pinus contorta*), ponderosa pine (*Pinus ponderosa*), western larch (*Larix occidentalis*) and mixed coniferous forests (Dixon and Saab 2000, Kotliar et al. 2002). This species' dependence on burned forests and forests that have undergone other types of large-scale disturbances (e.g., insect infestation, blowdowns) is well documented (Hutto 1995, Caton 1996, Kreisel and Stein 1999, Dixon and Saab 2000, Kotliar et al. 2002). They have a scattered distribution with populations responding to prey abundance (Caton 1996). Disturbed forests are attractive to the black-backed woodpecker because they feed on insects (mainly larvae of wood-boring beetles) that are particularly abundant following a disturbance event. In northeast Washington, black-backed woodpeckers were 20 times more abundant in burned versus unburned forests (Kreisel and Stein 1999), and often were restricted to standing dead forests created by recent stand-replacement fires

(Hutto 1995, Caton 1996). Home ranges in mature and old-growth forests of central Oregon ranged between 59 and 193 ha (147 and 478 ac; Goggans et al. 1988).

Nesting

In mature ponderosa pine and mixed conifer forests, black-backed woodpeckers nest predominantly in ponderosa and lodgepole pine (Bull et al. 1986). However, tree species composition varies regionally (Dixon and Saab 2000) and appears not to be as important a factor as forest condition (e.g., burned, insect damaged) for explaining the presence of nesting birds. This species nests in taller, small diameter, recently dead trees (>15 m [50 feet] in height, <50 cm [20 inches] in diameter-at-breast-height [dbh], and dead for five years or less) (Raphael and White 1984, Bull et al. 1986). They excavate nest cavities in live trees and hard snags (Spring 1965, Raphael and White 1984, Saab and Dudley 1997). Black-backed woodpeckers were commonly found in unlogged ponderosa pine/Douglas-fir forests with a high density of relatively small, hard snags (Saab and Dudley 1997). Johnsgard (1986) found black-backed woodpeckers nesting in similar habitat as the three-toed woodpecker (*Picoides tridactylus*).

In central Oregon's mixed conifer and lodgepole pine forests, black-backed woodpeckers selected mature and old-growth stands, and nested exclusively in lodgepole pine (Goggans et al. 1988). They avoided young stands and logged areas for both nesting and feeding. Live trees and snags used for nesting had heartrot and a mean dbh of 28 cm (11 in). However, it should be noted that lodgepole pine-dominated forests, such as the forests examined in the central Oregon research, are uncommon in Washington (J. Buchanan, personal communication).

Feeding

In northeastern Oregon, black-backed woodpeckers foraged in both live and dead trees, and showed a preference for ponderosa pine (Bull et al. 1986). During winter months, black-backed woodpeckers foraged almost entirely upon standing dead trees, and preferred western larch within burned forests of northeast Washington (Kreisel and Stein 1999). The larvae of wood-boring beetles such as the pine beetle (*Dendroctonus* spp.) constituted most of their diet (Goggans et al. 1988, Dixon and Saab 2000). Trees used for foraging averaged 19 m (62 ft) in height with a dbh of 34 cm (13 in) and had been dead less than 2 years (Bull et al. 1986). Black-backed woodpeckers most often used the trunk as foraging substrate (Raphael and White 1984, Villard 1994). They frequently obtained insects by chipping bark from dead and dying trees (Short 1974, Kreisel and Stein 1999), but also excavated into the wood of tree trunks and logs in search of insect larvae (Raphael and White 1984, Villard 1994).

Roosting

In Oregon's mixed conifer and lodgepole pine forests, black-backed Woodpeckers roosted mainly in cankers, trunk scars, mistletoe clumps or directly on pine trunks (Goggans et al. 1988). They chose mature and old-growth forests with an average canopy closure of 40%. Trees used for roosting averaged 28 cm (11 in) in diameter and 20 m (65 ft) in height. Studies examining roosting patterns in habitat-types more closely associated with the Washington landscape are lacking.

LIMITING FACTORS

The availability of burned areas that are not subjected to salvage logging, and of insect-damaged forests with numerous snags, limits the distribution of the black-backed woodpecker (Kotliar et al. 2002). Hutto (1995) found that this species is highly restricted to early post-fire conditions that become less suitable 5 to 6 years after a fire due to declining prey availability. Historical and recent fire management policies have negatively impacted this species by reducing the chance of large, high intensity wildfires that create suitable conditions for the black-backed woodpecker (Dixon and Saab 2000).

MANAGEMENT RECOMMENDATIONS

Suitable mature, old-growth and recently dead lodgepole pine, ponderosa pine and pine-dominated mixed coniferous forest stands that have experienced recent pine beetle infestation, large blowdowns or fire are important for the black-backed woodpecker (Dixon and Saab 2000). A recent review of studies in the western United States on post-fire salvage logging documented the serious negative impacts of this activity to the viability of black-backed woodpeckers (Kotliar et al. 2002). The review concluded that this species rarely used even partially-logged post-fire forests. Therefore, where salvage logging is planned, it is important to delay any work for the first five years after the disturbance event (Hutto 1995, Dixon and Saab 2000). This span is critical in providing habitat because the woodpecker's primary food source (wood-boring beetles) becomes less abundant after this period (Caton 1996). Salvage operations should also retain >104-123 snags/ha (>42-50 snags/ac) that are >23 cm dbh (>9 in dbh) (Dixon and Saab 2000, Wisdom et al. 2000).

Goggans et al. (1988) suggested that the traditional approach of managing cavity nesters by retaining a relatively small number of snags and green replacement trees in harvested stands may not maintain enough foraging substrate to sustain viable black-backed woodpecker populations. Instead, this specialized species may require larger areas of decaying, multi-layered older forests. They proposed that Woodpecker Management Areas (WMAs) be identified and withdrawn from commercial or salvage forestry and placed under special management to promote mature and old-growth conditions (Goggans et al. 1988). They suggest that WMAs should each encompass at least 387 ha (956 ac) of pine-dominated, mixed-conifer forest in mature or old-growth condition. This area is estimated based on average home-range sizes for nesting pairs during periods of abundant food. The researchers also recommended that WMAs be located below 1,372 m (4,500 ft) because this species is better adapted to conditions at lower elevations.

Goggans et al. (1988) recommended using the black-backed woodpecker rather than the three-toed woodpecker (*Picoides tridactylus*) as a management indicator species for mature and old-growth lodgepole pine forests. Black-backed woodpeckers are a better indicator species because they use a wider elevation range and are easier to monitor.

Woodpeckers and other insectivores play an important role in naturally reducing insect populations. Management to increase woodpecker populations should have the secondary benefit of increasing other insectivorous birds (Takekawa et al. 1982).

If pesticide or herbicide use is planned in areas inhabited by black-backed woodpeckers, refer to Appendix A, which lists contacts for assessing the use of pesticides, herbicides and other alternatives.

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PERSONAL COMMUNICATIONS

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Olympia, Washington

KEY POINTS

Habitat Requirements

- Inhabit mature and old-growth lodgepole pine, ponderosa pine, and mixed-conifer forests with numerous standing dead trees. Most abundant in burned and insect-infested stands.
- Forage on insects, mainly beetle larvae, in pole- and small sawtimber-sized snags.

Management Recommendations

- Avoid salvage logging of suitable mature and old-growth lodgepole pine forest stands that have experienced pine beetle infestation or large blowdowns.
- Retain >104-123 snags/ha (>42-50 snags/ac) that are >23 cm dbh (>9 in dbh) where salvage logging is planned. It is important to delay any salvage operation for approximately five years in woodpecker habitat areas after a disturbance event.
- Establish Woodpecker Management Areas of at least 387 ha (956 ac) within managed forests. The areas should be in pine-dominated, mixed-conifer forest in mature or old-growth condition located below an elevation of 1,372 m (4,500 ft).
- Refer to Appendix A if pesticide or herbicide use is planned in areas inhabited by this species. This lists useful contact for assessing the use of pesticides, herbicides, and other alternatives.

White-headed Woodpecker
Picoides albolarvatus

Last updated: 2002

Written by Jeffrey C. Lewis and Elizabeth Rodrick

GENERAL RANGE AND WASHINGTON DISTRIBUTION

White-headed woodpeckers breed from southern British Columbia and Idaho to southern California (Garrett et al. 1996).

In Washington they are found in ponderosa pine (*Pinus ponderosa*) forests on the east slopes of the Cascade Mountains as well as in the Okanogan Highland, Selkirk and Blue Mountain areas of the state (see Figure 1). They are uncommon throughout their range, but they can be locally abundant in optimal habitat.

Figure 1. Range of the white-headed woodpecker, Picoides albolarvatus, in Washington. Map derived from the literature.
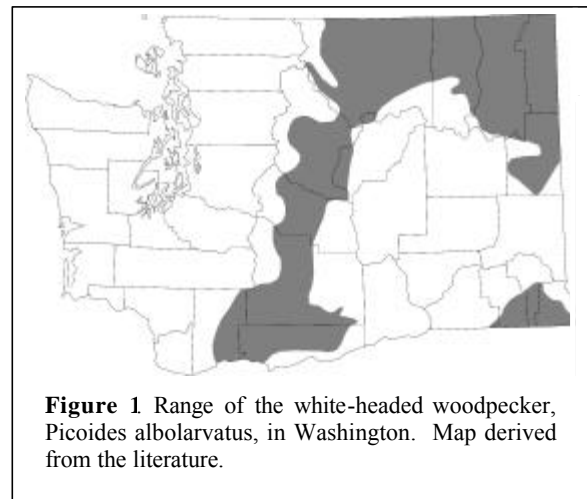
RATIONALE

The white-headed woodpecker is a State Candidate species. This species is vulnerable to loss of older, pine-dominated forests, and to the loss of large trees and snags within these forests.

HABITAT REQUIREMENTS

White-headed woodpeckers are primarily associated with open-canopied, mature and old-growth ponderosa pine forests. They require large, decayed snags for nesting and roosting while they forage primarily in the bark of large ponderosa pines [>60 cm (24 in) dbh] (Thomas et al. 1979, Raphael and White 1984, Garrett et al. 1996). White-headed woodpeckers prefer to forage for insects on the scaly bark of live trees (Raphael and White 1984, Morrison et al. 1987), and they feed heavily on seeds from unopened pine cones during winter (Ligon 1973, Garrett et al. 1996).

Nesting

The white-headed woodpecker usually nests low to the ground [<10 m (33 ft), mean = 2-3 m (6.5-10 ft)] in cavities within snags and stumps (Raphael and White 1984, Milne and Hejl 1989). This species infrequently nests in live trees (J. Buchanan, personal communication). Nest trees include ponderosa pine, jeffrey pine (*Pinus jeffreyi*), lodgepole pine (*Pinus contorta*), sugar pine (*Pinus lambertiana*), white fir (*Abies concolor*), red fir (*Abies magnifica*), and occasional quaking aspen (*Populus tremuloides*) (Raphael and White 1984, Milne and Hejl 1989, Dixon 1995b, Garrett et al. 1996). Studies conducted outside of Washington found that white-headed woodpeckers prefer nesting in snags or trees that are 4-8 m (13-26 ft) tall with a dbh of 65-80 cm (26-31 in) (Raphael and White 1984; Milne and Hejl 1989; Dixon 1995a, b; Garrett et al. 1996). Recent findings in eastern Washington concluded that this species nests primarily in ponderosa pine snags averaging 12.6 m (41.3 ft) in height with a mean dbh of 51.5 cm (20.3 in) (J. Buchanan, personal communication). Larger trees and snags characterized the immediate surroundings of active nest sites. The canopy closure in sites containing nesting birds was considerably open, averaging 7.2%.

Nest excavation begins in April to early May, while nesting occurs from late May to late June (Garrett et al. 1996). Incubation takes 14 days, and young leave the nest in late June to early July after a 26-day fledging period (Garrett et al. 1996).

Foraging

A significant portion of white-headed woodpecker diet consists of pine seeds, especially during winter and early spring (Ligon 1973). Other food sources include invertebrates, sap and other plant matter (Ligon 1973, Garrett et al. 1996). Their diet displays significant seasonal variation. The importance of pine seed in the white-headed woodpeckers diet appears to vary regionally (Morrison and With 1987).

Foraging involves gleaning insects from the trunks of live trees and snags, typically pines and firs (Raphael and White 1984, Morrison et al. 1987). Foliage gleaning and drilling into pine cones are also typical foraging techniques. Feeding on sap occurs only occasionally for this species (Garrett et al. 1996). White-headed woodpeckers regularly drink from open water sources, including pools, creeks, and puddles (Garrett et al. 1996).

Roosting

White-headed woodpeckers most frequently roost in cavities, but also roost in spaces behind peeling bark and in crevices within tree trunks (Dixon 1995a, b; Garrett et al. 1996). They typically roost in ponderosa pines (live trees and snags) averaging 60 cm (24 in) dbh and 7 m (23 ft) tall. Males roost in the nest cavity with their young until they fledge. Cavities are used as winter roosts, and frequently the same cavity is used over an entire season (Dixon 1995a, b; Garrett et al. 1996).

Home Range

Home ranges of white-headed woodpeckers in old-growth habitat averaged 104 ha (257 ac) and 212 ha (524 ac) for central and south-central Oregon, respectively. Home ranges in fragmented habitat average 321 ha (793 ac) and 342 ha (845 ac) for the same regions, respectively (Dixon 1995a, b).

LIMITING FACTORS

Availability of mature and old growth ponderosa pine forests with adequate snags for nesting and winter foraging has resulted in the decline of this species (Garrett et al. 1996). Logging of old ponderosa pine reduces suitable habitat and maintaining even-aged stands limits a site's capacity to replenish itself with large trees and snags. Fire suppression results in closed canopy, less suitable habitat, and eventually displaces important ponderosa pine with firs.

MANAGEMENT RECOMMENDATIONS

Management of habitat for this species should focus on providing snags suitable for nesting and the retention of large live trees for foraging (J. Buchanan, personal communication). Large trees should constitute 40-70% of the forest trees (Neitro et al. 1985).

Connor (1979) states that managing for the minimum habitat requirements may cause gradual population declines. Therefore, it is recommended that forests be managed using average rather than minimum suggested values. Based on research in eastern Washington, forest management should seek to retain 6-8 snags averaging 42.1 cm (16.6 in) dbh/0.8 ha (2-4 snags/ac) and 8 - 10 live trees averaging 63.4 cm (25.0 in) dbh/0.8 ha (4-5 trees/ac) in the immediate vicinity of nesting areas (J. Buchanan, personal communication). These figures are based on a sample of snags $ 20 cm (7.9 in) dbh and live trees $ 50 cm (19.7) dbh. Additionally, open canopy conditions are recommended for these same sites.

Woodpeckers and other insectivores play an important role in naturally reducing insect populations. Management to increase woodpecker populations should have the secondary benefit of increasing other insectivorous birds (Takekawa et al. 1982). If pesticides or herbicide use is planned in areas inhabited by this species, refer to Appendix A, which lists useful contacts for assessing pesticides, herbicides, and other alternatives.

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PERSONAL COMMUNICATIONS

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KEY POINTS

Habitat Requirements

- Mature and old-growth ponderosa pine and mixed conifer forests.
- Nests in snags averaging >65 cm (26 in) dbh.
- Home ranges in Oregon average 100-200 ha (247-484 ac) in old-growth habitat, and over 300 ha (741 ac) in fragmented habitat.
- Forages on insects in large [>60 cm (24 in) dbh] snags and live trees, and on pine seeds during winter and early spring.

Management Recommendations

- Maintain mature forest conditions or limit timber removal to moderate levels of selective cutting to maintain white-headed woodpecker populations. Mature ponderosa pine should constitute 40-70% of the forest trees.
- Retain 6-8 snags averaging 42.1 cm (16.6 in) dbh/0.8 ha (2-4 snags/ac) and 8 - 10 live trees averaging 63.4 cm (25.0 in) dbh/0.8 ha (4-5 trees/ac) where nesting occurs.
- Maintain open canopy conditions for sites within the immediate vicinity of nesting white-headed woodpeckers.
- Refer to Appendix A, that lists useful contacts for assessing pesticides, herbicides, and their alternatives, if pesticide or herbicide use is planned in areas inhabited by this species.

Pileated Woodpecker
Dryocopus pileatus

Last updated: 2003

Written by Jeffrey C. Lewis and Jeffrey M. Azerrad

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Pileated woodpeckers are year-round residents from northern British Columbia, across Canada to Nova Scotia, south through central California, Idaho, Montana, eastern Kansas, the Gulf Coast and Florida (Bull and Jackson 1995). The Washington range encompasses the forested areas of the state (see Figure 1; Smith et al. 1997).

RATIONALE

The pileated woodpecker is listed as a State Candidate species in Washington. The pileated woodpecker is a significant functional component of a forest environment

Figure 1. General range of the pileated woodpecker, *Dryocopus pileatus*, in Washington (Smith et al. 1997).

because it creates nesting cavities used by other forest wildlife species (Aubry and Raley 2002a). Their deep foraging excavations provide foraging opportunities for weak excavators, and they accelerate the decay process by physically breaking apart wood and exposing prey that can be consumed by other species (Aubry and Raley 2002a). For these reasons the pileated woodpecker is considered a "keystone habitat modifier" (Aubry and Raley 2002a). The availability of large snags (standing dead trees) and large decaying live trees used for nesting and roosting by pileated woodpeckers has declined in many areas as a result of forest conversion (e.g, removal of forest for urban development) and timber management practices (Bull and Jackson 1995, Ferguson et al. 2001).

HABITAT REQUIREMENTS

Pileated woodpeckers inhabit mature and old-growth forests, and second-growth forests with large snags and fallen trees (Bull and Jackson 1995, Aubry and Raley 1996). Large snags and large decaying live trees in older forests are used by pileated woodpeckers for nesting and roosting throughout their range (Mellen et al. 1992, Bull and Jackson 1995, Aubry and Raley 2002b). In western Oregon and western Washington, they may use younger forests (<40 years old) as foraging habitat (Mellen et al. 1992, Aubry and Raley 1996).

Nesting and Roosting

Pileated woodpeckers excavate large nest cavities in snags or large decaying live trees (Bull et al. 1986, Aubry and Raley 2002b). In northeast Oregon, Bull (1987) reported the dimension of the nest entrances were 12 cm (5 in) in height and 9 cm (4 in) in width; the internal dimensions were 57 cm (22 in) deep and 21 cm (8 in) wide. Wood chips are typically found on the cavity floor (Bull and Jackson 1995). During the breeding season, birds may start a number of cavity excavations, but only complete one nest cavity (Bull and Jackson 1995, Aubry and Raley 2002a). The breeding and nesting periods of the pileated woodpecker extends from late March to early July (Bull et al. 1990). Pileated woodpeckers lay 1-6 eggs/clutch; the eggs are white in coloration and are about 3.3 cm (1.3 in) in length and 2.5 cm (1 in) in breadth (Bull and Jackson 1995).

Preferred nest tree species and characteristics vary to some degree among different regions of the northwest (Table 1). Most nest cavities were observed in hard snags with intact bark and broken tops, or live trees with dead tops. Hard snags are characterized as being comprised of sound wood while soft snags are composed primarily of wood in advanced stages of decay or deterioration (Brown 1985). Researchers studying pileated woodpeckers on the Olympic Peninsula found that woodpeckers used snags and large decaying live trees for nesting (Aubry and Raley 2002b). Sites used for nesting and roosting in the Olympics had a higher diversity of tree species and a greater density of large decaying live trees and large snags than surrounding forested areas (Aubry and Raley 2002b).

Table 1. Diameter at breast height (DBH), height, and tree species reported for pileated woodpecker nest trees in Oregon and Washington.

Location	DBH (average)	DBH (range)	Height (average)	Height (range)	Species	References
Olympic Peninsula	101 cm (40 in)	65-154 cm (26-61 in)	39 m (128 ft)	17-56 m (56-184 ft)	Pacific silver fir (*Abies amabilis*), western hemlock (*Tsuga heterophylla*)	Aubry and Raley 2002b
Western Oregon	69 cm (27 in)	--	27 m (87 ft)	--	Douglas-fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*)	Mellen 1987, Nelson 1989
Northeastern Oregon	80-84 cm (31-33 in)	52-119 cm (20-47 in)	28 m (92 ft)	10-43 m (33-141 ft)	grand fir, ponderosa pine (*Pinus ponderosa*), western larch (*Larix occidentalis*)	Bull 1987; Bull et al. 1992b; E. Bull, personal communication

Pileated woodpeckers roost in hollow trees or vacated nest cavities at night and during inclement weather (Bull and Jackson 1995). Excavation of roost cavities may occur at any time during the year (E. Bull, personal communication). Pileated woodpeckers may use up to 11 roosts over a 3-10 month period; however, some individuals will use one roost for a long period before switching to a new roost, while others regularly switch among several roosts (Bull et al. 1992b). The availability of roost trees apparently explained why some birds roosted in a limited number of trees (Bull et al. 1992b)

Roost and nest trees of pileated woodpeckers differ with respect to species and physical characteristics. Pileated woodpeckers used live trees or snags for roosting and nesting and selected these based on tree species, wood condition and diameter at breast height (dbh) in both northeastern Oregon and the Olympic peninsula (Bull et al. 1992b, Aubry and Raley 2002b). Bull et al. (1992b) reported that roost trees [mean = 70 cm dbh (28 in)] were smaller than nest trees [mean = 80 cm dbh (31 in)]; in contrast to nest trees, roosts trees in northeastern Oregon were often hollow. The hollow interior of roost chambers was typically the result of heartwood decay rather than excavation (Bull et al. 1992b, Aubry and Raley 2002b). In northeastern Oregon, roost chambers had more entrance holes than nests, and roosts were predominantly in grand fir, whereas nest trees were predominantly ponderosa pine and western larch (Bull et al. 1992b). In the Olympics, pileated woodpeckers preferred to roost within western redcedar (*Thuja plicata*) (Aubry and Raley 2002b). The extensive use of grand fir in northeast Oregon and western redcedar in

the Olympics was attributed to the greater propensity for these species to form large, hollow chambers (Bull et al. 1992b, Aubry and Raley 2002b). Aubry and Raley (1996) found that 88% of all roosts were located in old or mature forests. The remaining roosts were primarily found in naturally regenerated young forests that were approximately 75 years old (Aubry and Raley 1996). Roosts east of the Cascades were also primarily found in old-growth forests (Bull et al. 1992b, McClelland and McClelland 1999). General characteristics of roost trees in Oregon and Washington are described in Table 2.

Table 2. DBH, height, and tree species reported for pileated woodpecker roost trees in Oregon and Washington.

Location	DBH (average)	DBH (range)	Height (average)	Height (range)	Species	References
Olympic Peninsula	149 cm (59 in)	37-309 cm (15-122 in)	36.5 m (120 ft)	11-63 m (36-207 ft)	Pacific silver fir, western hemlock, western redcedar	Aubry and Raley 2002b
Western Oregon	112 cm (44 in)	40-208 cm (16-82 in)	--	--	--	Mellen et al. 1992
Northeastern Oregon	71 cm (28 in)	40-131 cm (16-52 ft)	22 m (72 ft)	6-44 m (20-144 ft)	grand fir, ponderosa pine, western larch	Bull et al. 1992b; E. Bull, personal communication

Foraging

Pileated woodpeckers forage in forests containing large trees and snags that support abundant insect prey associated with dead and dying wood. Large rectangular/oval excavations in snags are indicative of pileated woodpecker foraging (McClelland 1979, Neitro et al. 1985, Bull and Jackson 1995). In Oregon and Washington, prey consisted of carpenter and thatching ants (Hymenoptera), beetle larvae (Coleoptera), termites (Isoptera), and other insects (Bull et al. 1992a, Torgersen and Bull 1995, Aubry and Raley 1996). Mature and old-growth coniferous forest are considered high quality foraging habitat (Aubry and Raley 1996), but forests as young as 40 years of age are used if snags, particularly large residual snags from burns or harvests, are present (Mellen et al. 1992). Pileated woodpeckers seldom use clearcuts, but will forage in clearcuts or shelterwood cuts if substantial foraging habitat is retained (see Mannan 1984, Mellen 1987). Researchers working in the Oregon Coastal Range determined that pileated woodpeckers used deciduous riparian for foraging activities (Mellen et al. 1992).

Pileated woodpeckers forage on large snags [>50 cm (20 in) dbh], live trees, logs, and stumps (Bull et al. 1986, Bull 1987, Torgersen and Bull 1995). Snags and live trees take on special importance in winter when logs and stumps may be covered with snow (McClelland 1979, Bull and Holthausen 1993). Pileated woodpeckers forage on snags in a broad range of decay conditions but appear to prefer large snags that may harbor more insects and larvae than smaller snags (Mannan et al. 1980). In contrast to foraging behavior east of the Cascade Range, downed logs are rarely used as foraging substrate in wet coastal forests (Aubry and Raley 2002b).

Home Range

Home ranges vary in size within the Pacific Northwest, ranging from 407 ha (1,006 ac)/breeding pair (data collected between June and March) in northeastern Oregon (Bull and Holthausen 1993), 480 ha (1,186 ac)/breeding pair during the summer in the central Oregon Coast Range (Mellen et al. 1992), and 863 ha (2,132 ac)/breeding pair annually on the Olympic Peninsula (Aubry and Raley 1996). The home range figures reported in the central Oregon Coast Range are likely smaller than the actual year-round home range for the pileated (Mellen et al. 1992). Home ranges for individuals that lost mates are larger than those of mated individuals (Bull and Holthausen 1993, Aubry and Raley 1996), and pairs with young have larger home ranges than pairs without young (Mellen et al. 1992). Although home ranges in the central Oregon Coast Range were actively defended, the ranges of adjacent birds overlapped (9-30% of an individual's home range overlapped) (Mellen et al. 1992). Home ranges in northeastern

Oregon generally consisted of >85% forested habitat (Bull and Holthausen 1993). Home ranges consisted primarily of late-successional forested habitat or second-growth forest with residual large snags (Bull and Holthausen 1993, Bull and Jackson 1995, Aubry and Raley 1996).

Urban/Suburban Habitat Use

Pileated woodpeckers are residents in some developing areas throughout Washington (M. Tirhi; P. Thompson; H. Ferguson, personal communications). In these areas they occupy remnant patches of forest, parks, and green-belts. Because of their need for large trees and their sizeable territory requirements, loss or reduction of extensive wooded tracts and large trees will impact the species (Moulton and Adams 1991). Pileated woodpeckers in suburban areas forage on a variety of substrates, including large and small diameter coniferous and hardwood trees and snags (P. Thompson, personal communication; J. Lewis, unpublished data), and occasionally on suet feeders, utility poles, and fruit trees (Bull and Jackson 1995; J. Buchanan, personal communication).

Although habitat use in urbanizing environments in Washington has been given little attention, it is likely that pileated woodpeckers select large diameter trees and snags for nesting and roosting. Similarly, sizes of home ranges in urban environments are unknown, but they may be relatively large due to the fragmented nature of remnant forest habitats in most suburban landscapes. The relationship between cavity-nesters and urbanizing areas in Washington has only been investigated by a single study in the greater Seattle area (see Rohila 2002)

LIMITING FACTORS

Timber harvest can significantly impact pileated woodpecker habitat (Bull and Jackson 1995). The removal of large snags, large decaying live trees and downed woody debris of the appropriate species, size and decay class eliminates nest and roost sites and foraging habitat. Intensively managed forests typically do not retain these habitat features (Spies and Cline 1988). However, more recent state and federal forest management guidelines call for the retention of a specified number of wildlife trees during timber harvest (Washington Forest Practices Board 2001, Aubry and Raley 2002a). Bull and Jackson (1995) suggest that fragmentation of forested habitat may lead to reduced population density and increased vulnerability to predation as birds are forced to fly between fragmented forested stands; however, information on predation effects is currently lacking. Known predators include the northern goshawk (*Accipiter gentiles*), Cooper's hawk (*A. cooperii*), red-tailed hawk (*Buteo jamaicensis*), great horned owl (*Bubo virginianus*), American martin (*Martes americana*), and gray fox (*Urocyon cinereoargenteus*) (Bull and Jackson 1995).

The amount of forest retained in the suburban and urbanizing environment will influence the degree to which an area is used by pileated woodpeckers for foraging and reproduction (Moulton and Adams 1991, Rohila 2002). If the collective area of these retained forest tracts is large enough, suburban and other urbanizing environments could support pileated woodpeckers (Rohila 2002). However, because of their need for larger trees and their sizeable territory requirements, loss or reduction of wooded tracts and large trees could eliminate or preclude pileated woodpeckers from an urbanizing area (Moulton and Adams 1991).

MANAGEMENT RECOMMENDATIONS

General Recommendations

Specific management prescriptions should be developed for actions that will be undertaken at the home range scale (Mellen et al. 1992, Bull and Holthausen 1993) as discussed later in this chapter. Management activities for pileated woodpeckers should focus on providing and maintaining a sufficient number of appropriate large snags and large decaying live trees for nesting and roosting (Aubry and Raley 2002b). Retaining snags and decaying live trees (of appropriate size, species and decay classes) provides suitable nesting and roosting structure for a longer period of time than retaining only hard snags (Aubry and Raley 2002b). Trees, snags and stumps with existing pileated nest cavities and foraging excavations should be retained (Bonar 2001).

Management of nesting and roosting habitat may be accomplished in several ways in managed forests. A variety of snag creation techniques are being developed and it is likely that such techniques can produce suitable snags in older second growth forests (e.g., removal of tree-top, girdling) (Neitro et al. 1985, Bull and Partridge 1986, Lewis 1998). Properly conducted uneven-aged management of forest stands can create adequate canopy closure and sufficient large snags and large decaying live trees to maintain suitable nesting and roosting habitat for pileated woodpeckers. Defective or cull trees can be retained during commercial thinning operations, or these can be recruited to become snags in subsequent rotations (Neitro et al. 1985). Because of the difficulties in recruiting large snags in managed forests (Wilhere 2003), one of the most effective means to improve snag densities may involve extending the length of harvest rotations (Neitro et al. 1985).

Managers may have some flexibility when providing foraging habitat. Naturally formed stumps and numerous large logs in various stages of decay can be retained to improve foraging habitat (Torgersen and Bull 1995). Management for large snags, culls, and green replacement trees can ultimately provide large downed logs as foraging habitat. Protection of riparian habitat throughout Washington and the provisions of buffers along streams may also ensure that adequate foraging habitat exists for pileated woodpeckers (Mellen et al. 1992, Knutson and Naef 1997). However, we currently lack adequate information to define appropriate riparian buffers for pileated woodpeckers in managed forests.

Forest managers often apply minimum size standards that are determined through research (e.g., the smallest recorded nest tree dbh) to achieve a combination of wildlife conservation and resource extraction goals (McClelland and McClelland 1999). Conner (1979) argued that managing forests using minimum size standards may cause gradual population declines and suggested that average values for habitat components should be used in forest management. The following set of recommendations is based primarily on average (rather than minimum) standards.

Western Washington

The following recommendations are primarily based on the goals identified by the Partners in Flight (PIF) Conservation Plan for the Westside Coniferous Forest region (Altman 1999). These goals were derived from research conducted in the Oregon Coast Range and Washington's Olympic Peninsula (Nelson 1989, Mellen et al. 1992, Aubry and Raley 1996, 2002b). The PIF recommendations for managed coniferous forests (stands with >70% conifer stems) of about 60 years of age or older include maintaining >70% canopy closure and an average of ≥5 nest snags/10 ha (2 snags/10 ac) that are >76 cm dbh (30 in). In areas used for both nesting and roosting, an average of 18 large snags/ha (7 snags/ac) and 8 decaying large trees/ha (3 trees/ac) should be retained (Aubry and Raley 2002b). Trees ≥27.5 m (≥90 ft) in height should be retained to provide nesting and roosting structures (Aubry and Raley 2002b). Overall, pileated woodpeckers selected larger trees for roosting than those used for nesting (see Buchanan, in press). Based on Aubry and Raley's (2002b) work in the Olympics, trees between 155 and 309 cm dbh (61-122 in) should be retained for roosting. In addition, an average of 30 foraging snags/ha (12 snags/ac) (mix of hard and soft snags) should be provided in the following size classes (see Table 3; Altman 1999).

Table 3. Suggested number of foraging snags to retain.

Size class	Foraging snags retained
• 25-50 cm dbh (10-20 in)	= ≥18 snags/ha (7 snags/ac)
• 51-76 cm dbh (20-30 in)	= ≥8 snags/ha (3 snags/ac)
• >76 cm dbh (>30 in)	= ≥5 snags/ha (2 snags/ac)

Population targets suggested by the PIF conservation plan called for about nine pairs of pileated woodpeckers per township (9.7 pairs/100 km^2), based on an average breeding season home range of 600 ha (Altman 1999:36-37). Using the annual home range size of 863 ha for the Olympic Peninsula (Aubry and Raley 1996), a comparable target could be adjusted to about six pairs per township (6.4/100 km^2) on the Olympic Peninsula (Buchanan, in press). At the landscape-level, an average of 60% of a landscape management unit (e.g., watershed, township) should be retained as suitable habitat (early successional forest with adequate snag densities, young forest [40-80 years] with adequate snag densities, and late successional forest), and >40% of this

suitable habitat should be retained in late-successional forest. Adequate snag densities are defined as the combination of nesting, roosting and foraging snag numbers (see above).

Eastern Washington

The following recommendations are based on research conducted in the Blue Mountains of northeastern Oregon (Bull 1987, Bull and Holthausen 1993) as well as research conducted in northwestern Montana (McClelland and McClelland 1999). Because most work on pileated woodpeckers in the inland northwest was conducted in the Blue Mountains, it should be noted that the following recommendations might be less applicable to areas outside of this region.

Several key habitat components are necessary to maintain suitable pileated woodpecker habitat. These include a mature forest with ≥2 canopy layers, the uppermost being 25-30 m (82-98 ft) in height; large live trees to provide cover and eventual replacement of dead trees; large dead trees for nesting; and dead trees and downed woody material for foraging (Bull 1987). Territory size for breeding pairs in the Blue Mountains averaged 407 ha (1006 ac) and was considered an adequate size to manage for each breeding pair in that region (Bull and Holthausen 1993). Researchers working in the Blue Mountains recommended that 75% of management areas be in grand fir forest types and they suggested that the composition of this area include 25% old growth and 75% mature stands. Additionally, they suggested that ≥50% of the management areas have ≥60% canopy closure and that at least 40% of the stands remain unlogged (Bull and Holthausen 1993).

Bull and Holthausen (1993) recommended retaining 8 snags/ha (3.2 snags/ac) with at least 20% being ≥ 51 cm (20 in) dbh for both nesting and roosting. Based on Bull's (1987) research, trees ≥ 28 m (92 ft) should be retained to provide nesting structures. Bull and Holthausen (1993) recommended retaining ≥100 logs/ha (40/ac) as foraging substrate in management areas, with a preference for logs ≥38 cm (15 in) dbh that include all species except lodgepole pine (*Pinus contorta* var. *latifolia*). McClelland and McClelland (1999) suggested that the optimum dbh for nest and roost trees should be: 77-91 cm (30-36 in) for western larch, 76-96 cm (30-38 in) for ponderosa pine, and 75-100 cm (30-39 in) for black cottonwood (*Populus balsamifera*).

Urban/Suburban Areas

Although pileated woodpeckers are known to use suburban and other urbanizing areas (Moulton and Adams 1991, Rohila 2002), few studies have examined habitat use in these areas. Consequently, the following generalized recommendations address the principle needs of pileated woodpeckers based primarily on the findings of a recent study conducted in the greater Seattle area (Rohila 2002). Additional research will be necessary to develop specific guidelines for urban and suburban areas.

In urbanizing areas, the greatest negative influence to pileated woodpeckers is likely the clearing of remnant forest patches. Based on research in greater Seattle, Rohila (2002) recommended that planners retain forest in the largest patches available (>30 ha [74 ac] would be considered large). Where large patches are unavailable, smaller patches should be retained; where the average size of smaller patches should be no less than approximately 3 ha (7 ac) (see Rohila 2002). Forest patches with high densities of existing snags and live trees should be targeted when selecting areas to retain during the planning process (Rohila 2002). The creation of snags or decaying live trees (Lewis 1998) may benefit pileated woodpeckers in suburban areas (see previous sections for preferred snag and tree size guidelines). Pileated woodpeckers and other cavity-dependent species would benefit from the retention of snags as well as the retention of live trees in the largest size classes available in the stand (Rohila 2002). Because designated suburban and urban parks often contain large forested tracts, park managers should also consider pileated woodpecker requirements.

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KEY POINTS

Habitat Requirements

- Inhabits mature and old-growth forests, and second-growth forests with large snags and fallen trees
- Excavates large nest cavities in snags or large decaying live trees
- Breeds and nests between late March to early July
- Roosts in hollow trees or vacated nest cavities at night and during inclement weather
- Forages in forests containing large trees and snags, and dead and dying wood

- Preys on carpenter and thatching ants, beetle larvae, termites, and other insects
- Present in some urban and suburban areas throughout Washington

Management Recommendations

General Recommendations

- Maintain large snags and large decaying live trees for nesting and roosting
- Retain naturally formed stumps and numerous large logs in various stages of decay to improve foraging habitat
- Use average size standards (rather than minimums) for managing pileated woodpecker habitat components (e.g., nest size standards).

Western Washington

- Maintain managed coniferous forests (stands with >70% conifer stems) of about 60 years of age or older at>70% canopy closure and an average of ≥5 nest snags/10 ha (2 snags/10 ac) that are >76 cm dbh (30 in)
- Retain an average of 18 large snags/ha (7 snags/ac) and 8 decaying large trees/ha (3 trees/ac) in areas used for both nesting and roosting
- Retain trees ≥27.5 m (≥90 ft) in height to provide nesting and roosting structures. Trees between 155 and 309 cm dbh (61-122 in) should be retained for roosting
- Retain an average of 30 foraging snags/ha (12 snags/ac)

Eastern Washington

- Maintain mature forest with ≥2 canopy layers, the uppermost being 25-30 m (82-98 ft) in height; large live trees to provide cover and eventual replacement of dead trees; large dead trees for nesting; and dead trees and downed woody material for foraging
- Retain 8 snags/ha (3.2 snags/ac) with at least 20% being ≥ 51 cm (20 in) dbh for both nesting and roosting
- Retain ≥100 logs/ha (40/ac) as foraging substrate in management areas, with a preference for logs ≥38 cm (15 in) dbh

Urban/Suburban Areas

- Conserve larger forest patches with large trees and snags
- Retain forest in the largest patches available (≥30 ha [74 ac] would be considered large). Where large patches are unavailable, smaller patches should be retained; where the average size of smaller patches should be no less than approximately 3 ha (7 ac).
- Retain or create snags as well as retain live trees in the largest size classes available in the stand

Loggerhead Shrike
Lanius ludovicianus

Last updated: 2003

Written by Matthew Vander Haegen

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Loggerhead shrikes are found in portions of British Columbia, Alberta and Saskatchewan, and throughout much of the United States (although rare in the northeastern U.S.) south to southern Mexico (Yosef 1996, Sibley 2000).

In Washington, the shrike is primarily a breeding resident of the shrub-steppe zone (see Figure 1; Miller 1931, Poole 1992). Shrikes depart for their migration south by September (Morrison 1981, Burnside 1987) and return around March (Poole 1992). Some individuals remain year-round in eastern Washington (Washington Department of Fish and Wildlife's Wildlife Information System, unpublished data).
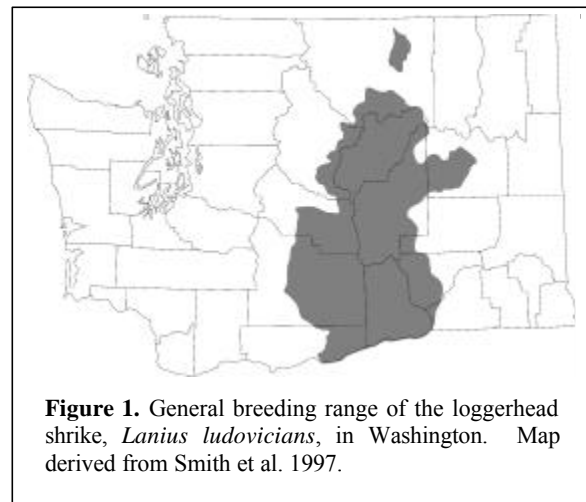
Figure 1. General breeding range of the loggerhead shrike, *Lanius ludovicians*, in Washington. Map derived from Smith et al. 1997.

RATIONALE

The Loggerhead shrike is a State Candidate species that has shown decreases in population from historical densities and distribution (Morrison 1981, Fraser and Luukkonen 1986, Sauer et al. 1995, Cade and Woods 1997). A recent analysis of Breeding Bird Survey data for the Columbia River Basin shows a significant decline in the shrike population over the last 26 years (Saab and Rich 1997). Loss of shrub-steppe habitat partially explains local declines of this species (Cade and Woods 1997). The Interior Columbia River Basin Ecosystem Management Project has listed loggerhead shrike as a species of high management concern for the region (Saab and Rich 1997).

HABITAT REQUIREMENTS

Loggerhead shrikes use open habitat during both breeding and nonbreeding seasons. Grasslands or pastures with short or patchy grasses are usually used for foraging. Scattered trees, shrubs or hedgerows are most often used for nesting and perching (Kridelbaugh 1983, Bohall-Wood 1987, Gawlik and Bildstein 1990). In the shrub-steppe of eastern Washington, Poole (1992) found shrikes were most abundant in lowland communities of sagebrush (*Artemisia* spp.), Sandberg's bluegrass (*Poa sandbergii*), and cheatgrass (*Bromus tectorum*); mixed shrub communities containing big sagebrush (*Artemisia tridentata*), bitterbrush (*Purshia tridentata*), Sandberg's bluegrass, Indian ricegrass (*Oryzopsis hymenoides*), and needle and thread grass (*Stipa comata*); and bitterbrush communities containing bitterbrush, Indian ricegrass, and needle and thread grass. Surveys in eastern Washington shrub-steppe revealed a greater abundance of loggerhead shrikes in deep, sand soil communities than in communities with loamy or shallow soils (Vander Haegen et al. 2000). The shrub-steppe communities occupied by shrikes could be described as a mixture of shrub patches and grassy or sandy openings (Poole 1992). Leu (1995) reported greater foraging success by juvenile shrikes in shrub-steppe stands having a more open grass/forb layers, where birds could readily spot and capture prey on the ground.

Trees or shrubs used for nesting share the common characteristics of having dense foliage (Poole 1992), being very bushy, and/or thorny (Kridelbaugh 1983, Brooks and Temple 1990a). Selection criteria for nesting trees or shrubs appear to be based on the amount of cover and protection the plant provides rather than a preference for a particular species of tree or shrub (Porter et al. 1975, Gawlik and Bildstein 1990). In eastern Washington, shrub species with the greatest number of nests were big sagebrush and bitterbrush, but nests also were found in mock orange (*Philadelphus lewisii*), greasewood (*Sarcobatus vermiculatus*) and clematis (*Clematis* spp.) (Miller 1931, Poole 1992). Shrikes in Idaho shrub-steppe nested in big sage (65.4%), bitterbrush (20.4%) and greasewood (12.3%), with shrubs used for nesting averaging 162 cm (64 in) in height (Woods and Cade 1996). Choice of nest shrub seemed unrelated to the success or failure of shrike nests in Idaho; other variables such as presence of foraging perches may have been more important in determining adequate shrike habitat (Woods and Cade 1996).

Loggerhead shrikes are highly territorial, maintaining larger territories than other insectivorous perching bird species of similar size (Yosef 1996). Mean territory size from 8 different studies ranged from 7.5 ha to 34 ha (18.5 - 84 ac) (Yosef 1996). Poole (1992) found that shrikes defended territories averaging 13.9 ± 2.0 ha (34.35 ± 4.9 ac) on the Hanford Site in Washington. The average distance a shrike nested to the closest adjacent nesting shrike was 610 m (2,000 ft) in shrub-steppe habitat in Washington (Poole 1992) and ranged from 115-670 m (377-2198 ft)in Idaho shrub-steppe (Woods 1995). In the upper Midwest, Brooks and Temple (1990a) observed shrikes hunting up to 400 m (1,312 ft) away from their nest site during nesting season.

Loggerhead shrikes are generalists, feeding on any animal they can subdue (Fraser and Luukkonen 1986, Gawlik and Bildstein 1990, Scott and Morrison 1990). Their diet consists of insects, small mammals, birds, reptiles and amphibians. On the Hanford Site, shrikes preferred grasshoppers, lizards and small mammals (Poole 1992). These prey items were more abundant in sagebrush and bitterbrush communities than in grassland and rabbitbrush (*Chrysothamnus* spp.) communities. Shrikes are the only perching birds that regularly kill and consume vertebrate prey by means of impaling (Fraser and Luukkonen 1986).

LIMITING FACTORS

Specific factors limiting loggerhead shrikes are unknown. Suggested causes of population decline include loss of breeding habitat (Kridelbaugh 1981, Burnside and Shepherd 1985, Tyler 1992), low overwinter survival through loss of wintering areas (Hass and Sloane 1989, Brooks and Temple 1990a,b), contamination by pesticides (Kridelbaugh 1981, Fraser and Luukkonen 1986) and high mortality due to vehicle collision (Gawlik and Bildstein 1990, Flickinger 1995).

MANAGEMENT RECOMMENDATIONS

Shrub-steppe communities should be left in reasonably undisturbed condition and fragmentation should be minimized (Woods and Cade 1996). Management activities that increase cheatgrass invasion or increase risk of wildfire also must be avoided (Leu and Manuwal 1996).

In shrub-steppe and associated riparian habitats, retain patches of tall shrubs for nesting and perching (Leu and Manual 1996). Herbaceous cover should average <20% and should be dominated by native species >30% of the ground should be bare (including areas of cryptogramic crust) (Altman and Holmes 2000). In agricultural areas, retain scattered trees, shrubs, hedgerows, as well as trees along fence lines for nesting and perching (Yosef 1996).

Removal of sagebrush should be considered only in rare instances when reducing shrub cover is necessary to meet ecological goals of habitat restoration. Sagebrush cover should be reduced on a site only after careful consideration of how the methods used may affect sagebrush regeneration and the opportunity for exotic vegetation to invade the site. Burning may create the greatest risk to local shrike populations because the damage is immediate and regeneration to pre-burn condition may take up to 30 years (Harniss and Murray 1973). Fire is not a suitable tool to reduce sagebrush cover in low rainfall zones because disturbance often leads to cheatgrass invasion and because sagebrush recovery is slow (e.g., Benton, Franklin and Grant Counties) (Wisdom et al. 2000). If chemical use is planned for areas where loggerhead shrikes occur, refer to Appendix A for a list of contacts to consult when using and assessing pesticides, herbicides and their alternatives.

Livestock grazing at low to moderate levels has not been shown to be detrimental to loggerhead shrike habitat (Saab et al. 1995); however, sustained grazing likely will reduce habitat suitability (Altman and Holmes 2000). In keeping with recommendations published for other shrub-steppe passerines (Altman and Holmes 2000), we recommend that grazing levels should be sufficiently low to allow >50% of the year's growth of perennial bunchgrass to persist through the following breeding season.

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KEY POINTS

Habitat Requirements

- Open habitats with short and/or patchy grasses for foraging and scattered trees, shrubs, or hedgerows for nesting and perching sites.
- The shrub-steppe communities occupied by shrikes could be described as a mixture of shrub patches and grassy or sandy openings.

Management Recommendations

- Retain shrub-steppe communities, especially big sagebrush and mixed shrub communities.
- Avoid wildfires and activities that may increase invasion by exotic vegetation.
- Retain patches of tall shrubs for nesting and perching in shrub-steppe and associated riparian habitats.
- Livestock grazing should be kept at low to moderate levels, with >50% of the year's growth of perennial bunchgrass persisting through the following breeding season.
- In agricultural areas (e.g., pastures), establish or retain scattered trees and tall shrubs, wind break, and hedgerow vegetation.
- Refer to Appendix A for a list of contacts to consult when using and assessing pesticides, herbicides and their alternatives if chemical use is planned for areas where this species occurs.

Purple Martin
Progne subis

Last updated: 2003

Written by David W. Hays and Ruth Milner

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Purple martins breed locally from southern Canada to central Mexico (Brown 1997) and winter in South America (Ehrlich et al. 1988)

In Washington, they typically breed near the waters around the Puget Sound, along the Strait of Juan de Fuca, the southern Pacific coastline, and near the Columbia River (see Figure 1; S. Kostka, personal communication). Unconfirmed records suggest that other potential breeding areas might also be found from the Willamette Valley up through Thurston County.
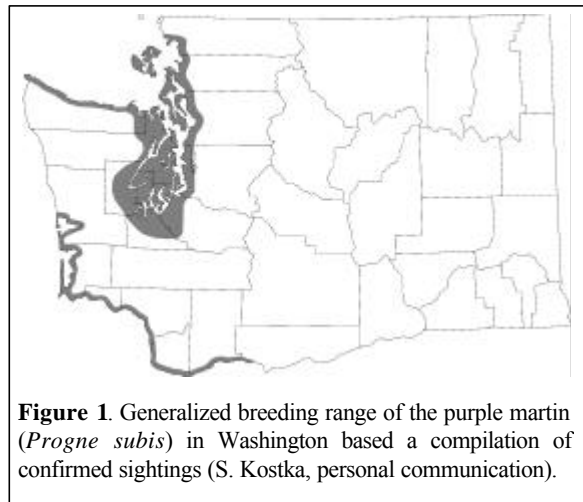
Figure 1. Generalized breeding range of the purple martin (*Progne subis*) in Washington based a compilation of confirmed sightings (S. Kostka, personal communication).

RATIONALE

The purple martin is a State Candidate species. This species has a high public profile and are vulnerable to population fluctuations due to a limited distribution and loss of suitable natural nesting cavities (Brown 1997).

HABITAT REQUIREMENTS

Purple martins are insectivorous, colonial nesting swallows that nest in cavities (Brown 1997). In Washington, most martins have been reported nesting in artificial structures near cities and towns in the lowlands of western Washington. Historically, they probably bred in old woodpecker cavities in large dead trees, but only a few such nests are known to exist in Washington today (Brown 1997, Russell and Gauthreaux 1999). The eastern race of purple martins often nest in apartment-style nest-boxes, while the western subspecies, found here in Washington, prefer to nest individually (Pridgeon 1997).

The nest site preferences of the purple martin have been studied at Fort Lewis in Pierce County (Bottorff et al. 1994). Martins nested in a variety of artificial nesting structures, including wood duck boxes. No purple martin nesting activity was detected in artificial nesting structures on land; all artificial cavities were over freshwater wetlands, ponds or saltwater. Swallows were found nesting in both natural and artificial cavities intermingled with martin nests, possibly competing for nest sites. More recent observations documented four pairs nesting in natural snag cavities near water at Fort Lewis (S. Kostka, personal communication). Martins were also recently found nesting in boxes well away from water just outside of the fort in Spanaway.

Purple martins feed in flight on insects (Ehrlich et al. 1988, Brown 1997). Favorable martin foraging habitat includes open areas, often located near moist to wet sites, where flying insects are abundant.

LIMITING FACTORS

The decline of the purple martin is attributed to the lack of snags containing nest cavities (Bottorff et al. 1994) as well as competition for nesting cavities with more aggressive European starlings (*Sturnus vulgaris*) and house sparrows (*Passer domesticus*; Bottorff et al. 1994, Brown 1997).

MANAGEMENT RECOMMENDATIONS

In Washington, purple martins are known to nest in cavities located in old pilings over water and occasionally in snags (United States Fish and Wildlife Service 1985, Milner 1987). These pilings and snags (especially snags near water) should be protected and left standing. The removal of creosote-coated pilings that contain a purple martin nest box or that possibly contain cavities used by martins should be closely coordinated with the Washington Department of Fish and Wildlife (M. Tirhi,

Figure 2. Purple martin nest box plan (Courtesy of Tom Lund, USFWS 1985).

personal communication). Snags should be retained during timber harvesting operations near saltwater and wetlands (Milner 1988), including salvage operations after burns, blow-downs, and insect infestations (United States Fish and Wildlife Service 1985). Prescribed burns can be used as a tool to create favorable martin foraging habitat. Snags can be created in forest openings, or at forest edges (e.g., by topping trees) where nesting cavities are lacking, especially within 16 km (10 mi) of an existing purple martin colony (United States Fish and Wildlife Service 1985). Because northern flickers and pileated woodpeckers excavate cavities used by martins, managing for these species will indirectly benefit martins (K. Bettinger, personal communication).

Because of their dependence on insects for food, purple martins can be impacted by the broad use of pesticides (United States Fish and Wildlife Service 1985). If insecticide or herbicide use is planned for areas where this species occurs, review Appendix A for contacts to assist in assessing the use of chemicals and their alternatives.

Although artificial nesting structures are an important tool for the conservation of purple martins, they should not replace the protection of natural nesting structures (e.g., snags) and the habitat used by this species (S. Kostka, personal communication). If natural sites are lacking and cannot be provided by manipulating habitat, artificial nesting structures can be provided. A number of artificial nest designs have been developed and work relatively well. Below are the specifications for one such design (United States Fish and Wildlife Service 1985):

1) Construct nest boxes using a design such as that shown in Figure 2. Box dimensions should be at least 10" x 7" x 7". It is important to make the entrance 1 1/4" high, continuous with the porch floor. The top of the opening should be sanded smooth. The porch is a necessary feature, and the floorboard should be rough to provide traction. These features, particularly the size of the opening, will aid in dissuading house sparrows and starlings from taking over the nest boxes.

2) Protect boxes from wet weather by sealing edges with caulking material. Painting or varnishing the wood, using cedar for construction or protecting the roof with galvanized tin, can provide additional protection. Provide drainage holes in the box floor and ventilation holes near the top.
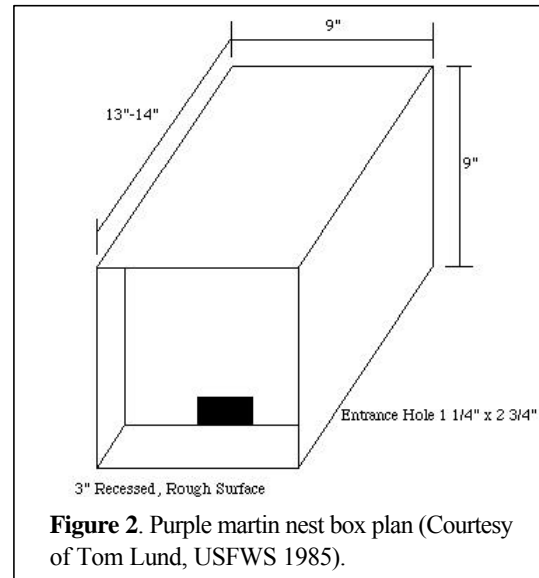
3) Locate boxes in existing colonies first. Locate additional boxes in suitable habitat within 16 km (10 mi) of existing colonies. A minimum of 3 boxes should be erected at each site for this colonial nesting species (J. Bottorff, personal communication); however, populations in the west do not appear to use the apartment style houses that eastern populations are so well known for (B. Tweit, personal communication).

4) Locate boxes near (preferably above) water or wetlands with minimum clear air space of 4.5 m (15 ft), preferably 30 m (100 ft), for circling and foraging around the nest. Erect houses high enough above the ground or water to avoid vandalism and high tides. J. Bottorff, personal communication) noted no difference in use of boxes erected from 1 m (3 ft) to 3 m (10 ft) above the water.

5) It is not necessary to remove martin nests from previous years. If nesting material is removed, it should be done in the spring and the contents placed in a dry spot beneath the nest. This is to allow for the emergence of chalcid wasps, which help to control Protocalliphora, a parasite on martin nestlings. The wasp larvae live in nest materials and will return to the martin boxes if old nests are left nearby.

6) Where European starlings and house sparrows are a problem, plug the box entrances from October to mid-April. If starlings establish themselves in a box, remove their nests, eggs, and young on a routine basis (they will renest several times in a breeding season). The same measures can be taken with house sparrows early in the breeding season; however, removal of sparrow nests later in the cycle may cause sparrows to wander into martin nests and destroy their young. Adult sparrows may be controlled. If this is impossible, remove eggs and young, but leave sparrow nests in later months to prevent sparrows from taking over martin nests.

7) Starlings and house sparrows are not classified as a protected species. However, other cavity-nesters that may inhabit martin boxes, such as swallows, are protected, and occupied swallow nests should not be removed.

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KEY POINTS

Habitat Requirements

- $ Nests in natural and artificial cavities, usually over water.
- $ Readily nest in bird boxes in areas where the species is already established.
- $ Usually nest in colonies.
- $ Foraging habitat includes open areas, often located near moist to wet sites, where flying insects are abundant.

Management Recommendations

- $ Retain snags during timber harvesting (especially near saltwater and wetland sites).
- $ Retain old pilings. The removal of creosote-coated pilings that contain a purple martin nest box or that contain cavities used by martins should be coordinated closely with the Washington Department of Fish and Wildlife.
- $ Create snags in forest openings and along forest edges if snags are lacking or limited.
- $ Use fires to create or maintain favorable martin foraging habitat, where appropriate.
- $ If pesticides are to be used in areas inhabited by martins, refer to Appendix A for contacts useful in assessing pesticides, herbicides, and their alternatives.
- $ Put up nest boxes when natural cavities are lacking or limited and cannot be created (see text for details).

Sage Thrasher
Oreoscoptes montanus

Last updated: 2003

Written by Matthew Vander Haegen

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Sage thrashers breed from British Columbia to eastern Montana, south to northern Arizona and west to California. They winter from central California to central Texas, south to southern Baja California into northern Mexico (American Ornithologists' Union 1983).

In Washington, they are found in the Columbia Basin shrub-steppe region (see Figure 1). Sage thrashers are documented in Adams, Asotin, Benton, Douglas, Franklin, Grant, Kittitas, Lincoln, Okanogan, Walla Walla and Yakima counties (Smith et al. 1997).
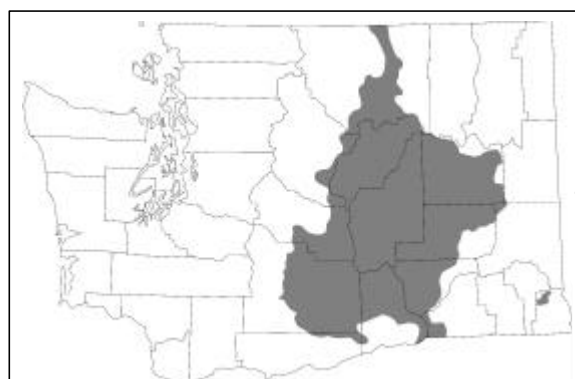
Figure 1. Breeding range of the sage thrasher, *Oreoscoptes montanus*, in Washington. Map derived from Smith et al. 1997.

RATIONALE

The sage thrasher is a State Candidate species that is highly dependent on healthy shrub-steppe communities comprised of tall, dense sagebrush (*Artemisia* spp.) (Rich 1980, Reynolds 1981, Reynolds and Rich 1978, Petersen and Best 1991). Shrub-steppe in Washington has become severely fragmented and reduced in extent over the last century (Dobler et al. 1996). Furthermore, the Interior Columbia River Basin Ecosystem Management Project listed the sage thrasher as a species of high management concern for the region (Saab and Rich 1997).

HABITAT REQUIREMENTS

Sage thrashers are closely associated with sagebrush and are considered obligates of sagebrush communities (Braun et al. 1976). In Idaho, sage thrashers used sites that were characterized as having high sagebrush cover within large blocks of shrub-steppe (Knick and Rotenberry 1995). Shrub-steppe describes a plant community consisting of one or more layers of grasses with a discontinuous overstory of shrub cover (Daubenmire 1988). Sage thrashers nest in stands of big sagebrush (*Artemisia tridentata*), placing their nests in or beneath shrubs that are generally 55 to 90 cm (22-36 in) tall (Reynolds and Rich 1978, Rich 1980, Reynolds 1981, Petersen and Best 1991). In Washington, nest shrubs averaged 102 cm tall (n = 122) (Washington Department of Fish and Wildlife, unpublished data). Thrasher nests are bulky and usually located in large bushes with substantially thick branches that provide adequate support

(Reyser 1985, Rich 1985). Reynolds (1981) found that nests built either on the ground or within shrubs had approximately the same depth of foliage over their nests (57.5 cm [23 in]). Petersen and Best (1991) reported that sage thrashers favored shrubs with high foliage density. They also found that thrashers preferred nesting in shrubs having branches or foliage within 30 cm (11.7 in) of the ground. Sage thrashers require a relatively open understory for foraging (Reynolds et al. 1999); however, the amount of bare ground around a typical nest site is usually less than that of the surrounding area (Petersen and Best 1991).

Sage thrashers in Washington occurred in greater abundance in shrub-steppe communities that ranged from fair to good condition (characterized by fewer invasive exotic plants) than at poor condition sites (Vander Haegen et al. 2000). Additionally, sage thrashers were more abundant in shrub-steppe communities with loamy and shallow soils rather than sandy soils.

Mean territory size for sage thrashers ranged from 0.39 ha (1 ac) in Washington (Stephens 1985) to 0.96 ha ± 0.12 ha (2.37 ac ± 0.3 ac) in Idaho (Reynolds and Rich 1978). Sage thrashers will nest in fragments of shrub-steppe set within agricultural areas (Vander Haegen et al. 2002). However, birds using these fragmented sites may experience greater rates of nest predation than their counterparts nesting in large blocks of shrub-steppe.

Sage thrashers forage primarily on the ground and mainly consume grasshoppers, ants, beetles and other insect larvae during the spring (Ryser 1985, Stephens 1985, Petersen and Best 1991). In summer, small fruits are added to their diet (Ryser 1985).

LIMITING FACTORS

Availability of shrub-steppe communities containing tall sagebrush for nesting likely limit the distribution of sage thrashers in Washington (Reynolds et al. 1999). Additionally, degradation of sagebrush stands by invasive plants such as cheatgrass (*Bromus tectorum*) also render sites less suitable to sage thrashers. Fragmentation of shrub-steppe by agriculture apparently does not exclude sage thrashers but will result in lost breeding habitat (Reynolds et al. 1999).

MANAGEMENT RECOMMENDATIONS

In order to maintain sage thrasher populations, shrub-steppe communities should be left in reasonably undisturbed condition and fragmentation should be minimized (Reynolds et al. 1999, Wisdom et al. 2000). Management activities that increase cheatgrass invasion or increase risk of wildfire also must be avoided.

Optimum habitat for sage thrashers in Washington consists of blocks of shrub-steppe > 16 ha (40 ac) with sagebrush cover ranging between 5-20% and shrubs averaging >80 cm (32 in) tall (Altman and Holmes 2000). An herbaceous cover of native species should average 5-20%, with $10% of the ground bare (including areas of cryptogramic crust) to allow movement on the ground. Exotic annual grasses should cover <10% of the ground. Although much of Washington's shrub-steppe is fragmented by agriculture, habitat restoration on formerly tilled fields could expand the range of shrub-steppe obligate birds in fragmented landscapes (Vander Haegen et al. 2000).

Removal of sagebrush should be considered only in rare instances when reducing shrub cover is necessary to meet ecological goals of habitat restoration (Wisdom et al. 2000). Sagebrush cover should only be reduced after careful consideration of how the removal methods may affect sagebrush regeneration and the spread of exotic vegetation. Burning may lead to serious negative impacts to local sage thrasher populations because the damage is immediate and regeneration to pre-burn condition may take up to 30 years (Harniss and Murray 1973). Fire is not a suitable tool to reduce sagebrush cover in low rainfall zones (e.g., Benton, Franklin and Grant Counties) because exotic plants overwhelm the natives plants and sagebrush is slow to recover (Knick and Rotenberry 1995, Reynolds et al. 1999, Wisdom et al. 2000). If chemical use is planned for areas where this species occurs, refer to Appendix A for a list of contacts to consult when using and assessing pesticides, herbicides and their alternatives.

Although data are limited on this subject, livestock grazing at low to moderate levels has not been shown to be detrimental to sage thrasher habitat (Saab et al. 1995). Because sage thrashers frequently nest and forage at ground level, Altman and Holmes (2000) state that grazing levels should be kept at low intensities. They also suggest allowing >50% of the year's growth of perennial bunchgrass to persist through the following breeding season.

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KEY POINTS

Habitat Requirements

- Closely associated with sagebrush and considered obligates of sagebrush communities. Require extensive stands of shrub-steppe.
- Nest in stands of big sagebrush, placing their nests in or beneath shrubs. Nests are bulky and usually located in large bushes having substantially thick branches that provide adequate support. Favor shrubs with high foliage density that have branches or foliage within 30 cm (11.7 in) of the ground.
- Abundant in shrub-steppe communities with loamy and shallow soils rather than communities with sandy soils.
- Feed primarily on insect larvae.

Management Recommendation

- Retain sagebrush communities and avoid fragmentation of existing sagebrush stands.
- Avoid activities that may increase invasion of cheatgrass and other exotic vegetation.
- Grazing of livestock should be kept at low to moderate levels, with >50% of the year's growth of perennial bunchgrass persisting through the following breeding season.
- Control wildfires in sagebrush habitat, especially in low rainfall zones.
- Removal of sagebrush should be considered only in rare instances when reducing shrub cover is necessary to meet ecological goals of habitat restoration.
- Retain blocks of shrub-steppe > 16 ha (40 ac) with sagebrush cover ranging from 5-20% and shrubs averaging >80 cm (32 in) tall. An herbaceous cover of native species should average 5-20%, with ≥10% of the ground bare (including areas of cryptogramic crust). Exotic annual grasses should cover <10% of the ground.
- Refer to Appendix A for a list of contacts to consult when using and assessing pesticides, herbicides and their alternatives.

Sage Sparrow
Amphispiza belli

Last updated: 2003

Written by Matthew Vander Haegen

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Sage sparrows breed from southeastern Washington to northwestern Colorado, and south to southern California, northern Arizona and northwestern New Mexico (Martin and Carlson 1998). They winter at low elevations in southern portions of their range (Farrand 1983).

In Washington, their distribution coincides with sagebrush (*Artemisia* spp.) and bunchgrass (*Agropyron* spp.) communities of the central portion of the state (Larrison and Sonnenberg 1968). Sage sparrows are documented in Adams, Benton, Douglas, Franklin, Grant, Kittitas, Lincoln, Okanogan and Yakima Counties (see Figure 1; Smith et al. 1997).

Figure 1. General breeding range of the sage sparrow, *Amphispiza belli*, in Washington. Map derived from Smith et al. 1997.

RATIONALE

The sage sparrow is a State Candidate species that depends almost entirely on sagebrush-steppe habitat (Braun et al. 1976, Rich 1980, Reynolds 1981, Petersen and Best 1985). This habitat in Washington has become severely fragmented and reduced in extent over the last century (Dobler et al. 1996), particularly the deep-soil communities that this species apparently prefers (Vander Haegen et al. 2000). Furthermore, the Interior Columbia River Basin Ecosystem Management Project listed the sage sparrow as a species of high management concern for the region (Saab and Rich 1997).

HABITAT REQUIREMENTS

Sage sparrows are closely associated with sagebrush-steppe plant communities (Braun et al. 1976, Wiens and Rotenberry 1981). Sagebrush-steppe describes a plant community consisting of one or more layers of grasses and forbs with a discontinuous overstory of sagebrush shrub cover (Daubenmire 1988). Sage sparrows are sensitive to fragmentation of sage cover and are found more frequently in extensive areas of continuous sage (Knick and Rotenberry 1995, Vander Haegen et al. 2000).

Sage sparrows commonly nest within or beneath sagebrush plants (Martin and Carlson 1998). Nesting takes place from late March through June, with pairs typically producing 1-2 broods/year (Bent 1968, Alcorn 1978, Rich 1980, Ryser 1985, Petersen and Best 1987). Shrubs that are at least 75% living are selected for nesting, and nests are always located outside of the dead portion of the shrub (Petersen and Best 1985). The height of shrubs used for nesting generally ranged between 40 and 100 cm (16-40 in) (Rich 1980, Reynolds 1981, Petersen and Best 1985) and averaged 90 cm (35 in) in eastern Washington (Washington Department of Fish and Wildlife, unpublished data).

Contiguous breeding territories generally are established by males in March (Petersen and Best 1987). Territory sizes of mated males vary greatly (Weins et al. 1985), ranging from 0.8 ha (2 ac) (Petersen and Best 1987) to 4.4 ha (11 ac) (Rich 1980). A study in southeastern Washington found that the size of breeding territories ranged between 0.65 ha (1.6 ac) and 1.57 ha (3.9 ac); territories also tended to decrease in size with an increase in population density (Weins et al. 1985). Boundaries between adjacent territories have been found to overlap, and the size and shape may fluctuate daily during the breeding season (Rich 1980).

In spring, sage sparrows are primarily insectivorous, feeding on grasshoppers, beetles and moth larvae (Martin and Carlson 1998). They glean food from the ground and from shrub branches within reach of the ground (Moldenhauer and Wiens 1970, Petersen and Best 1985, Ryser 1985). Sparrows also have been observed walking to and from their nests (T. Rich personal communication and B.M. Winter personal communication *in* Petersen and Best 1985). Thus, optimal foraging habitat should include an overstory of shrubs with clearings in the grass/forb layer to allow movement on the ground (Petersen and Best 1985).

LIMITING FACTORS

Availability of extensive sagebrush-steppe habitat is a primary factor limiting sage sparrow populations (Martin and Carlson 1998, Vander Haegen et al. 2000). Sage sparrows are sensitive to fragmentation of sagebrush stands and are found more frequently in large, undisturbed stands (Vander Haegen et al. 2000). Degradation of sagebrush stands by invasive plants such as cheatgrass (*Bromus tectorum*) also may render sites less suitable to sage sparrows (Dobler et al. 1996).

MANAGEMENT RECOMMENDATIONS

Sage sparrows are dependent on stands of sagebrush for nest sites, food, and cover (Martin and Carlson 1998). In order to maintain sage sparrow populations, sagebrush communities should be left in relatively undisturbed condition and fragmentation should be avoided. Management activities that increase cheatgrass and other exotic species that increase the risk of wildfire also should be avoided.

Optimum habitat for sage sparrows in Washington consists of large (>1000ha) blocks of sagebrush-steppe with sagebrush cover ranging from 10-25% and shrubs averaging >50 cm in height (Altman and Holmes 2000). Herbaceous cover of native species should average >10%, with ≥10% of the ground remaining bare (including areas of cryptogramic crust) to allow movement on the ground. Exotic annual grasses should cover <10% of the ground. Although much of Washington's sagebrush-steppe is fragmented by agriculture, habitat restoration on formerly tilled fields could expand the range of sagebrush-steppe obligate birds in fragmented landscapes (Vander Haegen et al. 2000).

Removal of sagebrush should be avoided, with the exception of rare instances when reducing shrub cover is necessary to meet ecological goals of habitat restoration (Wisdom et al. 2000). Sagebrush cover should be reduced on a site only after careful consideration of how the methods used may affect sagebrush regeneration and the opportunity for exotic vegetation to invade the site. Burning may lead to serious negative impacts to local sage sparrow populations because the damage is immediate and regeneration to pre-burn condition may take up to 30 years (Harniss and Murray 1973). Fire is not a suitable tool to reduce sagebrush cover in low rainfall zones (e.g., Benton, Franklin, and Grant Counties) where exotic vegetation often becomes dominant and sagebrush is slow to recover (Knick and Rotenberry 1995, Wisdom et al. 2000). If chemical use is planned for areas where this species

occurs, refer to Appendix A for a list of contacts to consult when using and assessing pesticides, herbicides and their alternatives.
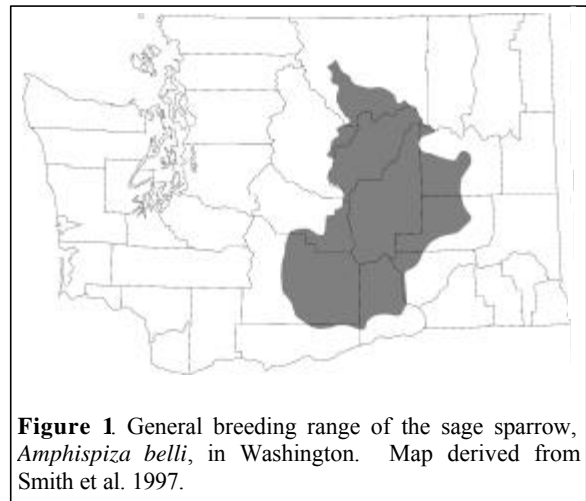
Although limited data are available on this subject, livestock grazing at low to moderate leve ls has not been shown to be detrimental to sage sparrow habitat (Saab et al. 1995). Because sage sparrows in Washington frequently nest on the ground early in the spring (Washington Department of Fish and Wildlife, unpublished data), and because they primarily forage at ground level, grazing levels should be kept at low levels (Altman and Holmes 2000). Researchers suggest allowing >50% of the year's growth of perennial bunchgrass to persist through the following breeding season.

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KEY POINTS

Habitat Requirements

• Strong association with sagebrush habitat, especially in extensive, unfragmented stands.
• Sagebrush cover between 10 and 25%, with shrubs averaging >50 cm in height.
• Herbaceous cover (native species) >10%, with ≥10% of the ground bare (including areas of cryptogramic crust); exotic annual grasses should cover <10% of the ground.

Management Recommendation

• Retain large blocks of sagebrush communities and avoid fragmentation of existing stands.
• Establish or retain 10-25% sagebrush cover and shrubs averaging >50 cm in height. Maintain an herbaceous cover of native species averaging >10%, with ≥10% of the ground bare (including areas of cryptogramic crust). Reduce exotic annual grasses to <10% of the ground cover.
• Avoid activities that may increase invasion of cheatgrass and other exotic vegetation.
• Livestock grazing should be kept at low to moderate levels, with >50% of the year's growth of perennial bunchgrass persisting through the following breeding season.
• Control wildfires in sagebrush habitat, especially in low rainfall zones.
• Refer to Appendix A for a list of contacts to consult when using and assessing pesticides, herbicides and other alternatives.
• Avoid the removal of sagebrush, with the exception of rare instances when reducing shrub cover is necessary to meet ecological goals of habitat restoration.

APPENDIX A: Contacts to assist in evaluating the use of herbicides, pesticides, and their alternatives

Government Organizations

United States Environmental Protection Agency
Provides information, brochures, and technical help on pesticide application.
Region 10 Public Affairs Office, Seattle   1-800-424-4372

Washington State Department of Agriculture

Pesticide Management
General Information...(360) 902-2010
Toll Free General Information ....(877) 301-4555
Assistant Director..(360) 902-2011

Compliance
Enforces state and federal pesticide laws; investigates complaints of pesticide misuse.
Manager ....(360) 902-2036
Olympia Compliance ....(360) 902-2040
Moses Lake   ....(509) 766-2575
Spokane Compliance ....(509) 533-2690
Wenatchee Compliance..(509) 664-3171
Yakima Compliance   ....(509) 225-2647

Registration and Licensing
Registers pesticides sold and used in Washington.
Manager ....(360) 902-2026
Pesticide Registration - Olympia ....(360) 902-2030
Pesticide Registration - Yakima ....(509) 255-2647

Program Development
Licenses pesticide application equipment and pesticide dealers; commercial, public, and private pesticide applications; and operators and consultants. Conducts waste pesticide disposal program; responsible for public outreach and education.
Manager ....(360) 902-2051
Pesticide Licensing and Recertification
     Eastern Washington...(509) 225-2639
     Western Washington...(360) 902-1937

Waste Pesticide Collection...(360) 902-2050
Farmworker Ed. and Pest. Licensing - Yakima ....(509) 255-2639

Washington Department of Ecology, Regional Contacts

DOE provides information and permits on applying pesticides directly or indirectly into open bodies of water.

Eastern Region, Spokane ....(509) 456-2926
Central Region, Yakima ....(509) 575-2490
Northwest Region, Bellevue ....(206) 649-7000
Southwest Region, Lacey....... ....(360) 407-6300

Washington Department of Fish and Wildlife

Regional Contacts

Your regional program manager will direct your questions to a biologist. The department can provide information on what priority habitats and species are known to be in your area, and the life requisites of priority species.

Region 1, Spokane ....(509) 456-4082
Region 2, Ephrata.. ....(509) 754-4624
Region 3, Yakima ....(509) 575-2740
Region 4, Mill Creek.. ....(206) 775-1311
Region 5, Vancouver.. ....(360) 696-6211
Region 6, Montesano ....(360) 249-4628

Habitat Research and Information Services

Mapped information and management recommendations for Washington's priority habitats and species can be obtained by calling (360) 902-2543.

Washington Poison Control Center .. ..(800) 222-1222

Provides information on who to contact in case of exposure to or spill of pesticides or other toxic substances.

Non-Government Organizations

Agricultural Support Groups

Tilth Producers........................ ....(206) 442-7620
Chapter of Washington Tilth
P.O. Box 85056
Seattle, WA 98145-1056

Provides a directory of organic growers, food and farm suppliers, and resources, called the Washington Tilth Directory. Can help place farmers wishing to reduce pesticide use in touch with those who have already done so.

Northwest Coalition for Alternatives to Pesticides.................(541) 344-5044
P.O. Box 1393
Eugene, OR 97440-1393
> *Provides information on a network of farmers practicing sustainable agriculture.*

Palouse-Clearwater Environmental Institute .. ..(208) 882-1444
P.O. Box 8596
112 W. 4th, Suite 1
Moscow, ID 83843
> *Coordinates farm/consumer improvement clubs in eastern Washington and is the western coordinator of the Campaign for Sustainable Agriculture.*

Alternative Energy Resources Organization... ....(406) 443-7272
25 S. Ewing Suite 214
Helena, MT 59601
> *Coordinates a network of farm improvement clubs and produces a list of organic growers in Montana. Has information on growing grains in the Palouse region.*

Financial Support for Farmers Shifting to Sustainable Agriculture

Cascadia Revolving Loan Fund ....(206) 447-9226
1901 NW Market Street
Seattle, WA 98107
> *A non-profit organization that lends money to small businesses.*

Sustainable Agriculture Research and Education ....(435) 797-2257
Western Region SARE
Room 305 Agricultural Science Building
4865 Old Main Hill Road
Logan, UT 84322-4865
> *A federal grant program for farmer-directed, on-farm research. The grants are called Farmer/Rancher Research Grants.*

The Organic Farming Research Foundation.........................(831) 426-6606
P.O. Box 440
Santa Cruz, CA 95061
> *Provides funding for organic farming methodology research.*

Insectaries

Northwest Biocontrol Insectary/Quarantine Insectary..........(509) 335-5504
Terry Miller
> *Can provide limited technical advice on using beneficial insects as biological control agents.*

Integrated Pest Management and Non-Chemical Alternatives

Bio-Integral Resource Center) ....(510) 524-2567
P.O. Box 7414
Berkeley, CA 94707
>*Publishes "Common Sense Pest Control Quarterly", and "The IPM Practitioner Monitoring the Field of Pest Management."*

Integrated Fertility Management..(800) 332-3179
333 Ohme Gardens Rd.
Wenatchee, WA 98801
>*Provides information on organic farming, biological pest control, and soil amendments. Also provides a network with which growers can contact each other.*

Northwest Coalition for Alternatives to Pesticides................(541) 344-5044
>*Located in Oregon, provides information regarding integrated pest management, a list of private consultants, as well as other sources and contacts.*

Washington Toxics Coalition...(206) 632-1545
>*Has an information file on many topics involving chemical pesticides, including effects on the environment and on human health, as well as alternatives to household and garden chemicals.*

National Organizations

Appropriate Technology Transfer for Rural Areas................(800) 346-9140
P.O. Box 3657
Fayetteville, AR 72702
>*Information service on sustainable agriculture. Not ideal for questions that are regionally specific, but good for crop production questions.*

Chemical Referral Center ....(800) 262-8200
>*This center, which is sponsored by the Chemical Manufacturers Association, will refer the caller to the manufacturer of the chemical in question, and provide telephone numbers of other hotlines.*

National Agricultural Library ....(301) 504-6559
Alternative Farming Systems Information Center
10301 Baltimore Blvd.
Beltsville, MD 20705-2351
>*Provides bibliographies on topics such as cover crops, living mulches, compost, etc. Will do individual searches on national agricultural databases for free. This organization's strong point is specific, technical information.*

National Pesticide Telecommunication Network ....(800) 858-PEST (7378)

> *Provides 24-hour information on pesticide products, poisoning, cleanup and disposal, enforcement contacts, certification and training programs, and pesticide laws.*

Safety, Storage, Handling, and Disposal

Washington Toxics Coalition...(206) 632-1545

> *Has an information file on many topics involving chemical pesticides, including effects on the environment and on human health.*

Local Solid Waste/Recycling Centers

> *Your county or municipal solid waste center may be of assistance when disposing of pesticides and herbicides.*

Washington State University Cooperative Extension Service, County Agents

County	Address	City	Phone #	County	Address	City	Phone #
Adams	210 W. Broadway	Ritzville 99169	(509) 659-3209	Lewis	360 NW North St. MS: AES01	Chehalis 98532	(360) 740-1212
Asotin	2535 Riverside Drive	Asotin 99402	(509) 758-5147	Lincoln	PO Box 399	Davenport 99122	(509) 725-4171
Benton	5600-E W Canal Drive	Kennewick 99336	(509) 735-3551	Mason	11840 Hwy 101 N.	Shelton 98584	(360) 427-9670 Ext. 395
Chelan	303 Palouse Street	Wenatchee 98801	(509) 667-6540	Okanogan	PO Box 391	Okanogan 98840	(509) 422-7245
Clallam	223 East 4th St.	Port Angeles 98362	(360) 417-2279	Pacific	PO Box 88	South Bend 98586	(360) 875-9331
Clark	11104 NE 149th Street	Bush Prairie 98606	(360) 397-6060	Pend Oreille	PO Box 5045	Newport 99156	(509) 447-2401
Columbia	202 S. 2nd Street	Dayton 99328	(509) 382-4741	Pierce	3049 S 36th, Suite 300	Tacoma 98409	(253) 798-7180
Cowlitz	207 4th Ave N	Kelso 98626	(360) 577-3014	San Juan	221 Weber Way, Suite LL	Friday Harbor 98250	(360) 378-4414

County	Address	City	Phone #	County	Address	City	Phone #
Douglas	PO Box 550	Waterville 98858	(509) 745-8531	Skagit	306 S First Street	Mount Vernon 98273	(360) 428-4270
Ferry	350 E. Delaware Ave #9	Republic 99166	(509) 775-5235	Skamania	PO Box 790	Stevenson 98648	(509) 427-9427
Franklin	Courthouse 1016 N. 4th	Pasco 99301	(509) 545-3511	Snohomish	600 128th St. SE	Everett 98208	(425) 338-2400
Garfield	PO Box 190	Pomeroy 99347	(509) 843-3701	Spokane	222 N Havana	Spokane 99202	(509) 477-2048
Grant	PO Box 37 35 C Street NW	Ephrata 98823	(509) 754-2011 Ext. 413	Stevens	985 S Elm, Suite A	Colville 99114	(509) 684-2588
Grays Harbor	PO Box R 32 Elma-McCleary Road	Montesano 98541	(360) 482-2934	Thurston	720 Sleater Kinney Road SE, Suite Y	Lacey 98503	(360) 786-5445
Island	PO Box 5000 101 NE 6th	Coupeville 98239	(360) 679-7327	Wahkiakum	PO Box 278	Cathlamet 98612	(360) 795-3278
Jefferson	201 W. Patison	Port Hadlock 98339	(360) 379-5610	Walla Walla	328 W Poplar Street	Walla Walla 99362	(509) 527-3260
King	919 SW Grady Way, Suite 120	Renton 98055	(206) 205-3100	Whatcom	1000 N Forest Street, Suite 201	Bellingham 98225	(360) 676-6736
Kitsap	614 Division Street MS-16	Port Orchard 98366	(360) 337-7157	Whitman	310 N Main, Room 209	Colfax 99111	(509) 397-6290
Kittitas	507 Nanum Ave, Room 2	Ellensburg 98926	(509) 962-7507	Yakima	128 N 2nd Street, Room 233	Yakima 98901	(509) 574-1600
Klickitat	228 W Main, MS-CH 12	Goldendale 98620	(509) 773-5817				

Appendix B. Native plants suitable for a thicket-like visual barrier around a heron colony.

Scientific Name	Common Name [a]	Comments
Cornus sericea	red-osier dogwood	• Wet and moist soils • Full sun • Native throughout Washington and British Columbia.
Crataegus douglasii	black hawthorn	• Moist soils • Partial shade • Thorny • Ensure you know the variety and care necessary to encourage growth as a shrub rather than a tree • Native throughout Washington and British Columbia
Crataegus suksdorfii	Suksdorf's hawthorn	• Moist soils • Partial shade • Thorny • Ensure you know the variety and care necessary to encourage growth as a shrub rather than a tree • Native to areas west of the Cascades
Malus fusca	western crabapple	• Wet and moist soils • Full to some shade • Thorny • Native to areas west of the Cascades
Prunus emarginata	bitter cherry	• Moist soils • Full sun • Native to coastal and interior Washington and British Columbia • For creating a barrier, plant the shrub variety (*Prunus emarginata* var. *emarginata*)
Ribes divaricatum	straggly gooseberry	• Dryer soils • Full to partial sun • Thorny • Native to areas west of the Cascades
Rosa spp.	native rose	• Native species include nootka rose, bald hip rose, and clustered rose.
Rubus parviflorus	thimbleberry	• Dryer soils • Mostly sunny • Native to areas west of the Cascades
Rubus spectabilis	salmonberry	• Wet and moist soils • Full to partial sun • Native from the East Cascades to the coast
Spiraea douglasii	hardhack	• Wet and moist soils • Full to mostly sunny • Native throughout region, except for in the Columbia Basin
Symphoricarpos albus	common snowberry	• Moist and dry soils • Mostly to part sun • Native throughout Washington and British Columbia

[a] Click on common names for more information about requirements of each plant species.

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