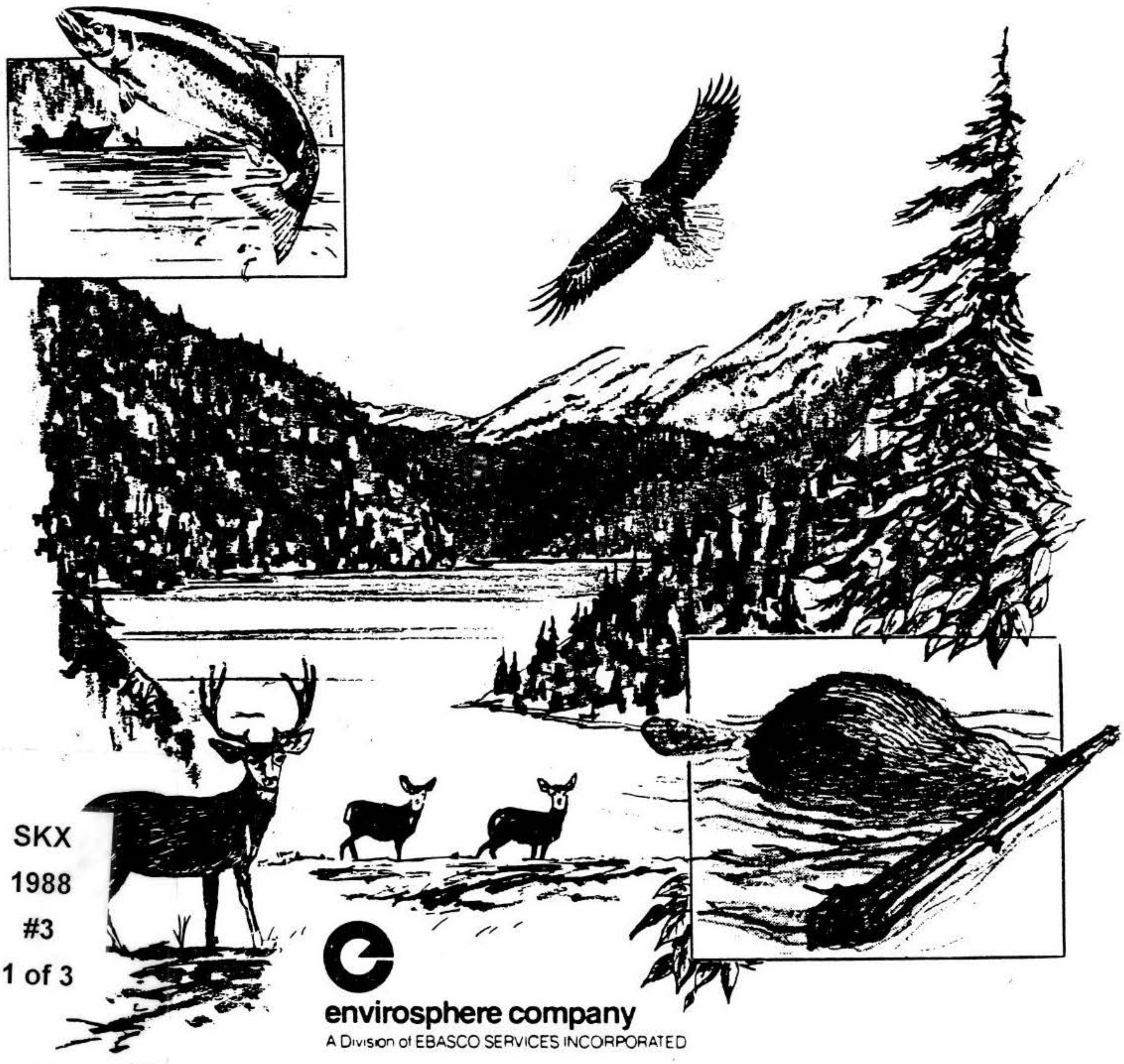
STUDY OF SKAGIT DAMS ORIGINAL IMPACTS ON WILDLIFE AND FISH HABITATS AND POPULATIONS

SEATTLE CITY LIGHT



envirosphere company
A Division of EBASCO SERVICES INCORPORATED

E-fish
363 a,

STUDY OF SKAGIT DAMS ORIGINAL IMPACTS ON WILDLIFE AND FISH HABITAT AND POPULATIONS

DRAFT REPORT

Prepared By

envirosphere company
A Division of EBASCO SERVICES INCORPORATED
BELLEVUE, WASHINGTON

PROJECT MANAGER
John J. Brueggeman

CONTRIBUTORS
Colleen McShane
David Every
John Knutzen
Ron Tressler

PREPARED FOR

SEATTLE CITY LIGHT
PROJECT MANAGER
Richard E. Rutz

MARCH 1988

- Marten - 6,656 AAHUs
- Deer - 6,300 AAHUs
- Black-capped Chickadee - 5,034 AAHUs
- Osprey - 2,982 AAHUs
- Pileated Woodpecker - 2,915 AAHUs
- Yellow Warbler - 2,644 AAHUs
- Beaver - 935 AAHUs
- Ruffed Grouse - 693 AAHUs
- Red-Tailed Hawk - 539 AAHUs
- American Dipper - 49 AAHUs

These estimates of the net impacts of the project on wildlife reflect a 12,400 acre increase in lacustrine habitat and a corresponding decrease in riverine, upland, riparian, and wetland habitats. The Marten incurred the largest loss because it uses mature upland and riparian forests which were abundant and provided high quality habitat for this species prior to the project. The smallest loss was for the American Dipper.

Other species evaluated for this study were the peregrine falcon, bald eagle, osprey, and grizzly bear. Four osprey nests were observed in the Study Area during 1987 and osprey production appeared to be similar to that documented for northwestern Washington. The remaining three species are federally listed threatened or endangered species for which a HEP analysis was not appropriate. Insufficient data are available to estimate impacts of the Project on the peregrine falcon and grizzly bear. It is unlikely that the Project had a significant impact on the bald eagle population wintering in northwestern Washington.

Historical information indicates that the falls and rapids on the upper Skagit River under pre-project conditions discouraged fish from migrating above the current location of Diablo Dam. Small numbers of chinook salmon and steelhead may have spawned in several of the creeks above the current location of Gorge Dam. Impacts of the Skagit Hydroelectric Project on resident fish were determined by comparing the population estimates based on studies conducted on the three reservoirs in the early 1970s to those developed for the evaluation of pre-impoundment conditions. The lack of information on pre-impoundment fish populations led to the use of three different methods to obtain a range of estimates. Results of the fisheries analysis indicate that the catchable resident fish population in the three reservoirs is probably 8 to 27 times higher than the population estimated to have been present in the Skagit River under pre-impoundment conditions.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF TABLES

1.0
INTRODUCTION

1.0 INTRODUCTION

The Skagit Hydroelectric Project includes three dams owned and operated by Seattle City Light: 1) Gorge; 2) Diablo; and 3) Ross. Gorge Dam was issued a permit by the Department of Agriculture in 1918 and constructed between 1919 and 1924 when operations commenced. The dam was modified in 1950 from a crib dam to a concrete diversion dam and then to the existing Gorge High Dam in 1961. Diablo Dam, a concrete arch dam, was licensed by the Federal Power Commission (FPC) in 1927, constructed between 1927 and 1929, and put into operation in 1936. Ross Dam, the largest of the three dams, was built in several stages. Construction of the first stage, Ruby Dam, began in 1937 and was completed in 1940. The dam was modified six times between 1946 and 1967 and renamed Ross Dam. These three dams have a maximum power generating capacity of 784 megawatts and provide 25 percent of the City of Seattle's electricity.

The three projects were authorized as amendments to the license originally issued for Diablo Dam in 1927 by the FPC (later known as the Federal Energy Regulatory Commission (FERC)). The license expired in 1977 and Seattle City Light currently operates the projects on an annually renewed license from FERC. This study was initiated by Seattle City Light in anticipation of environmental review requirements for the relicensing. The original impacts of these projects, which impounded approximately 12,400 acres, on fish and wildlife have not been determined.

Information required to assess impacts on the fish and wildlife populations in the Skagit Hydroelectric Study Area was very limited until 1970 when Seattle City Light proposed the High Ross Dam project. Wildlife studies were conducted in the United States (Taber 1972-1976) and the Canadian portions (Slaney and Company 1972, 1973) of the Ross Lake area to assess impacts from the proposed High Ross Dam project. These studies concentrated on deer and their associated habitats, although some abundance and distribution data were obtained on other wildlife. The Washington Department of Wildlife (WDW, formerly Department of Game), developed a wildlife mitigation plan subsequent to these studies to compensate for proposed habitat losses from High Ross Dam (Nelson et al. 1980, 1981). The mitigation plan incorporated the findings reported by Taber (1972-1976) and was based on the U.S. Fish and Wildlife Service's (USFWS) Habitat Evaluation Procedure (HEP) (Schamberger and Farmer 1978). Studies were concurrently conducted by the Fisheries Research Institute at the University of Washington (Burgner 1977; Seattle City Light 1973) to determine impacts of High Ross Dam on fish populations in Ross Lake and its tributaries. While these fish and wildlife studies provided a base of information, they did not address the Skagit Hydroelectric Project's original impacts on fish and wildlife.

The purpose of our study was to assess the fish and wildlife impacts resulting from the original construction of Gorge, Diablo, and Ross dams. The objectives were the following:

1. Prepare an annotated bibliography documenting published and unpublished information on wildlife and fish populations to describe conditions in the impact area prior to, during, and after construction of the Skagit Hydroelectric Project dams.
2. Identify the cover types and their value to key wildlife in the impact area prior to, during, and after construction of the Skagit Hydroelectric Project dams. Use the Habitat Evaluation Procedure to determine the net impacts of the project on wildlife by comparing conditions "with-the-project" to conditions "without-the-project."
3. Determine the impact of the project on anadromous and resident fish populations by:
   - o Identifying the original potential for passage of anadromous fish upstream of the Gorge Dam powerhouse, and
   - o Determining the quantity and quality of resident fish habitat inundated by the project and estimating the net change in the population size between the conditions "with-the-project" and "without-the-project."

A detailed description of the study area, methods, results, and conclusions of our studies for addressing these objectives is provided in the following sections.

Seattle City Light gratefully wishes to acknowledge the participation of the following individuals in this study:

- Art Stendall and Brian Hauger -- Washington Department of Wildlife
- Estyn Mead -- U.S. Fish and Wildlife Service
- Jonathan Jarvis, Jonathan Bjorkland, and Robert Kuntz -- National Park Service
- Joe and Margaret Miller and Patrick Goldsworthy -- North Cascades Conservation Council
- Holly Coccoli -- Volunteer
- Percy Washington -- GAIA

2.0
STUDY AREA

2.0 STUDY AREA

The 15,721 acre Study Area is located in Whatcom County and lies within the Ross Lake National Recreation Area (Figure 2-1). It encompasses Diablo and Gorge lakes, the United States portion of Ross Lake and the land within 125 ft elevation above the maximum pool level of each of these three reservoirs. Over 78 percent of the Study Area is represented by the three reservoirs; the remaining 22 percent of the Study Area consists of undeveloped land and recreational sites.

Ross Lake is 11,700 acres at full pool, 24 miles long, and covers about 11,400 acres in the United States and 300 acres in British Columbia, Canada. The reservoir is used for flood control and power generation and has a storage capacity of 1,434,000 acre-feet. Full pool level is 1,602.5 ft above mean sea level (MSL) and is reached by August 1 of each year. Minimum pool level is 1,475 ft MSL. The lands bordering the reservoir above the high water mark are moderately to steeply sloped and forested. Major tributaries of Ross include Big Beaver, Little Beaver, Ruby, Lightning, and Devil's creeks.

Diablo Lake is located just south of Ross Lake. It is 4.5 miles long, covers 910 acres at full pool, and has a storage capacity of 90,000 acre-feet. Full pool is 1,205 ft MSL and the annual water fluctuation in Diablo is only 10 to 12 ft. Normal minimum pool level is about 1,197 ft MSL, although the reservoir can be drawn down to an elevation of 1,125 ft MSL. Much of the land surrounding Diablo consists of steep, exposed rock or talus sparsely covered with scattered conifers and shrubs. The remaining area is moderately to steeply sloped and forested. The few flat areas contain recreational or operations facilities. The major tributary of Diablo Lake is Thunder Creek.

Gorge Lake is the smallest of the three Skagit reservoirs. It is 4.5 miles long, covers approximately 240 acres at full pool, and has a storage capacity of 8,500 acre-feet. Annual water fluctuation in Gorge Lake is only a few feet and full pool level is 875 ft MSL. Gorge Lake is

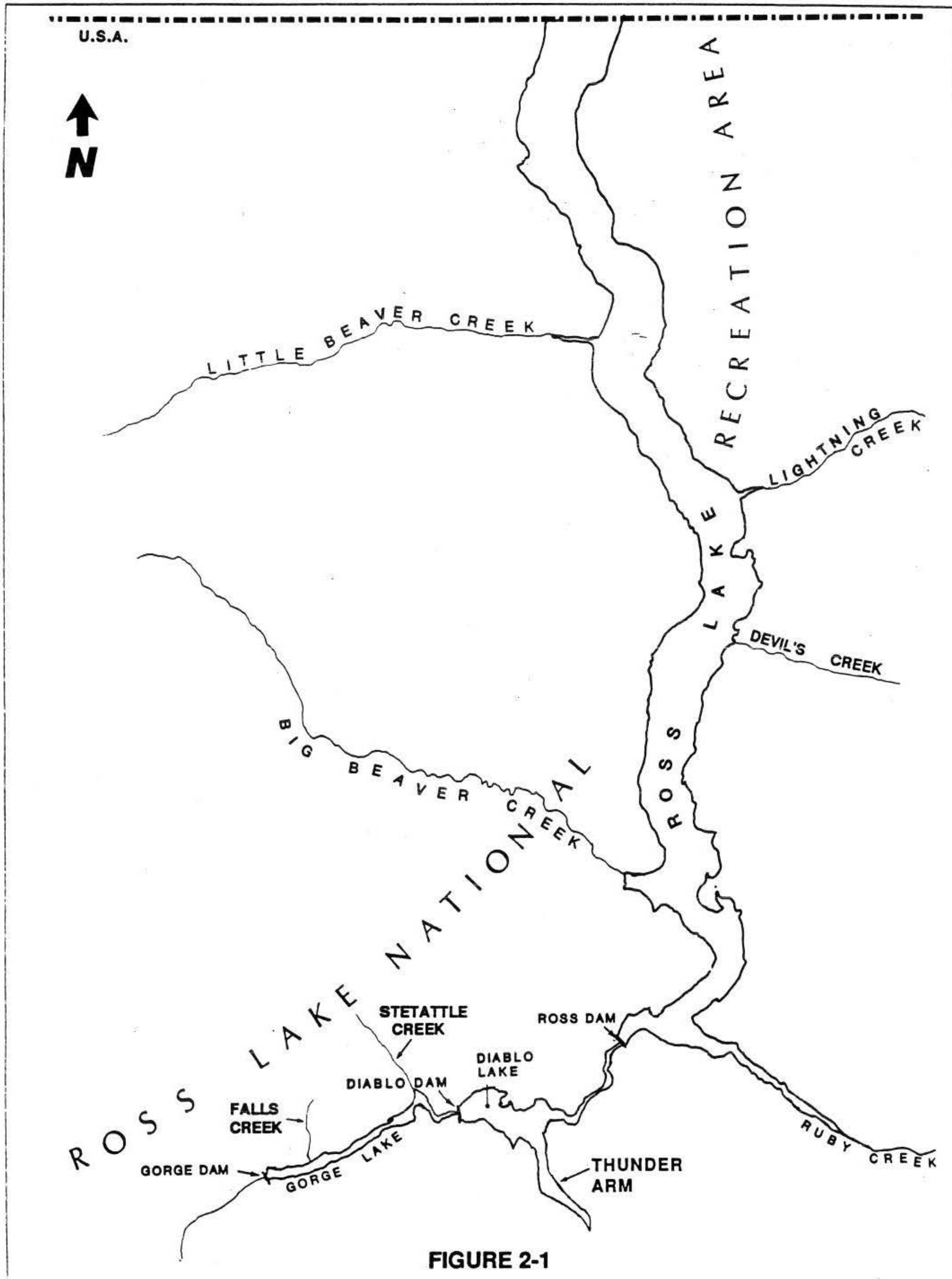


FIGURE 2-1

SKAGIT DAMS ORIGINAL IMPACTS STUDY AREA

aptly named because cliffs and rock talus compose much of the area bordering the reservoir. The few flat areas adjacent to the reservoir are developed. The remaining lands are timbered and moderately to steeply sloped.

The vegetation of the Study Area is represented by the Western Hemlock Zone (Franklin and Dyrness 1973). Dominant conifer species include Douglas fir, western hemlock, western red cedar, and lodgepole pine. About two percent of the Study Area is composed of transmission line corridors, campgrounds, recreational facilities, parking lots, roads, residential areas, and the operation facilities associated with the dams.

The vegetation types in the Study Area provide habitat for a variety of game and nongame wildlife and fish. The predominant game species is deer, which in this region of the North Cascades is an integrated mix of black-tailed and mule deer. Deer inhabit the area year-round and concentrate there during the winter months. Other important wildlife include black bear and osprey. The predominant fish species is rainbow trout, which provides an important sports fishery to the region.

3.0 WILDLIFE STUDIES

3.0 WILDLIFE STUDIES

3.1 INTRODUCTION

The U.S. Fish and Wildlife Service's Habitat Evaluation Procedure was used to determine the net effects of the Skagit River dams on wildlife and their habitat (USFWS 1980a). This procedure was followed because: 1) data are collected in a standardized way which can be compared between various points in time to determine changes in conditions (i.e., pre-impoundment vs. post-impoundment); 2) it is a habitat-based approach which is less affected by natural variability than population-based approaches; 3) it was developed by USFWS specifically for assessing wildlife impacts from hydroelectric projects; and 4) it is the approach recommended by the WDW for wildlife impact assessment studies. The HEP has been applied to wildlife studies throughout the United States and results have been reported in scientific journals (Urich and Graham 1983; Rhodes et al. 1983; Schamberger and Farmer 1978) and technical reports (Brueggeman et al. 1986).

The HEP combines measures of quality and quantity of available habitat into a single value, termed a Habitat Unit (HU), for selected evaluation species. Habitat quality is expressed as a Habitat Suitability Index (HSI) which ranges from 0.1 to 1.0, with 1.0 representing optimum conditions. Thus, each time an HSI value is assigned, a habitat is compared to the optimum conditions for that habitat. The HSI is calculated from species habitat models that define the structural components or habitat characteristics most strongly correlated with wildlife distribution and abundance. This value, when multiplied by the area of available habitat, provides a measure of both habitat quality and quantity, termed Habitat Units. Habitat Units are annualized over the life of any given project and compared between conditions "without-a-project" and "with-a-project" to determine net impacts. For the Study of Skagit Dams Original Impacts, the Average Annual Habitat Units (AAHUs) were compared for conditions "without-the-project" and "with-the-project" to determine the net effect of the hydroelectric projects on the wildlife habitat.

Consequently, application of the HEP to the Study of Skagit Dams Original Impacts provided a numeric measure of habitat lost or gained for selected wildlife resulting from the Gorge, Diablo, and Ross hydroelectric projects.

3.2 METHODS

A series of steps are involved in applying the HEP, including the following:

- Selection of an evaluation team
- Inventory of cover types or habitats
- Selection of evaluation species
- Identification of life requisites for evaluation species
- Field measurements of habitat parameters
- Assignment of HSIs and calculation of HUs
- Selection of target years and calculation of AAHUs

3.2.1 Selection of an Evaluation Team

The application of the HEP requires the formation of an evaluation team comprised of representatives of the federal and state wildlife agencies and the project proponent. The responsibility of the team is to mutually define the approach for completing each step of the HEP. This team concept ensures input by the agencies or intervenor into the design and execution of the study. Moreover, it precludes future conflicts between the agencies, intervenor, and project proponents about the outcome of a study, since their representatives are key players in the study. Consequently, the study culminates in a product that is acceptable to the project proponent, the wildlife agencies, and other intervenors.

The procedure we followed for selecting an evaluation team was to send letters to the USFWS; WDW; National Park Service (NPS); upper Skagit, Sauk-Suiattle, Swinomish Tribal Community; North Cascades Conservation Council (N3C); Washington Department of Fisheries; Washington Department of Ecology; National Marine Fisheries Services; and U.S. Forest Service (USFS) inviting them to participate in the project. The WDW, USFWS, and NPS decided to fully participate in the HEP, the N3C provided observers, and the other organizations or agencies did not participate. Representatives from the participating agencies along with those from the City of Seattle and Envirosphere Company that comprised the evaluation team included:

Richard Rutz and Christine Psyk - Seattle City Light, Environmental Affairs Division

Brian Hauger and Art Stendall - Washington Department of Wildlife

Estyn Mead - U. S. Fish and Wildlife Service

Jonathan Jarvis - National Park Service

John Brueggeman, Colleen McShane, and David Every - Envirosphere Company

Meetings were held throughout the project by the team to define each step in the HEP. The decisions reached at each meeting were documented in formal letters prepared by Envirosphere and sent to the team members. Each participant of the meeting was required to sign the letter before executing the decisions. This procedure confirmed that decisions reached at a meeting were acceptable to the respective agencies and the City of Seattle. Letters documenting full agreement by the team members as representatives of their agencies or organizations on decisions followed in the application of the HEP to the Study of Skagit Dams Original Impacts are provided in Appendix A.

3.2.2 Habitat Inventory

The habitat inventory is an integral step in the HEP since it defines and qualifies the wildlife habitat types. A "habitat" is defined as a unique combination of physical, biological, and structural features of the environment that provide one or more life requisites for wildlife. Vegetation "cover types" are defined as habitats when discussing the use of a particular type by a wildlife species. As a result, "cover type" and "habitat type" are used interchangeably throughout this study.

The purpose of the habitat inventory was to classify, map, and quantify the habitats of the Study Area for evaluating the changes resulting from the Skagit River Hydroelectric Project. This was achieved by using a systematic process that included the following steps: 1) selection of a habitat classification system; 2) classification and delineation of habitats; 3) calculation of habitat areas; and 4) production of a habitat map. The inventory was keyed on land cover types distinguishable on aerial photographs. A detailed description of each step of the habitat inventory is provided below.

3.2.2.1 Classification System Selection

The habitat (cover type) classification system selected by the HEP team for this study was based on systems developed by the USFWS (1980b) and Cowardin et al. (1979). The habitat types defined by USFWS (1980a) for the Pacific Northwest coastal region were used as the basis for classification of upland habitat types, and the system described by Cowardin et al. (1979) was followed for classification of wetland types. Both systems have been widely used in the western United States, and are scientifically acceptable. The dual system provided a wide-ranging hierarchical system of land use and land cover classification that permitted the comparison of other classification systems (Anderson et al. 1976) and the use of information in other reports developed for the Study Area. The final classification system defined 45 cover types in the Study Area (Table 3-1).

3.2.2.2 Classification and Delineation of Habitats

Habitats were classified and delineated using aerial photographs according to the following five steps.

Selection of Photographic and Mapped Data Sources

The process of selecting materials for cover-typing the Skagit Study Area involved a thorough search of all potential sources of aerial photographs, maps, and oblique photographs. The primary source was Seattle City

Light. In addition, the USFS (including records stored in the Federal Records Center in Seattle), the NPS, the U.S. Geological Survey (USGS), and the Washington State Department of Natural Resources information bases were queried to compile a complete list of potential source materials (Table 3-2).

Complete stereo aerial photography was available for the post-impoundment, but not for the pre-impoundment period for all three reservoirs. Aerial photographs taken in 1978 were selected to represent post-impoundment conditions for all three reservoir areas. For pre-impoundment coverage of Ross Lake, 1936 and 1946 aerial photographs were used. The 1946 photos were clear and easy to use, but the first level of the reservoir had already inundated part of the Study Area by this time. The 1936 photographs were poor in quality, but covered the entire Study Area. A complete pre-impoundment cover type map of the Ross Lake area was developed by using these two sets of aerial photographs and old timber maps and descriptions.

Since the construction of Gorge and Diablo dams preceded the use of aerial photography, other source materials were required to develop pre-impoundment cover type maps of these areas. The primary sources were old photographs taken from various vantage points, old USFS timber and fire maps, and topographic maps. Information from these sources was confirmed or expanded through extrapolations of the habitats currently adjacent to the reservoirs and used to identify and delineate the pre-impoundment cover types for Gorge and Diablo.

Photo Interpretation Aids

Interpretation aids were used by trained photo-interpreters to identify habitat types. A systematic key was developed that defined the photo signature of each habitat type (Table 3-3). The key provided a guide for consistently identifying each type and delineating its spatial boundaries. The key was developed by viewing a series of photos selected to define the range of photo characteristics for the successional stages represented by a particular habitat type.

TABLE 3-2

DATA SOURCES FOR COVER TYPING
SKAGIT DAMS IMPACT STUDY

Data Source	Year	Source Agency	Scale	Coverage	
Aerial photography	circa 1930	USFS[1/]	Oblique	Views of Diablo Lake & Ross Basin	2/
	1930	NPS[3/]	Oblique	Views of Diablo Basin after clearing	4/
	1936	SCL	1:8,700	Ruby Creek to Canada	4/
	1945	SCL	1:12,000	Diablo to Devil's Creek	
	1946	SCL	1:12,000	Ross Dam into Canada	4/
	1947	SCL	1:12,000	Ross Dam to Lightning Creek	
	1948	SCL	1:12,000	Ross Dam to Hozomeen	
	1949	SCL	1:12,000	Big Beaver Creek to Hozomeen	
	1950	SCL	1:12,000	Ross Dam to Canada	
	1951	SCL	1:12,000	Noname Creek to Canada	
	1971	SCL	1:5,000	Thunder Creek	
	1971	SCL	1:5,000	Big Beaver Creek	
	1971	SCL	1:5,400	Little Beaver Valley	
	1974	USGS[6/]	1:24,000	Diablo Dam, Ross Dam, Pumpkin Mountain, Hozomeen, Crater Mountain	
Orthophoto Maps	1978	SCL	1:22,000	Gorge, Diablo & Ross Basins	4/

1/ United States Forest Service
2/ Secondary data sources.
3/ National Park Service
4/ Primary data sources.
5/ Seattle City Light
6/ United States Geological Survey

TABLE 3-2 (continued)

DATA SOURCES FOR COVER TYPING
SKAGIT DAMS IMPACT STUDY

Data Source	Year	Source Agency	Scale	Coverage	
Ground	1935 NPS	N/A		Panorama from Sourdough Mtn.	2/
photography	1920 - 1950	SCL	N/A	Various scenes in Gorge, Diablo, & Ross Basins	4/
Maps	1922, 1941	SCL	1:24,000	Ross Basin Topography	2/
	1925	SCL	1:48,000	Diablo Basin Topography	2/
	1931	SCL	1:6,100	Ross Basin Topography	4/
	1922	Federal Archives	?	Gorge, Diablo & Ross Basins	4/
	1930's	SCL	Not to scale	Lower Ross Basin	2/
	1932	Federal Archives	?	Ross Basin	4/
	1934	UW Map Room 7/	1:126,720	Gorge, Diablo, & Ross Basins	4/
	?	SCL	?	Gorge Basin Topography	2/
	1963-1969	USGS	1:24,000	Diablo Dam, Ross Dam, Pumpkin Mountain, Hozomeen, Crater Mountain, Quadrangles	1/

7/ University of Washington Library

TABLE 3-3

KEY TO THE COVER TYPES OF
THE SKAGIT DAMS PROJECT

1.a.	Land	2
2.a	Lands where human use or activity is the dominant characteristic	3
3.a	Reservoir drawdown area	Reservoir drawdown
3.b	Disturbed lands nearly barren of vegetative cover (<30%)	4
4.a.	Industrial sites (dam, powerhouse, mine, etc.)	Industrial
4.b.	Commercial	Commercial
4.c.	High density residential	H. Residential
4.d.	Intensive-use recreational sites	Recreational
4.e.	Roads, parking lots	Roads, Parking Lots
3.c.	Developed lands with vegetative cover (>30%)	5
5.a.	Agricultural cropland or pastureland	Agricultural
5.b.	Low density residential	L. Residential
5.c.	Forest campground	Campground
5.d.	Transmission or highway right-of-way	Right-of-Way
2.b.	Lands with a "natural" character	6
6.a.	Non-vegetated (cover <30% herb., 20% shrub, or 10% forest)	7
7.a.	Exposed bedrock	Exposed Rock
7.b.	Rockpile on a slope	Talus
7.c.	Gravel or sand bars (a riverine type)	Gravel Bar
6.b.	Vegetated lands (cover ≥30% herb., 20% shrub, or 10% forest)	8
8.a.	Uplands (without wetland or riparian characteristics)	9

TABLE 3-3 (continued)

KEY TO THE COVER TYPES OF
THE SKAGIT DAMS PROJECT

9.a.	Forested (≥10% tree cover).	10
10.a.	Conifers comprise ≥70% of forest cover.	11
11.a.	Large trees, broken tops, canopy openings .	<u>Old Growth Conifer</u>
11.b.	Mature trees, continuous canopy (≥50% closure)	
12.a.	Dark green, tall timber (usually ≥50 feet).	<u>Closed Canopy Conifer</u>
12.b.	Yellow-green, shorter timber (usually <50 feet)	<u>Closed Canopy Lodgepole</u>
11.c.	Mature trees, open canopy (10% - 50% closure)	
13.a.	Dark green, tall trees (usually >50 feet).	<u>Open Canopy Conifer</u>
13.b.	Yellow-green, shorter trees (usually <50 feet).	<u>Open Canopy Lodgepole</u>
11.d.	Young trees, sapling to pole stage	
14.a.	Dark Green.	<u>Regeneration Conifer</u>
14.b.	Yellow-green	<u>Regeneration Lodgepole</u>
10.b.	Forest cover <70% conifer	15
15.a.	Young trees, sapling to pole state (<10% mature trees)	<u>Regeneration Broadleaf/Mixed</u>

TABLE 3-3 (continued)

KEY TO THE COVER TYPES OF
THE SKAGIT DAMS PROJECT

15.b. At least 10% of the trees mature.	16
16.a. Tree cover ≥70% broadleaf.	Broadleaf
16.b. Tree cover <70% broadleaf.	Mixed
9.b. Shrub or herbaceous dominated (<10% tree cover)	17
17.a. Herbaceous vegetation (<20% shrub cover).	18
18.a. Grasses and grass-like plants dominant. . .	Grassland
18.b. Forbs or ferns dominant	Forb/Fern
17.b. Shrubs dominant (≥20% shrub cover).	19
19.a. Restricted to avalanche chutes	Avalanche Tracks
19.b. Occurring elsewhere	Shrub
8.b. Riparian or wetland areas, vegetation showing the influence of the water or stream	20
20.a. Lands with saturated soils, with standing water at least part of the growing season, supporting hydrophytic plants (Palustrine wetlands)	21
21.a. Herbaceous vegetation dominant.	22
22.a. Emergent plants dominate, little or no Sphagnum, photo image grey or green (Palustrine Emergent)	Wet Meadow/Marsh
22.b. Sphagnum characteristic, often with low shrubs and sedges, photo image white or yellow (Palustrine moss).	Bog

TABLE 3-3 (continued)

KEY TO THE COVER TYPES OF
THE SKAGIT DAMS PROJECT

21.b.	Trees or shrubs dominant.	23
23.a.	Shrubs dominant (Palustrine Scrub-shrub). .	Shrub Swamp
23.b.	Trees dominant (Palustrine Forest, $\geq$10% tree cover)	24
24.a.	Tree cover $\geq$70% conifer	Conifer Swamp
24.b.	Tree cover $\geq$70% broadleaf	Broadleaf Swamp
24.c.	Tree cover 30-70% conifer	Mixed Swamp
20.b.	Lands adjacent to streams, in floodplain, vegetation influenced by the stream....Riparian types---go back to leads 9.a. and 9.b. to determine the type of Riparian cover	
1.b.	Water ($\pm$ permanent)	25
25.a.	Lake, reservoir, or pond	26
26.b.	Natural waterbody >29 acres and >2 meters deep (Lacustrine)	Lake
26.c.	Small, shallow natural waterbody (<20 acres and <2 meters deep) Palustrine)	Pond
25.b.	Stream (Riverine)	27
27.a.	Tributary of the Skagit River (divided into gradient categories using lead 28).	Tributary
27.b.	Main Skagit River	28
28.a.	Stream gradient <1%	Riverine
28.b.	Stream gradient 1-3%	Riverine
28.c.	Stream gradient 3-6%	Riverine
28.d.	Stream gradient 6-12%	Riverine
28.e.	Stream gradient >12%	Riverine

Interpretations from the key were supplemented by information obtained from topographic maps, forest type maps, fire maps, and cover type maps prepared by investigators from other studies in the Study Area. Topographic maps were particularly useful for defining boundaries of riparian types during the pre-impoundment period, while the other maps were useful for confirming our classification of habitats inundated by the reservoirs.

Photo Interpretation Procedures

Aerial photographs were acquired in stereo pairs so that the three-dimensional view with a mirror stereoscope could be used to enhance the accuracy of the photo interpretation. One set of photographs covering each reservoir Study Area for each time period (pre-impoundment and 1978) was overlaid with mylar drafting film. The project boundaries, as determined by the HEP team, were marked on mylar overlays, and the outline of each cover patch (polygon) was delineated. A symbol, specific to each habitat type, was marked on the mylar within each polygon. The minimum mapping unit was one acre for riparian and wetland types and five acres for upland types.

Verification of Habitat Typing

The initial photo interpretation of habitat types was done by one photo interpreter and then checked by a second photo interpreter. The typing was also reviewed by the HEP team representative from Seattle City Light who was familiar with the project area. The mapping was 100 percent field verified during the spring of 1987. Additional verification occurred during field sampling in the summer.

Data Transfer to Orthophoto Maps

Complete orthophoto coverage (1:24,000 scale) of the Study Area was obtained from the USGS. The information mapped on aerial photos was transferred to overlays on the orthophotos to correct for angular distortion inherent in aerial photos. The distortion at the edges of aerial photographs was corrected by using recognizable landmarks to establish polygon shape and location. This procedure provided an accurate base of data for determining the area of each cover type and producing a map.

3.2.2.3 Area Calculation and Map Production

Habitat types were mapped and their areas calculated with a Geographic Information System (GIS). A GIS is a database management system with capabilities of resource mapping, accounting, and analysis. The HEP team decided that the habitat inventory should incorporate the use of a GIS. The following four steps were required to calculate area and map habitats.

Digitizing

The mylar data sheets from the orthophoto quadrangle maps were positioned on digitizing tablets and the cover patch boundaries (polygons) were digitized. Section corners and other known ground control features were digitized to remove distortion and ensure accurate area calculation. Each polygon in the Study Area was assigned a unique identifying number that also associated it with a specific quadrangle map. The symbol identifying the habitat type of each polygon was plotted by the GIS on a working draft map and was linked with the polygon number in the digital data base.

Map Registration and Checking

The GIS used for this project was an arc-based topological system in which line data were stored as a series of arcs (line segments). The arcs were then merged into polygons. The data from separately digitized mylars were linked by the GIS into a single project-wide data set that could be presented at a variety of map scales. This was done by digitizing a master control grid from the USGS 1:100,000 quadrangle orthographic map. The control grid consisted of section corners and other identifiable land features. The data base was set up to retrieve data for each reservoir area separately and for the Ross Lake areas east and west of the river or reservoir. A set of working maps or edit plots (line maps with symbols) at 1:24,000 scale was produced for both pre-impoundment and post-impoundment conditions showing the habitat symbol associated with each polygon. Each polygon was then checked against the original photo-interpreted data to confirm that each polygon had the proper cover type.

Area Calculations

A software program was run with the GIS that calculated the area of each polygon and produced summary statistics for pre-impoundment and post-impoundment periods. The data were reported by habitat type for each reservoir (and for the east and west sides of the reservoir for Ross Lake). The reports also listed each polygon number within each habitat type and the acreage within the polygon.

Map Production

The final habitat map was photographically produced, with the USGS 1:100,000 quadrangle map covering the Study Area as the base map. The GIS produced edit plots at 1:50,000 scale for final map composition which had been previously registered to the same quadrangle map. Color separation was accomplished using a rastorizing (grid) system which allowed the colors to be seen and manipulated on the monitor screen. The computerized data were then used to generate color separation negatives for a four-color reproduction process. A color proof was checked before producing the final 1:50,000 scale map.

3.2.3 Selection of Evaluation Species

Ten species were selected by the HEP team for study in the Skagit River Study Area. There were seven bird and three mammal species. These species represented both aquatic and terrestrial animals associated with the range of forested and nonforested habitats in the Study Area. The species selected were the following:

- Yellow Warbler
- Pileated Woodpecker
- Black-capped Chickadee
- Pine Marten
- Ruffed Grouse
- Mule Deer
- Beaver
- American Dipper
- Red-tailed Hawk
- Osprey

These species were selected from a systematic process developed by the HEP team. This process involved: 1) compiling a comprehensive list of species in the Study Area; 2) rating each species' importance in the Study Area; 3) evaluating the capability of the top-ranked species to fulfill the objectives of the HEP; and 4) selecting the final ten evaluation species. This decision-making process combined technical data with the knowledge of the HEP team to formulate a list of species that best reflected the impacts of the project on wildlife.

A list of 198 species of wildlife was compiled for the Study Area (Appendix Table B-2). The composition included 141 species of birds, 44 of mammals, and 13 of amphibians and reptiles. Each species was associated with a habitat(s) in the Study Area and a life form. A life form is a grouping of species based on specific combinations of habitat requirements for reproduction and feeding (Thomas 1979). Associating species with habitats was necessary for assessing wildlife impacts from habitat changes caused by the project. Associating species with life forms was needed to evaluate impacts on groups of species with similar habitat requirements. This stage in the species selection process permitted the HEP team to examine which species and species groups would best reflect changes in the Study Area habitats. This information was compiled from wildlife findings documented in the Ross Lake area by the University of Washington (Taber 1972-1976), or reported in field guides (Wahl and Paulson 1971; Larrison 1970; Larrison and Sonnenberg 1968), and technical reports (Brown 1985; Ingles 1979) for Washington.

The second stage in the selection process involved ranking the wildlife species found in the Study Area (Appendix Table B-3). Species were ranked within each life form according to the following five criteria: 1) seasonality; 2) abundance; 3) availability of information; 4) status of HEP model; and 5) versatility. Information for these criteria was obtained from the sources used to compile the species list. Seasonality was evaluated in order to rate species use of the Study Area. Use was rated high for species that were annual residents, moderate for winter or summer residents, and low for migrants. Annual residents were rated highest because all of their life requisites are completed in the Study Area. Conversely, migrants were rated low because only a part of their life requisites are obtained in the Study Area and impacts from the project may be less severe than for residents. For instance, the Marten was rated high because it is an annual resident and project impacts could affect feeding, cover, and breeding areas.

Abundance was used to judge the prominence of a species in the Study Area. Prominence was rated according to four categories: abundant, common, uncommon, and rare. Abundant species received the highest rating since they were considered to be most successful in the Study Area. Rare species were considered to be least successful and project impacts on their regional populations lower than species more suited to the habitats of the Study Area. For instance, black-capped chickadees were rated abundant in the Study Area because suitable habitat was available, whereas elk were considered rare because the habitat was not particularly suitable for them. Species that were on the federal threatened or endangered list were excluded from this evaluation and treated separately by the HEP team.

Availability of information for species in the Study Area was used to identify the state-of-knowledge. This criterion was rated high if site-specific information was available for a species, low if information had been collected near the Study Area, and zero if no or only general information was available. This criterion was considered important because there had to be sufficient information available about a species in order to assess the impacts of the project on it. The assessment would be most accurate for species where site-specific data were available and least accurate for species where there were little or no data. For instance, deer were rated high because site-specific information was available, whereas the river otter was rated low because there was very little information on this species.

Species occurring in the Study Area were also rated according to the availability and status of a HEP model. A species was rated high if a final model was available, moderate if the model was a draft, low if the model was preliminary, and zero if there was no model. This criterion was evaluated because the HEP for this study was designed to incorporate existing models and not to develop models. Furthermore, confidence in the results would be highest for species with final models, since they have been reviewed by the USFWS.

Lastly, species were rated according to their versatility. Versatility is based on the number of plant communities and successional stages used for breeding and feeding. Single cover type species were rated high and multi-cover type species low. Single cover type species were considered to be specialists in their habitat use patterns. These species would be less likely to adjust to a loss of habitat and more likely to respond to a gain in habitat. Conversely, multi-cover species were considered to be generalists in their habitat use patterns. These species would be less responsive to habitat changes and more adaptable. Consequently, specialist species like pileated woodpecker would be more directly affected by changes in old-growth forest characteristics than generalist species like the common crow.

The numeric values assigned for each evaluation criterion were summed to derive a single value for each species. The HEP team evaluated the capability of the top-ranked species in each life form to fulfill the objectives of the HEP. These objectives were to select a set of species that represented: 1) birds, mammals, reptiles, or amphibians; 2) different guilds present in the Study Area; 3) primarily specialists but also several generalists to reflect juxtaposition of habitat; 4) major feeding strategies (carnivore, herbivore, insectivore); 5) all prominent or sensitive habitats in the Study Area; and 6) changes in habitat from pre-impoundment to post-impoundment conditions. The ten evaluation species that were selected by the HEP team through this structured process of selection and evaluation and which most closely met the study objectives are briefly described below:

- The Yellow Warbler (*Dendroica petechia*) is a specialist that reproduces and feeds in shrubs, primarily in wetlands and secondarily in riparian areas. The Yellow Warbler represents a guild of species that requires hydrophytic shrubs to meet their life requisites. The American goldfinch, red-winged blackbird, and common yellow throut represent this guild (Appendix Table B-6). Changes in the quantity or structure of riparian or palustrine shrub habitat would be reflected by the Yellow Warbler.
- The Pileated Woodpecker (*Dryocopus pileatus*) is a specialist that inhabits primarily old growth coniferous forests. This species feeds on insects excavated from snags, large trees, and logs and requires large snags for reproduction. Its presence in an area can influence species diversity since cavity-nesting birds and denning mammals that do not make their own holes depend on the excavations of the Pileated Woodpecker. The guild of species represented by the Pileated Woodpecker requires large trees (>50 cm dbh) for reproduction, cover, and feeding. The hairy woodpecker and spotted owl are also representatives of this guild (Appendix Table B-7). The Pileated Woodpecker also represents the guild of species that requires snags for reproduction and includes the Vaux's swift and hairy woodpecker (Table Appendix B-8). Changes in the quantity and quality of old-growth forests would be reflected by the Pileated Woodpecker.
- The Black-capped Chickadee (*Parus atricapillus*) reproduces in snags that are much smaller (>23 cm dbh) than those required by the Pileated Woodpecker (see Appendix Table B-8). It is a generalist that forages from the ground to the tops of trees in a variety of forest habitats. The Black-capped Chickadee represents a group of species including the brown creeper and chestnut-back chickadee that uses relatively small cavities for nesting and a wide variety of habitats for feeding. Changes in the quantity and quality of forested areas will be reflected by the Black-capped Chickadee.

- The Marten (Martes americana) is a specialist that completes its entire life cycle in old-growth and mature coniferous stands and, to a much lesser degree, mixed forests. It is a carnivore and requires downfall for cover. The Marten represents a group of species including the fisher and ermine that is carnivorous and lives in cavities in mature forests. Changes in the quantity and the forest floor characteristics of old-growth, mature conifer, and mixed forest stands will be reflected by the Marten.
- The Ruffed Grouse (Bonasa umbellus) is a generalist that feeds and reproduces in a variety of cover types. Extensive areas of a single cover type are less valuable to this species than the juxtaposition of different cover types. The Ruffed Grouse represents a guild of species that uses a number of diverse habitats but requires areas with moderately high stem density to meet at least one of their life requisites. Species in this guild include the meadowlark. Changes in the interspersion, quantity, or stem density of forest or shrub cover types will be reflected by the Ruffed Grouse.
- Deer (Odocoileus hemionus hemionus) in the Ross area are an intergrade of black-tailed and mule deer and are the most common large game species in the Study Area. The Study Area provides critical winter habitat for this species although a portion of the herd uses the area year-round. Deer are generalists and utilize a variety of forest and shrub habitats for food and cover. Deer will reflect changes in quantity, juxtaposition, and quality of these habitats on the Study Area.
- The Beaver (Castor canadensis), a highly specialized aquatic furbearer, is a herbivore that prefers herbaceous vegetation over woody vegetation. The beaver requires a permanent supply of water, trees, and shrubs of a diameter suitable for cutting to use as food and cover. The steep, rocky terrain surrounding Gorge and Diablo during both the pre- and post-impoundment periods is not beaver habitat. Therefore, the beaver was used as an evaluation species for Ross only. Changes in the quantity

and quality of riverine, riparian, and palustrine habitat at Ross will be reflected by the Beaver. The response of this species to habitat changes will be similar to other aquatic furbearers including the mink, river otter, and muskrat.

- The American Dipper (Cinclus mexicanus) is a large passerine that lives along swift, rocky streams. It is a specialist that requires rocky ledges or cliffs for nesting and fast-flowing open water for foraging aquatic insects. The American Dipper was selected to reflect the changes in habitat resulting from conversion of a river to a reservoir at Gorge and Diablo. The Ross section of the Skagit River was considered too slow-moving to provide suitable American Dipper habitat, so it was excluded from the analysis.
- The Red-tailed Hawk (Buteo jamaicensis), like the deer, is a generalist that utilizes a mosaic of forested and nonforested habitats for food and cover. The Red-tailed Hawk represents avian predators, such as the rough-legged hawk, that feeds in open habitats. The quality of these habitats also reflects the condition of the prey base. The Red-tailed Hawk, furthermore, represents avian predators such as the goshawk and sharp-skinned hawk that require large trees for reproducing (Appendix Table B-7). Changes in the interspersion, quantity, and quality of forest and open habitats on the Study Area will be reflected by the Red-tailed Hawk.
- The Osprey (Pandion Haliaetus), like the Red-tailed Hawk, is an avian predator. However, it is a specialist that requires clean water with live fish for feeding and large trees or snags adjacent to rivers, lakes, or reservoirs for nesting and perching. The ability of this species to meet its life requisite depends upon the quality of the aquatic prey (fish) as well as the habitat itself. This species was selected to reflect changes in habitat resulting from the conversion of a river to reservoirs. The response of the Osprey to these changes will be similar to most other fish-eating predators such as the bald eagle and river otter.

3.2.4 Identification of Life Requisites for Evaluation Species

Life requisites selected by the HEP team for the ten evaluation species are presented in Table 3-4. Life requisites represent critical elements of habitats that are required by a species to complete its life cycle and survive. These elements are broadly defined as water, food, escape cover, thermal cover, and reproductive cover. The quantity and quality of these elements determine the capacity of an area to support wildlife. Typically, the life requisite in lowest abundance or quality limits the growth of a population.

The life requisites of the ten evaluation species were obtained from the species models. The HEP team associated the life requisites with habitats used by each species. The life requisite(s) considered by the HEP team to be most limiting to the growth of a population in the Study Area provided the basis for assessing impacts for the evaluation species. For instance, since the Study Area provides critical winter habitat for Deer, winter food and cover life requisites were evaluated for this species.

Conversely, since Red-tailed Hawk, American Dipper, and Osprey summer in the Study Area, reproductive cover as well as food were evaluated for them.

This approach is the standard process used in the HEP to confine an impact assessment to those life requisites most limiting the population growth of key wildlife species.

3.2.5 Habitat Parameter Measurements

3.2.5.1 <u>Field Sampling Design</u>

The Study Area was stratified into four areas: Gorge Lake, Diablo Lake, East Ross Lake, and West Ross Lake. A total of 60 randomly selected polygons were sampled on the lands bordering these areas: 6 on Gorge, 17 on Diablo, and 37 on Ross (21 on the east side and 16 on the west side)

TABLE 3-4

LIFE REQUISITES FOR THE EVALUATION SPECIES
CHOSEN FOR OF THE SKAGIT DAMS ORIGINAL IMPACTS STUDY

Species Common Name	Scientific Name	Habitat Type: Conif. Forests 1/	Ldgpl. Forest	Brdlf. Forest	Mixed Forest	Regen. Forests	Shrub Dominated	Non-Vegetated	Palustrine	Riparian	Riverine	Lacustrine
Mule Deer	Odocoileus hemionus hemionus	WC,WF 2/	WC,WF	WC,WF	WC,WF	WC,WF	WC,WF	--- 3/	---	WC,WF	---	---
Beaver	Castor canadensis	---	---	---	---	---	---	---	WF,W	WF	W	WF,W
Marten	Martes americana	WC	WC	---	WC	---	---	---	---	WC	---	---
Osprey	Pandion haliaetus	R	---	---	---	---	---	---	---	R	F	F
Red-tailed Hawk	Buteo jamaicensis	R	---	R	R	---	F	F	---	R	---	---
Pileated Woodpecker	Dryocopus pileatus	C,F,R	---	C,F,R	C,F,R	---	---	---	---	C,F,R 5/	---	---
Black-capped Chickadee	Parus atricapillus	F,R	F,R	F,R	F,R	F,R	---	---	F,R 5/	F,R	---	---
Yellow Warbler	Dendroica petchia	---	---	---	---	---	---	---	R 4/	R	---	---
Ruffed Grouse	Bonsas umbellus	C	C	C	C	C	C	---	---	C	---	---
American Dipper	Cinclus mexicanus	---	---	---	---	---	---	R	---	---	F,W	---

1/ Other than lodgepole pine
2/ C = Cover; WC = Winter Cover; W = Water; F = Food; WF = Winter Food; R = Reproduction
3/ Dash (--) signifies life requisite absent from habitat
4/ Shrub swamp only
5/ Palustrine forest only

(Table 3-5, Figure 3-1). The total number of polygons sampled was fixed by the 15 days provided in the contract for field measurements. The number of polygons allocated to each reservoir was based on the size of an area and the complexity of cover types. Ross had the largest area and most diverse cover types so it was allocated the highest number of polygons. Conversely, Gorge had the smallest area and fewest cover types so it was allocated the lowest number. Diablo was intermediate to these two areas. A total of 12 polygons representing eight cover types that were currently absent or poorly represented, but present prior to flooding by the reservoir were sampled outside the Study Area. Consequently, a total of 72 polygons were sampled to characterize the habitat types of the Study Area associated with the ten wildlife evaluation species.

A total of 122 sites were randomly selected in the 72 polygons for measuring the quality of cover types for wildlife (Table 3-5). This included 8 sites at Gorge, 30 sites at Diablo, and 60 sites at Ross. An additional 24 sites were sampled in the 12 polygons examined off the Study Area. We attempted to sample 3 sites in 3 different polygons for each cover type at Gorge and Diablo. A total of 5 sites were sampled in 3 polygons for each cover type at Ross because of the geographic variation caused by the larger area; 1 polygon contained 3 sites and the 2 other polygons contained single sites. The measurements in the polygon with 3 sites provided information on the local variability of the structural characteristics in a given cover type. The measurements compared among the 3 polygons provided information on the variability within the cover type over the entire Ross area. Sampling intensity on Ross was adjusted downward for poorly represented cover types and upward for abundant or important cover types such as old-growth forest. Sampling in poorly represented (riparian and swamp types) cover types was generally limited by the area available to 1 polygon. Consequently, the sampling program was designed to quantify the quality of cover types for wildlife in each reservoir area and to estimate the variability of the measurements used to derive the quality values.

TABLE 3-5

NUMBER AND DISTRIBUTION OF POLYGONS SAMPLED IN EACH COVER-TYPE
IN THE STUDY AREA FOR THE SKAGIT DAMS' ORIGINAL IMPACTS PROJECT

Cover Type	Gorge		Diablo		West Ross		East Ross		Off-Project[a]		Total	
	Polygons	Sites	Polygons	Sites	Polygons	Sites	Polygons	Sites	Polygons	Sites	Polygons	Sites
Old Growth Conifer Forest	--[b]	---	2	4	2	4	2	4			6	12
Closed Canopy Forest	3	3	3	4	5	9	4	4			15	20
Open Canopy Forest	1	1	3	3	**[c]	**	3	6			7	10
Lodgepole Pine Forest	--	--	2	3	1	1	2	4			5	8
Regenerative Conifer Forest	**	**	**	--	1	3	3	3			4	6
Regenerative Mixed Forest	--	--	--	--	1	1	2	4			3	5
Broadleaf Forest	--	--	2	3	1	3	2	2			5	8
Mixed Forest	1	2	1	3	1	3	2	2			5	10
Shrubland	--	--	**	**	**	**	**	**	2	4	2	4
Wet Meadow/Marsh	--	--	--	--	**	**	**	**	3	5	3	5
Shrub-Swamp	--	--	--	--	**	**	1	1	2	4	3	5
Broadleaf Swamp	--	--	--	--	1	3	**	**			1	3
Mixed Swamp	--	--	--	--	**	**	**	**	1	3	1	3
Riparian Old Growth Conifer Forest	**	**	1	4	1	1	**	**	1	2	3	7
Riparian Closed Canopy Forest	--	--	1	2	**	**	**	**			1	2
Riparian Broadleaf Forest	--	--	2	4	**	**	**	**	1	1	3	5
Riparian Mixed Forest	--	--	--	--	1	1	**	**	1	3	2	4
Riparian/Avalanche Shrub	1	2	--	--	1	1	**	**	1	2	3	5
Total	6	8	17	30	16	30	21	30	12	24	72	122

a/ Off-Project lands were sampled for cover-types absent or under represented on the Project Area. These cover-types were primarily present during pre-impoundment, but they were flooded by the reservoirs. Off-Project lands sampled were either in Big Beaver Valley, Lightning Creek, or the Canadian Skagit.

b/ Dashes signify that the cover-type was not present for pre- or post-project conditions.

c/ Asterisks signify that the cover-type was present for pre-impoundment conditions, but presently absent, under-represented or not accessible for sampling. The evaluation was based on measurements made off-project or at one of the other reservoirs.

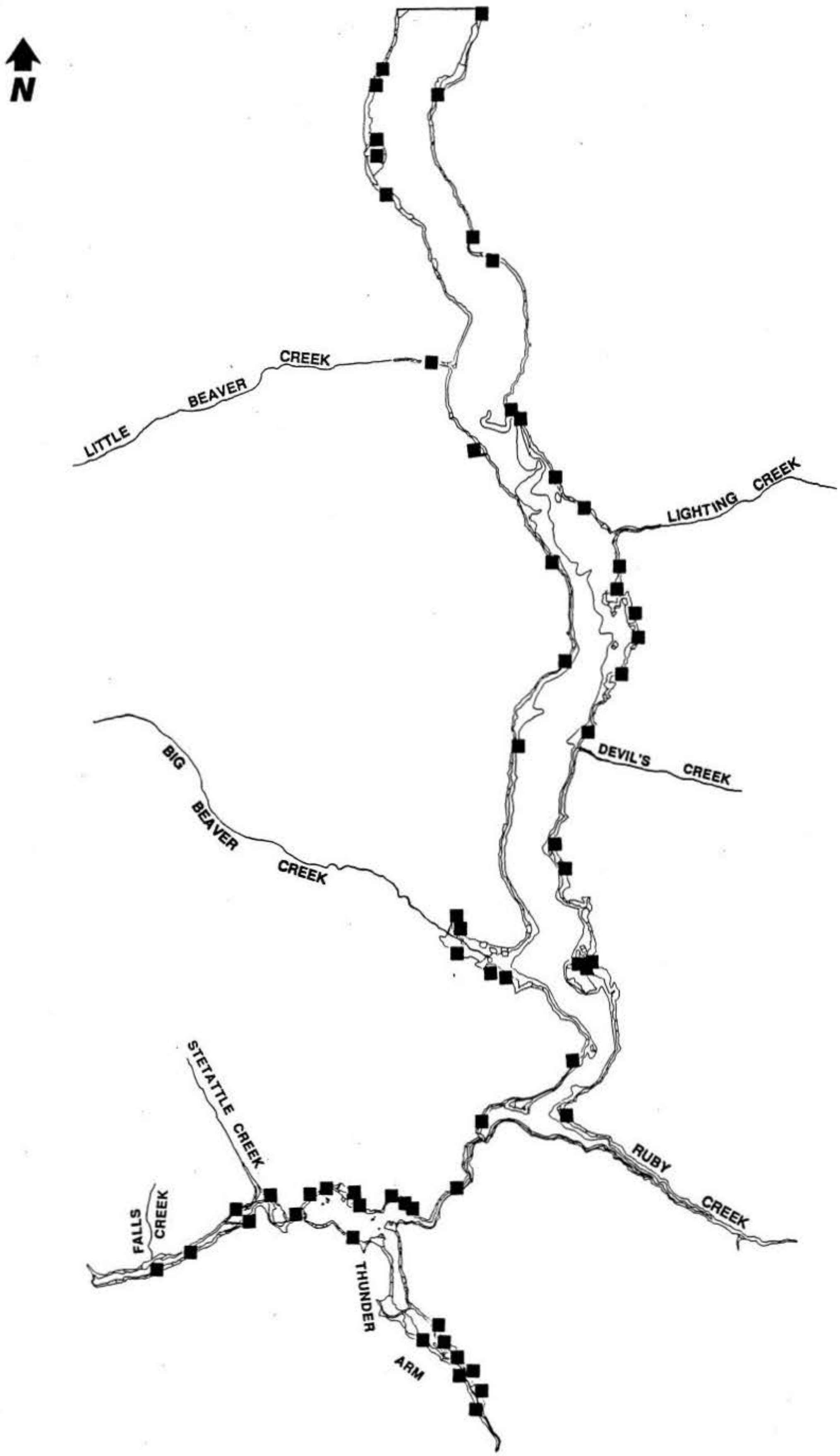


FIGURE 3-1
DISTRIBUTION OF SAMPLING SITES (■)
IN SKAGIT STUDY AREA

A 25 m x 25 m quadrat was established at each sampling site in a given polygon for measuring the cover type characteristics. The site was located by randomly selecting one quarter of a polygon marked on an aerial photograph, pacing 55 m in a direction perpendicular to the reservoir, and then pacing 10 m in a randomly chosen direction. The end point represented the first corner of the quadrat. The quadrat was oriented by randomly selecting the first side of the quadrat and flipping a coin to determine the location of the adjacent side. Additional quadrats, required in polygons with multiple sampling sites, were established by pacing 50 m in a preselected direction from a randomly chosen corner of the previous quadrat. Quadrats were replaced by a 50 m transect line in herbaceous cover types because density measurements were not required in these types.

These procedures were adjusted for small or narrow polygons and polygons sampled outside the Study Area. Small polygons were entered from the most accessible point and the 55 m distance was reduced to 30 m to accommodate the quadrat. The distance between multiple quadrats was also reduced in small polygons. The distance between multiple quadrats in long, narrow polygons was 50 m but the sampling sites were oriented along the long axis. Sampling sites were rejected if they were within 20 m of the edge of the polygon, in a disturbed area, or in a nonrepresentative inclusion. Polygons sampled outside the Study Area were entered from the most accessible point and the site was randomly selected by pacing in a direction perpendicular to a trail or road. The location of each sampling site was mapped on aerial photographs and marked with a numbered wooden stake.

The sampling design for lacustrine and riverine cover types differed from that described above for the upland, riparian, and wetland cover types. Measurements in riverine areas were required for the American Dipper and measurements in lacustrine habitats were needed for the Osprey. Riverine cover types providing American Dipper habitat were absent from the Study Area, so counts of rock walls and cliffs and observations of bottom substrate were made for the American Dipper along 0.3 mi segments of the

Skagit River between the Gorge Dam and Powerhouse. Potential nest and perch trees for the Osprey were counted from a boat for randomly chosen polygons of the forested cover types along each reservoir. A Secchi Disc was used to evaluate water clarity for the Osprey at several randomly chosen locations on Ross, Diablo, and Gorge reservoirs.

3.2.5.2 Field Sampling

The habitat parameters measured in each cover type were defined by the HSI models for the ten evaluation species (Appendix Tables B-9 and B-10). Habitat parameters were measured during June 15-19, June 22-26, and July 27-31, 1987. This time period corresponded to the peak of vegetal growth when habitat quality was near optimal for most wildlife.

Three basic sampling procedures were used to measure the habitat parameters: (1) quadrat, (2) line-intercept, and (3) plot frame (Appendix Tables B-9 and B-10). A quadrat (25 m x 25 m or 0.625 h) was used for measurements of stem density. Tree and shrub heights and the diameters of live and dead trees were also measured within the quadrat. Density was determined from visual counts, tree height from a combination of measures taken with a clinometer (vertical angles) and range finder (horizonal distance), and tree diameter from a diameter tape. Shrub height was measured with a graduated rod. The quadrat size was reduced to two 5 m x 5 m areas when stem densities were high and uniformly distributed.

The line-intercept procedure (Canfield 1941) was used for measurements of tree and shrub percent canopy cover and downed woody material. Measurements were made along two adjacent, randomly selected 25 m sides of the quadrat. Percent cover or downed woody material were estimated by measuring the distance between the outer boundaries of tree and shrub canopies or downed woody material along the tape and calculating the proportion of the total length of tape represented by each parameter. A plot frame (Daubenmire 1959), 0.1 m^2, was used for measurements of herbaceous cover and height. The frame was spaced every 5 m along two sides of a quadrat to estimate percent cover. A meter stick was used to

3.2.6.2 Habitat Suitability Indices and Habitat Units

Habitat Suitability Index models have been developed by the USFWS or other research institutions for each of the evaluation species chosen for the Skagit project (Appendix D). These models define the parameters that were measured in the field to determine habitat suitability for a given species. A Suitability Index was assigned to each parameter by linking the mean polygon value calculated from field measurements to the SI graph for a particular species HSI model. The SI values were weighted by the area of each polygon and averaged by reservoir for each cover type. Each of the HSI models contained an equation or set of equations which mathematically combined the SIs for all the parameters into an index of overall habitat suitability for a given species. A software package called HSI (USFWS 1987) was used to assign SI values and calculate the average HSI for each cover type. HSIs were calculated separately for each reservoir, for "without-the-project" and "with-the-project." SI values for polygons sampled off-site were used to obtain an HSI for those habitats that were present prior to project construction but are currently poorly represented.

Habitat Units are a measure of both the quality and quantity of habitat available to a given species. HUs for a species in a particular habitat type were calculated by multiplying the HSI by the area (in acres) of the habitat type. The HUs for each habitat type used by that species were then summed by life requisite to obtain the total number of HUs available for "with-the-project" and "without-the-project" conditions at Gorge, Diablo, and Ross.

3.2.7 Assignment of Target Years and Calculation of Average Annual Habitat Units

3.2.7.1 Target Years

The HEP requires estimating the change in HUs over the life of the project. This is accomplished by weighting intervals of time bracketed by target years. Target years represent events when major changes occur in the habitat quality or quantity. These events typically correspond to the construction, operation, or modification of a hydroelectric dam and succession. Other events may include fire and logging which reverse the normal sequence of plant community succession.

Target years were defined for each reservoir of the Skagit River project: Gorge, Diablo, and Ross. The initial target year (TY0) always represents the year before disturbance, while TY1 through N are the sequential periods of major changes, which for this project are dam construction and modification. The last year is the end of the life-of-the-project. The last target year was 1987 for the Skagit River project, although the end of the license period was 1978. The HEP team agreed to use 1987 because the license has been annually extended each year since 1978. Target years were not defined for logging or fire events. Logging did not significantly occur in the area, and the federal designation as a Primitive Area in 1935 would have precluded logging in the Ross basin. Fires burned large areas in the project before construction of the dams, but they have been small in size over the life of the project. Since there have been no other major disturbances in the Study Area, the target year analysis is entirely based on the changes resulting from the hydroelectric project and succession.

The number of target years selected for each dam and reservoir was: 5 for Gorge; 4 for Diablo; and 7 for Ross (Table 3-6). The target years for Gorge spanned from TY0 in 1918 to TY69 in 1987. A target year was not assigned to the 1950 construction of a diversion dam at Gorge because the change in acreage was very small (< 10 acres). Similarly a target year for succession was not assigned to Gorge because of the small change in acreage. The target years for Diablo spanned from TY0 in 1927 to TY60 in 1987. The original dam was never modified so the target years reflect one period of construction and operation as well as succession. The target years for Ross, which had six dam modifications, spanned from TY0 in 1936 to TY51 in 1987 (Figure 3-2). One period of modification between 1945 and 1946 was not assigned a target year because the change in area was small and short in duration (1 year). The other periods of

TABLE 3-6

TARGET YEARS SELECTED TO CALCULATE
AAHUs FOR GORGE, DIABLO, AND ROSS RESERVOIRS

Gorge			Diablo			Ross		
Year	Pool Elevation[a/]	Target Year	Year	Pool Elevation[a/]	Target Year	Year	Pool Elevation[a/]	Target Year
1918	-0-	TY 0	1927	-0-	TY 0	1936	-0-	TY 0
1919	-0-	TY 1	1928	-0-	TY 1	1937	-0-	TY 1
1924	778	TY 6	1929	1250	TY 2	1940	1380	TY 4
1950	787	TY 6[b/]	1957	1250	TY 30	1946	1425	TY 4[c/]
1961	880	TY 43	1987	1250	TY 50	1947	1500	TY 11
1982	880	TY 69				1948	1562.5	TY 12
						1949	1582	TY 13
						1953	1600	TY 13[d/]
						1966	1600	TY 30[e/]
						1967	1602.5	TY 30
						1987	1602.5	TY 51

a/ Elevation in feet at mean sea level.

b/ Construction of a diversion dam in 1950 increased the area of the reservoir by approximately 10 acres. This change in area was considered to be too small by the HEP team to assign a target year. The 1924 TY 6 includes this time period.

c/ The 1946 modification of Ross Dam did not increase the reservoir area sufficiently enough to assign a target year. The HEP team decided to include this time period with the 1940 TY 4.

d/ The 1953 and 1967 modifications of Ross Dam did not substantially increase the reservoir area from the 1949 modification. The HEP team decided to use the 1967 pool level for the period from 1949 through 1987.

e/ A target year was assigned to 1966 to represent changes caused by succession.

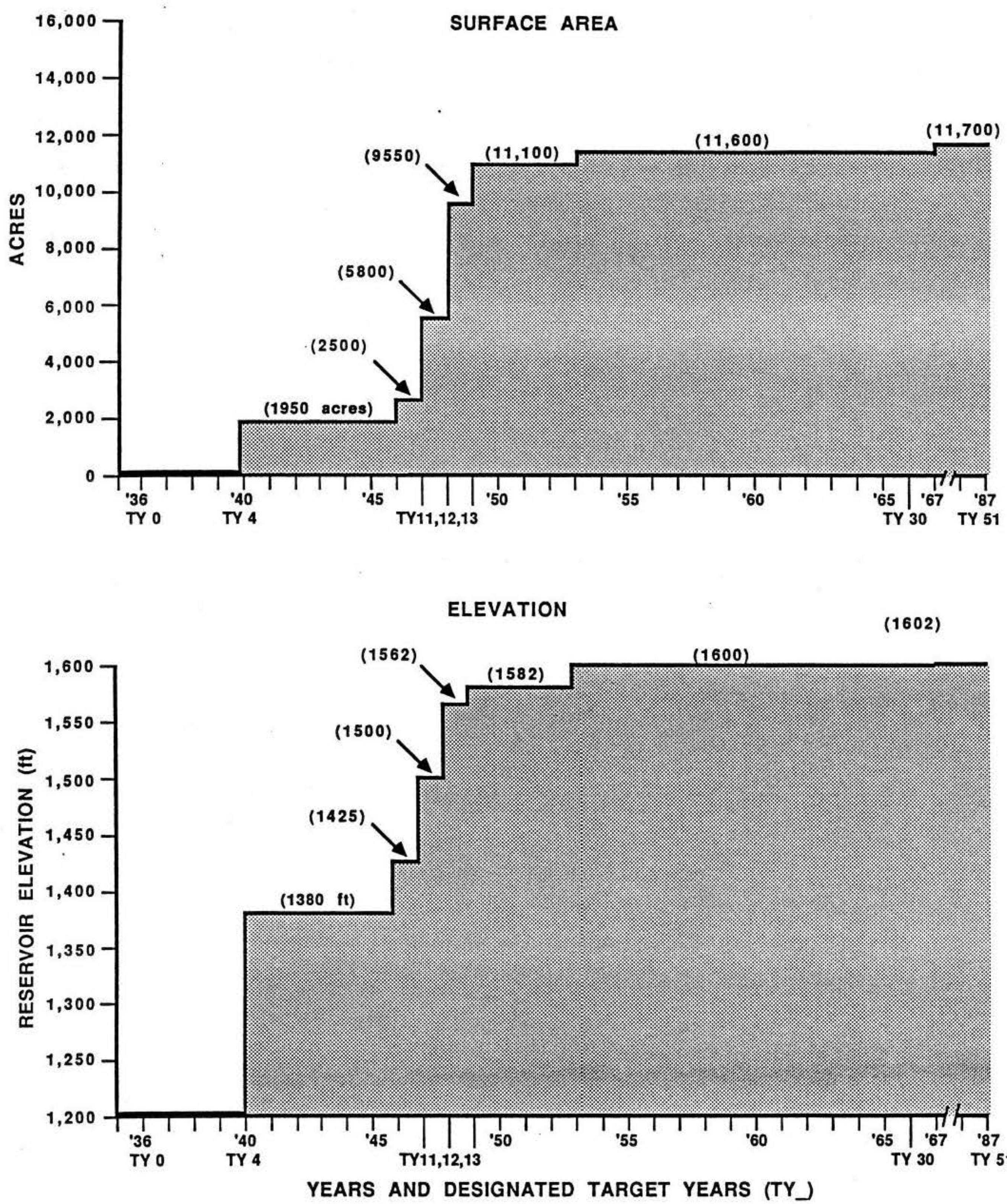


FIGURE 3-2. Chronology of elevation and associated surface area changes of Ross Lake pool.

modification represented by 1949 to 1952, 1953 to 1966, and 1967 to present were combined because the changes in area were also relatively small. Consequently, five periods of dam modification were assigned target years for Ross. A target year was assigned to 1966 (TY30) for adjusting the cover types for changes caused by succession. The changes in area calculated for each target year for the three reservoirs are given in Appendix F.

3.2.7.2 Average Annual Habitat Units

Average Annual Habitat Units were calculated to determine the net impact of the project on the evaluation species. The HSIs and associated habitat areas were used to calculate HUs for each target year which were then averaged over the life of the project to obtain Average Annual Habitat Units (AAHUs). This averaging procedure was accomplished by using the USFWS "HEP Accounting" procedure (USFWS 1985).

3.3 RESULTS

3.3.1 Habitat Inventory

The habitat inventory determined the amount of each cover type present in the Study Area under pre- (TY0) and post-impoundment conditions (1987) and provided information on acreage changes for target years. In order to estimate the acreage of each cover type for the target years, it was necessary to determine: 1) the amount of area affected by each modification to the dam and 2) the effects of succession. The area of each cover type affected by the project in any given target year was estimated using the digitizing and cartographic methods described in Section 3.2.2. The effects of succession on each cover type in the Study Area are described below.

3.3.1.1 Ecological Succession and Disturbance History

Succession is defined as the sequential change in the species composition and structure of a plant community over time. Classic succession in the Northwest has the following general pattern: forb-grassland to shrubland to regeneration forest to closed canopy forest (includes a wide range of age classes) to climax old-growth forest (Figure 3-3). However, successional patterns and rates vary depending on local conditions.

Succession in the Study Area was estimated from aerial photographs by comparing habitat type changes over time. More than 150 sites were tracked from aerial photographs taken at various time intervals during a 50-year period (Table 3-7). The photos provided site-specific information for developing successional rates. The successional patterns observed are illustrated below and then the rates of change are defined.

Pathway	Definition of Abbreviations
S ---> CR ---> CC ---> COG	S = Shrub
S ---> CR ---> OC ---> CC ---> COG	CR = Regeneration Conifer
CR ---> CC ---> COG	LR = Regeneration Lodgepole Pine
CR ---> OC ---> CC ---> COG	OC = Open Canopy Conifer
LR ---> CL ---> CC ---> COG	CC = Closed Canopy Conifer
	CL = Closed Canopy Lodgepole Pine
	COG = Old-Growth Conifer

The estimated rates of habitat change included:

- o Regenerative Conifer Forest: All Regenerative Conifer Forest types changed to Closed Canopy Conifer in 30 years.

- o Open Canopy Conifer Forest: A total of 25 percent of the Open Canopy Conifer Forest changed to Closed Canopy Conifer Forest in 50 years; 75 percent did not change.

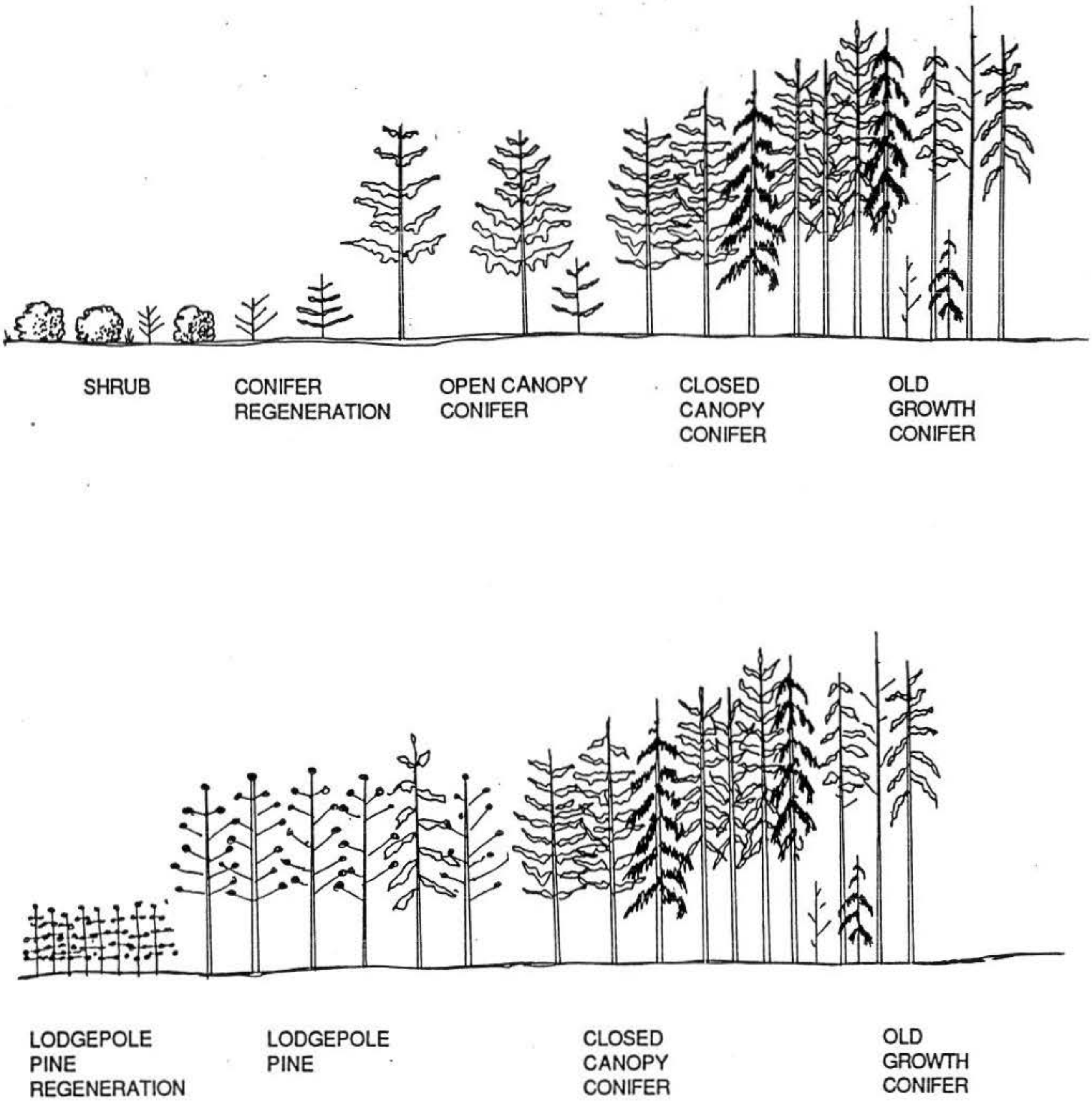


FIGURE 3-3

SUCCESSIONAL PATTERNS IN THE SKAGIT STUDY AREA

TABLE 3-7

SUCCESSIONAL CHANGES OBSERVED ON THE SKAGIT STUDY AREA

Observed Successional Trend		Polygons suitable to track over the Life-of-Project[a]					Projected change in total acres due to succession			
		Polygons available to sample[b]		Polygons sampled[c]			Without-the Project		With-the-Project	
Original Cover Type	New Cover Type	Total Number	Total Acres	Total Number	Total Acres	% Total Acres	Original Type	New[d] Cover Type	Original Cover Type	New[d] Cover Type
Regeneration Conifer	Closed Canopy Conifer			15	693	99.7	1525	1520	769	767
Regeneration Conifer	Open Canopy Conifer			1	2	0.3	1525	5	769	2
Subtotal		44	1525	16	695					
Regeneration Lodgepole	Closed Canopy Lodgepole	11	180	3	96	100	180	180		
Shrub	Closed Canopy Conifer			2	13	5.0	362	18	60	3
Shrub	Open Canopy Conifer			1	10	3.9	362	14	60	2
Shrub	Shrub			1	236	91.1	362	330	60	55
Subtotal		18	362	4	259					
Closed Canopy Lodgepole	Closed Canopy Conifer			6	61	18	679	122	234	42
Closed Canopy Lodgepole	Closed Canopy Lodgepole			8	269	82	679	557	234	192
Subtotal		21	679	14	330					
Open Canopy Conifer	Closed Canopy Conifer			10	54	26	728	189	279	73
Open Canopy Conifer	Open Canopy Conifer			17	157	74	728	539	279	206
Subtotal		62	728	27	211					
Closed Canopy Conifer	Old Growth Conifer			2	29	0.9	4534	41	2156	20
Closed Canopy Conifer	Closed Canopy Conifer			47	3194	99.1	4534	4493	2156	2136
Subtotal		94	4534	49	3223					
Exposed Rock	Open Canopy Conifer			1	3	13	37	4.8	25	3
Exposed Rock	Closed Canopy Conifer			1	1	4	37	1.5	25	1
Exposed Rock	Exposed Rock			6	20	83	37	30.7	25	21
Subtotal		12	37	8	24					
Talus	Mixed Conifer/Broadleaf			1	7	39	34	13.3	17	7
Talus	Talus			3	11	61	34	20.7	17	10
Subtotal		9	34	3	18					

a/ Number and area of polygons in the study area above the reservoir level that could be tracked on aerial photos over the life of the project to determine cover type changes due to succession.

b/ Total number of polygons and area in the polygons for the original cover type.

c/ Total number of polygons and area in the polygons sampled for each successional change and the percent of the acres sampled for each cover type.

d/ Acres new cover type was calculated by multiplying the percent of sampled acres by the acres of original cover type.

e/ Dash signifies not applicable.

- Closed Canopy Conifer Forest: Only 1 percent of the Closed Canopy Conifer Forest changed to Old Growth Conifer Forest in 50 years; 99 percent did not change.

- Closed Canopy Lodgepole Pine: A total of 20 percent of the Closed Canopy Lodgepole Pine changed to Closed Canopy Conifer Forest in 50 years; 80 percent did not change.

- Exposed Rock: A total of 17 percent of the Exposed Rock changed to Open Canopy Conifer Forest in 50 years; 83 percent did not change.

- Talus: A total of 39 percent of the Talus changed to Mixed Broadleaf/Conifer Forest in 50 years; 61 percent did not change.

- Riparian Forest: Percent changes among types were assumed to be identical to the upland forest counterparts.

- Other types: All other types were assumed to remain the same over the life of the project. Most of these types were small in area (i.e., agriculture, grassland, etc.) or they have been reported by other investigators (Colinvaux 1973) to change very slowly over time (i.e., wetlands).

Not all of a given type would be expected to change to the next type along the forecasted pathway or to proceed at the same rate because succession is influenced by edaphic (soil/moisture/temperature) conditions, fire, and other disturbances. Forest fires have had a major influence on plant succession in the North Cascades (Agee et al. 1985). A large fire in 1926 affected a broad area north of Pumpkin Mountain extending across the river and up the east and west slopes of the valley. A much smaller fire burned patches of old-growth timber left by the 1926 fire on the west side of the valley in about 1936. This fire apparently occurred soon after the first aerial photographs were taken (1936), because substantial regeneration had occurred by the time of the 1946 aerial photographs. Three small fires dated 1945, 1952, and 1980 were documented in the Lightning Creek area (Agee et al. 1986). Sites of other types of disturbance in the Study Area included timber clearing at Ross Dam (about 1937) and at the northern end of Ross Lake, south of the U.S. border (1948-1951).

This information on succession, fire, and other disturbances was used to adjust the area of each habitat type. These adjustments were applied to target years to calculate the AAHUs for conditions "without-the-project" and, when appropriate, for conditions "with-the-project."

3.3.1.2 Cover Type Descriptions

The Skagit dams inundated approximately 12,400 of the 15,728 acres in the Study Area (Table 3-8). The amount of area inundated by each reservoir included 11,416 acres at Ross, 761 acres at Diablo, and 213 acres at Gorge (Tables 3-9 through 3-11). The magnitude of the change in area is illustrated on the color map located in the map pocket at the back of this report. Note that the cover type labeled as Mature Conifer Forest on the map is Open and Closed Canopy Conifer forests dominated by 30-200 year old trees.

Forests dominated the Study Area before the construction of the Skagit dams (Figure 3-4). Approximately 86 percent of the area was forest, which primarily consisted of mature and old growth timber (75 percent). Riparian Old Growth Conifer Forest was almost three times more abundant than upland Old Growth Conifer Forest. The proportion of area represented by other types included 9 percent for wetlands and rivers, 4 percent for non-forests, and less than 1 percent for areas disturbed or developed. While most of these types currently occur in the Study Area, the upland types are best represented and the riparian, wetland, and riverine types are poorly represented.

Table 3-8. Summary of Habitats, Acreages, and Changes in the Skagit Study Area.

Community Type	Pre-project				With-project							
	# Polygons	Acreage	Percent of Total	Average Polygon Size	# Polygons	Acreage	Percent of Total	Average Polygon Size	Lost Acreage	Gained Acreage	Percent Loss	Relative Percent Loss
old growth conifer	35	1057.30	6.72%	30.21	10	285.05	1.81%	28.51	772.25	0.00	-73.04%	5.92%
closed canopy conifer	94	4533.74	28.83%	48.23	98	1634.33	10.40%	16.68	2899.41	0.00	-63.95%	22.23%
open canopy conifer	62	727.52	4.63%	11.73	32	157.09	1.00%	4.91	570.43	0.00	-78.41%	4.37%
closed canopy lodgepole pine	21	678.83	4.32%	32.33	29	174.16	1.11%	6.01	504.67	0.00	-74.34%	3.87%
open canopy lodgepole pine	7	114.29	0.73%	16.33	4	11.60	0.07%	2.90	102.69	0.00	-89.85%	0.79%
regenerative conifer	44	1525.12	9.70%	34.66	16	193.92	1.23%	12.12	1331.20	0.00	-87.28%	10.21%
regenerative lodgepole	11	180.08	1.14%	16.37	0	0.00	0.00%	0.00	180.08	0.00	-100.00%	1.38%
regenerative broadleaf/mixed	1	3.56	0.02%	3.56	5	82.96	0.53%	16.59	0.00	79.40	0.00%	0.00%
broadleaf	7	40.38	0.26%	5.77	14	89.74	0.57%	6.41	0.00	49.36	0.00%	0.00%
mixed conifer/broadleaf	0	0.00	0.00%	0.00	23	111.55	0.71%	4.85	0.00	111.55	0.00%	0.00%
grassland/meadow	2	8.84	0.06%	4.42	3	8.51	0.05%	2.84	0.33	0.00	-3.73%	0.00%
agriculture	1	9.46	0.06%	9.46	0	0.00	0.00%	0.00	9.46	0.00	-100.00%	0.07%
avalanche shrub	4	25.46	0.16%	6.37	2	4.21	0.03%	2.11	21.25	0.00	-83.46%	0.16%
shrubland	18	361.77	2.30%	20.10	1	5.09	0.03%	5.09	356.68	0.00	-98.59%	2.73%
rock talus	9	33.90	0.22%	3.77	16	27.01	0.17%	1.69	6.89	0.00	-20.32%	0.05%
exposed rock	12	36.86	0.23%	3.07	13	35.58	0.23%	2.74	1.28	0.00	-3.47%	0.01%
wet meadow/marsh	2	7.07	0.04%	3.54	0	0.00	0.00%	0.00	7.07	0.00	-100.00%	0.05%
bog	2	8.20	0.05%	4.10	0	0.00	0.00%	0.00	8.20	0.00	-100.00%	0.06%
shrub swamp	30	385.01	2.45%	12.83	1	2.10	0.01%	2.10	382.91	0.00	-99.45%	2.94%
conifer swamp	7	38.31	0.24%	5.47	0	0.00	0.00%	0.00	38.31	0.00	-100.00%	0.29%
broadleaf swamp	3	32.47	0.21%	10.82	1	9.31	0.06%	9.31	23.16	0.00	-71.33%	0.18%
mixed swamp	4	44.89	0.29%	11.22	0	0.00	0.00%	0.00	44.89	0.00	-100.00%	0.34%
pond	4	53.82	0.34%	13.46	0	0.00	0.00%	0.00	53.82	0.00	-100.00%	0.41%
reservoir	0	0.00	0.00%	0.00	8	5424.05	34.50%	678.01	0.00	5424.05	0.00%	0.00%
tributary	8	117.33	0.75%	14.67	3	33.26	0.21%	11.09	84.07	0.00	-71.65%	0.64%
riverine	12	675.08	4.29%	56.26	0	0.00	0.00%	0.00	675.08	0.00	-100.00%	5.18%
gravelbar	9	35.33	0.22%	3.93	3	5.27	0.03%	1.76	30.06	0.00	-85.08%	0.23%
drawdown area	0	0.00	0.00%	0.00	8	6965.58	44.31%	870.70	0.00	6965.58	0.00%	0.00%
riparian old growth conifer	68	3106.72	19.75%	45.69	2	20.58	0.13%	10.29	3086.14	0.00	-99.34%	23.66%
riparian closed canopy conifer	37	625.69	3.98%	16.91	3	62.21	0.40%	20.74	563.48	0.00	-90.06%	4.32%
riparian open conifer	2	16.05	0.10%	8.03	0	0.00	0.00%	0.00	16.05	0.00	-100.00%	0.12%
riparian regenerative conifer	1	25.30	0.16%	25.30	1	1.71	0.01%	1.71	23.59	0.00	-93.24%	0.18%
riparian regenerative broadleaf/conifer	0	0.00	0.00%	0.00	1	8.96	0.06%	8.96	0.00	8.96	0.00%	0.00%
riparian broadleaf	47	551.47	3.51%	11.73	3	19.56	0.12%	6.52	531.91	0.00	-96.45%	4.08%
riparian mixed conifer/broadleaf	30	450.40	2.86%	15.01	1	6.46	0.04%	6.46	443.94	0.00	-98.57%	3.40%
riparian shrubland	38	195.56	1.24%	5.15	2	1.96	0.01%	0.98	193.60	0.00	-99.00%	1.48%
developed—campground	0	0.00	0.00%	0.00	21	194.14	1.23%	9.24	0.00	194.14	0.00%	0.00%
developed—industrial	0	0.00	0.00%	0.00	5	44.77	0.28%	8.95	0.00	44.77	0.00%	0.00%
developed—intensive recreational	0	0.00	0.00%	0.00	0	0.00	0.00%	0.00	0.00	0.00	0.00%	0.00%
developed—low density residental	3	21.98	0.14%	7.33	1	6.87	0.04%	6.87	15.11	0.00	-68.74%	0.12%
developed—high density residental	0	0.00	0.00%	0.00	2	10.75	0.07%	5.38	0.00	10.75	0.00%	0.00%
developed—roads, parking	0	0.00	0.00%	0.00	4	47.85	0.30%	11.96	0.00	47.85	0.00%	0.00%
transmission right of way	0	0.00	0.00%	0.00	6	36.57	0.23%	6.10	0.00	36.57	0.00%	0.00%
TOTALS	635	15727.79	100.00%	24.77	341	15721.05	100.01%	46.10	13043.53	12972.98		

Table 3-9. Summary of Habitats, Acreages, and Changes in the Ross Basin.

Community Type	Pre-project				With-project							
	# Polygons	Acreage	Percent of Total	Average Polygon Size	# Polygons	Acreage	Percent of Total	Average Polygon Size	Lost Acreage	Gained Acreage	Percent Loss	Relative Percent Loss
old growth conifer	32	957.96	6.97	29.94	7	192.30	1.40	27.47	765.66	0.00	-79.93	6.51%
closed canopy conifer	75	3485.43	25.37	46.47	57	1214.08	8.85	21.30	2271.35	0.00	-65.17	19.31%
open canopy conifer	51	637.00	4.64	12.49	21	114.62	0.84	5.46	522.38	0.00	-82.01	4.44%
closed canopy lodgepole pine	15	443.84	3.23	29.59	16	106.72	0.78	6.67	337.12	0.00	-75.96	2.87%
open canopy lodgepole pine	5	85.07	0.62	17.01	4	11.60	0.08	2.90	73.47	0.00	-86.36	0.62%
regenerative conifer	39	1341.45	9.76	34.40	15	192.21	1.40	12.81	1149.24	0.00	-85.67	9.77%
regenerative lodgepole	11	180.08	1.31	16.37			0.00	0.00	180.08	0.00	-100.00	1.53%
regenerative broadleaf/mixed	1	3.56	0.03	3.56	5	82.96	0.60	16.59	0.00	79.40	0.00	0.00%
broadleaf	2	3.33	0.02	1.67	9	71.19	0.52	7.91	0.00	67.86	0.00	0.00%
mixed conifer/broadleaf			0.00	0.00	13	65.63	0.48	5.05	0.00	65.63	0.00	0.00%
grassland/meadow	2	8.84	0.06	4.42	3	8.51	0.06	2.84	0.33	0.00	-3.73	0.00%
agriculture	1	9.46	0.07	9.46			0.00	0.00	9.46	0.00	-100.00	0.08%
avalanche shrub	3	22.18	0.16	7.39	1	2.10	0.02	2.10	20.08	0.00	-90.53	0.17%
shrubland	18	361.77	2.63	20.10	1	5.09	0.04	5.09	356.68	0.00	-98.59	3.03%
rock talus	7	21.88	0.16	3.13	6	14.45	0.11	2.41	7.43	0.00	-33.96	0.06%
exposed rock	9	23.92	0.17	2.66	7	21.27	0.15	3.04	2.65	0.00	-11.08	0.02%
wet meadow/marsh	2	7.07	0.05	3.54			0.00	0.00	7.07	0.00	-100.00	0.06%
bog	2	8.20	0.06	4.10			0.00	0.00	8.20	0.00	-100.00	0.07%
shrub swamp	30	385.01	2.80	12.83	1	2.10	0.02	2.10	382.91	0.00	-99.45	3.26%
conifer swamp	7	38.31	0.28	5.47			0.00	0.00	38.31	0.00	-100.00	0.33%
broadleaf swamp	3	32.47	0.24	10.82	1	9.31	0.07	9.31	23.16	0.00	-71.33	0.20%
mixed swamp	4	44.89	0.33	11.22			0.00	0.00	44.89	0.00	-100.00	0.38%
pond	4	53.82	0.39	13.46			0.00	0.00	53.82	0.00	-100.00	0.46%
reservoir			0.00	0.00	3	4450.26	32.42	1483.42	0.00	4450.26	0.00	0.00%
tributary	6	74.24	0.54	12.37	1	7.44	0.05	7.44	66.80	0.00	-89.98	0.57%
riverine	7	554.08	4.03	79.15			0.00	0.00	554.08	0.00	-100.00	4.71%
gravelbar	8	29.44	0.21	3.68	2	4.30	0.03	2.15	25.14	0.00	-85.39	0.21%
drawdown area			0.00	0.00	8	6965.58	50.75	870.70	0.00	6965.58	0.00	0.00%
riparian old growth conifer	64	3075.04	22.38	48.05			0.00	0.00	3075.04	0.00	-100.00	26.14%
riparian closed canopy conifer	35	607.71	4.42	17.36	2	60.77	0.44	30.39	546.94	0.00	-90.00	4.65%
riparian open conifer	2	16.05	0.12	8.03			0.00	0.00	16.05	0.00	-100.00	0.14%
riparian regenerative conifer	1	25.30	0.18	25.30			0.00	0.00	25.30	0.00	-100.00	0.22%
riparian regenerative broadleaf/conifer			0.00	0.00	1	8.96	0.07	8.96	0.00	8.96	0.00	0.00%
riparian broadleaf	47	551.47	4.01	11.73			0.00	0.00	551.47	0.00	-100.00	4.69%
riparian mixed conifer/broadleaf	30	450.40	3.28	15.01			0.00	0.00	450.40	0.00	-100.00	3.83%
riparian shrubland	38	195.56	1.42	5.15			0.00	0.00	195.56	0.00	-100.00	1.66%
developed—campground			0.00	0.00	14	113.13	0.82	8.08	0.00	113.13	0.00	0.00%
developed—industrial			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
developed—intensive recreational			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
developed—low density residental	1	2.60	0.02	2.60			0.00	0.00	2.60	0.00	-100.00	0.02%
developed—high density residental			0.00	0.00	1	1.20	0.01	1.20	0.00	1.20	0.00	0.00%
developed—roads, parking			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
transmission right of way			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
TOTALS	562	13737.43	100.00	24.44	199	13725.78	100.00	68.97	11763.67	11752.02		

Table 3-10. Summary of Habitats, Acreages, and Changes in the Diablo Basin.

Community Type	Pre-project # Polygons	Pre-project Acreage	Pre-project Percent of Total	Pre-project Average Polygon Size	With-project # Polygons	With-project Acreage	With-project Percent of Total	With-project Average Polygon Size	Lost Acreage	Gained Acreage	Percent Loss	Relative Percent Lost
old growth conifer	3	99.34	6.84	33.11	3	92.75	6.37	30.92	6.59	0.00	-6.63	0.70%
closed canopy conifer	13	694.35	47.82	53.41	28	253.23	17.38	9.04	441.12	0.00	-63.53	47.16%
open canopy conifer	7	55.22	3.80	7.89	8	25.02	1.72	3.13	30.20	0.00	-54.69	3.23%
closed canopy lodgepole pine	5	234.93	16.18	39.17	13	67.44	4.63	5.19	167.55	0.00	-71.30	17.91%
open canopy lodgepole pine	2	29.22	2.01	14.61			0.00	0.00	29.22	0.00	-100.00	3.12%
regenerative conifer	3	166.62	11.48	55.54	1	1.71	0.12	1.71	164.91	0.00	-98.97	17.63%
regenerative lodgepole			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
regenerative broadleaf/mixed			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
broadleaf	5	37.05	2.55	7.41	5	18.55	1.27	3.71	18.50	0.00	-49.93	1.98%
mixed conifer/broadleaf			0.00	0.00	5	20.13	1.38	4.03	0.00	20.13	0.00	0.00%
grassland/meadow			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
agriculture			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
avalanche shrub			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
shrubland			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
rock talus			0.00	0.00	9	8.70	0.60	0.97	0.00	8.70	0.00	0.00%
exposed rock	2	10.50	0.72	5.25	5	10.40	0.71	2.08	0.10	0.00	-0.95	0.01%
wet meadow/marsh			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
bog			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
shrub swamp			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
conifer swamp			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
broadleaf swamp			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
mixed swamp			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
pond			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
reservoir			0.00	0.00	3	760.66	52.22	253.55	0.00	760.66	0.00	0.00%
tributary	2	43.09	2.97	21.55	2	25.82	1.77	12.91	17.27	0.00	-40.08	1.85%
riverine	3	59.89	4.12	19.96			0.00	0.00	59.89	0.00	-100.00	6.40%
gravelbar			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
drawdown area			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian old growth conifer	3	20.34	1.40	6.78	2	20.58	1.41	10.29	0.00	0.24	0.00	0.00%
riparian closed canopy conifer	1	1.39	0.10	1.39	1	1.44	0.10	1.44	0.00	0.05	0.00	0.00%
riparian open conifer			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian regenerative conifer			0.00	0.00			0.12	1.71	0.00	1.71	0.00	0.00%
riparian regenerative broadleaf/conifer			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian broadleaf			0.00	0.00	3	19.56	1.34	6.52	0.00	19.56	0.00	0.00%
riparian mixed conifer/broadleaf			0.00	0.00	1	6.46	0.44	6.46	0.00	6.46	0.00	0.00%
riparian shrubland			0.00	0.00	2	1.96	0.13	0.98	0.00	1.96	0.00	0.00%
developed—campground			0.00	0.00	6	79.67	5.47	13.28	0.00	79.67	0.00	0.00%
developed—industrial			0.00	0.00	3	11.70	0.80	3.90	0.00	11.70	0.00	0.00%
developed—intensive recreational			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
developed—low density residental			0.00	0.00	1	6.87	0.47	6.87	0.00	6.87	0.00	0.00%
developed—high density residental			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
developed—roads, parking			0.00	0.00	3	20.13	1.38	6.71	0.00	20.13	0.00	0.00%
transmission right of way			0.00	0.00	3	4.00	0.27	1.33	0.00	4.00	0.00	0.00%
TOTALS	50	1452.00	100.00	29.04	107	1456.78	100.12	13.61	935.35	941.84		

Table 3-11. Summary of Habitats, Acreages, and Changes in the Gorge Basin.

Community Type	Pre-project				With-project							Relative
	# Polygons	Acreage	Percent of Total	Average Polygon Size	# Polygons	Acreage	Percent of Total	Average Polygon Size	Lost Acreage	Gained Acreage	Percent Loss	Percent Loss
old growth conifer			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
closed canopy conifer	6	353.96	65.75	58.99	13	167.02	31.02	12.85	186.94	0.00	-52.81	54.26%
open canopy conifer	4	35.30	6.56	8.83	3	17.45	3.24	5.82	17.85	0.00	-50.57	5.18%
closed canopy lodgepole pine			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
open canopy lodgepole pine			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
regenerative conifer	2	17.05	3.17	8.53			0.00	0.00	17.05	0.00	-100.00	4.95%
regenerative lodgepole			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
regenerative broadleaf/mixed			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
broadleaf			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
mixed conifer/broadleaf			0.00	0.00	5	25.79	4.79	5.16	0.00	25.79	0.00	0.00%
grassland/meadow			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
agriculture			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
avalanche shrub	1	3.28	0.61	3.28	1	2.11	0.39	2.11	1.17	0.00	-35.67	0.34%
shrubland			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
rock talus	2	12.02	2.23	6.01	1	3.86	0.72	3.86	8.16	0.00	-67.89	2.37%
exposed rock	1	2.44	0.45	2.44	1	3.91	0.73	3.91	0.00	1.47	0.00	0.00%
wet meadow/marsh			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
bog			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
shrub swamp			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
conifer swamp			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
broadleaf swamp			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
mixed swamp			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
pond			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
reservoir			0.00	0.00	2	213.13	39.58	106.57	0.00	213.13	0.00	0.00%
tributary			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riverine	2	61.11	11.35	30.56			0.00	0.00	61.11	0.00	-100.00	17.74%
gravelbar	1	5.89	1.09	5.89	1	0.97	0.18	0.97	4.92	0.00	-83.53	1.43%
drawdown area			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian old growth conifer	1	11.34	2.11	11.34			0.00	0.00	11.34	0.00	-100.00	3.29%
riparian closed canopy conifer	1	16.59	3.08	16.59			0.00	0.00	16.59	0.00	-100.00	4.82%
riparian open conifer			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian regenerative conifer			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian regenerative broadleaf/conifer			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian broadleaf			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian mixed conifer/broadleaf			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian shrubland			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
developed—campground			0.00	0.00	1	1.34	0.25	1.34	0.00	1.34	0.00	0.00%
developed—industrial			0.00	0.00	2	33.07	6.14	16.54	0.00	33.07	0.00	0.00%
developed—intensive recreational			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
developed—low density residental	2	19.38	3.60	9.69			0.00	0.00	19.38	0.00	-100.00	5.63%
developed—high density residental			0.00	0.00	1	9.55	1.77	9.55	0.00	9.55	0.00	0.00%
developed—roads, parking			0.00	0.00	1	27.72	5.15	27.72	0.00	27.72	0.00	0.00%
transmission right of way			0.00	0.00	3	32.57	6.05	10.86	0.00	32.57	0.00	0.00%
TOTALS	23	538.36	100.00	23.41	35	538.49	100.00	15.39	344.51	344.64		

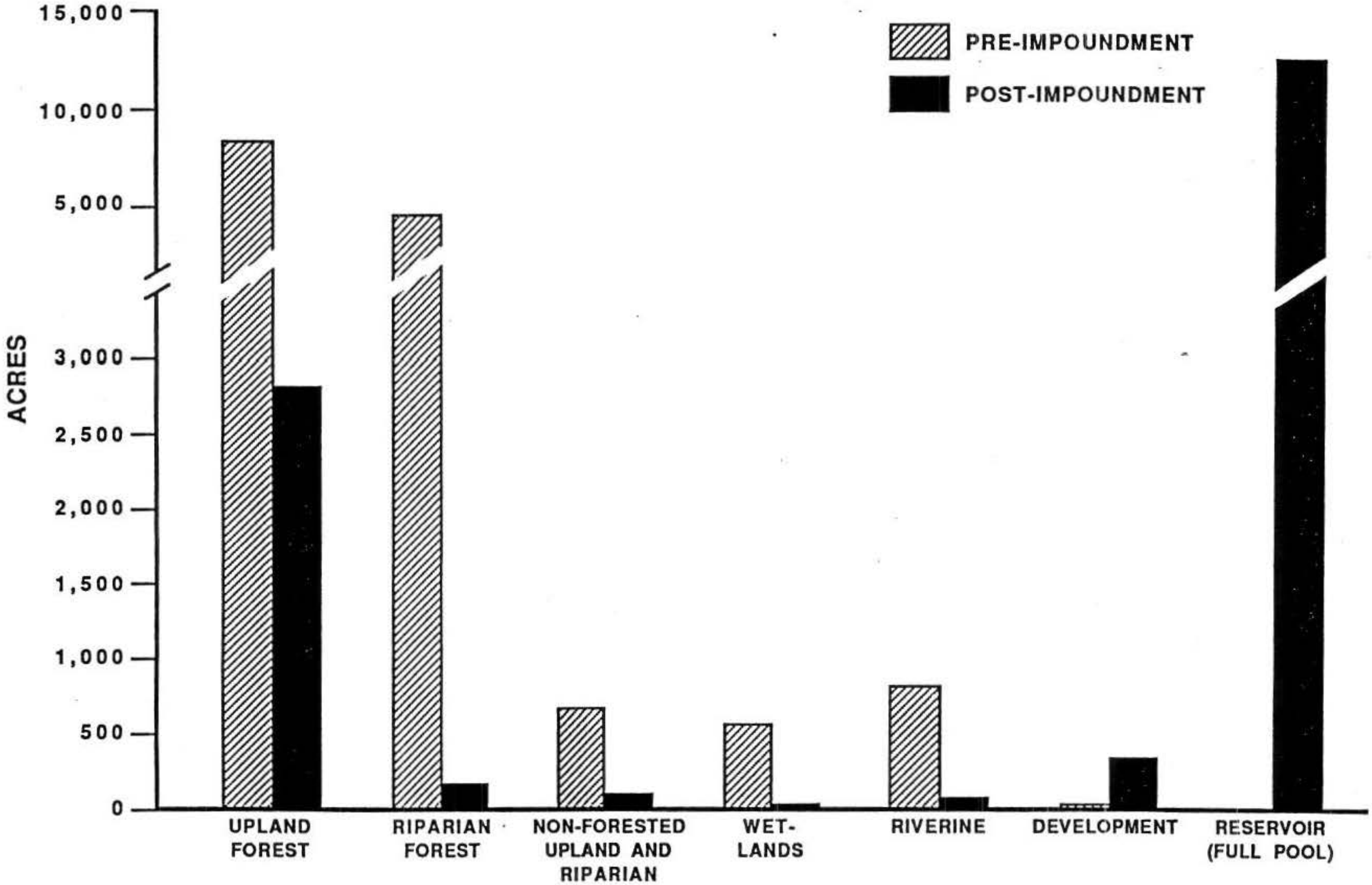


FIGURE 3-4 HABITAT ACREAGE CHANGES IN THE SKAGIT STUDY AREA

Upland Forested Habitats

Upland habitats are distinguished from wetland habitats by having vegetation that is not directly influenced by a stream or other surface water. Forests were defined by having at least 10 percent tree canopy closure.

Approximately 72 percent of the original 8,861 acres of upland forest in the Study Area was inundated by the dams of the Skagit project (Table 3-8). Upland Forest covered almost 56 percent of the Study Area before the dams were built. Ross Basin had 81 percent (7,138 acres) of the total area, Diablo Basin 15 percent (1,317), and Gorge Basin 4 percent (406 acres) (Tables 3-9 through 3-11). The Study Area currently has approximately 2,500 acres of upland forests which represent almost 84 percent of the total area upslope of the reservoirs.

Ten upland forest types were identified in the Study Area. These included four conifer types, three lodgepole pine types, and three broadleaf and mixed conifer/broadleaf types. Each type is described below.

Old Growth Conifer Forest: Old Growth Conifer Forests were an important component of the pre-impoundment vegetation (6.7 percent of the area) and are a notable part of the present vegetation of the Study Area (8.5 percent of the nonreservoir area). Approximately 73 percent of the initial 1,057 acres of this habitat was flooded by the Skagit dams (Table 3-8). The majority of the change was in the Ross Basin where there was an 80 percent reduction (Table 3-9). About 7 percent of the 100 acres of old growth in the Diablo Basin was lost (Table 3-10). The Gorge Basin had no Old Growth Conifer Forest either before or after dam construction (Table 3-11).

The term "Old Growth Forest" is defined in the literature to include 200-500 year old forest communities dominated by western red cedar, western hemlock, and Douglas fir. Structural diversity is high, with trees in all age classes from seedling to standing dead, and with an understory community composed of multi-layered shrub and herbaceous canopies

(Franklin and Dyrness 1973). Stands dominated by western red cedar or western hemlock are self-sustaining climax communities. Major changes in species composition occur only following catastrophic disturbance. Old growth Douglas fir forest is typically replaced by hemlock and cedar forest, although on the driest sites Douglas fir may be a component of the climax community. Understory species vary in response to local soils and moisture, but generally include vine maple, Alaska huckleberry, red huckleberry, strawberry, trailing blackberry, bunchberry, and several fern and moss species. In addition, old growth forest communities typically contain snags, logs, and areas of sparse understory vegetation. These features, in addition to the multi-layered herbaceous, shrub, and tree canopies differ from younger forests.

The structural characteristics that define Old Growth Conifer Forests were corroborated by field measurements (Appendix Tables C-6 and C-7). Field measurements showed that Old Growth Conifer Forests in the Study Area had the highest densities ($\bar{x}$ = 161.3 trees per ha), the largest trees (>51 cm dbh), relatively high densities ($\bar{x}$ = 29.3 per ha) of large snags (>51 cm), and many downed logs and decaying stumps ($\bar{x}$ = 294.7 per ha). The dominant species of trees was Douglas fir. These characteristics result from the long time period required for an Old Growth Conifer Forest to develop.

Very little successional change was observed in the old growth habitat. Approximately 1 percent of the area of Closed Canopy Conifer changed to Old Growth Conifer. This is expected, since the structure of old forests requires a long time period to develop. The reduction of old growth habitat between pre-impoundment and 1987 conditions was due primarily to inundation by the reservoirs, but nearly 300 acres above the pool level were cleared for the Skagit dams projects.

<u>Closed Canopy Conifer Forest</u>: Closed Canopy Conifer Forests occupied the largest area of any terrestrial habitat, both before the dams were built (28.8 percent) and in 1987 (10.4 percent of the Study Area, but about 50 percent of the nonreservoir area). The total area of this type was

reduced by 64 percent (4,534 acres to 1,634 acres) from pre-impoundment to 1987 (Table 3-8). This reflects a reduction of 65 percent in the Ross basin, 64 percent in the Diablo basin, and 53 percent in the Gorge basin, which indicates that this cover type was important throughout the Study Area (Tables 3-9 through 3-11).

This cover type is similar to Old Growth Conifer Forest in species composition, but it has fewer snags and logs, and smaller trees form the overstory. This type is quite broad, and includes relatively young to mature forest communities that are 30 to 200 years old. Overstory dominants are often shade-intolerant species such as Douglas fir, while younger conifers in the understory are shade-tolerant species such as western hemlock and western red cedar. These species will eventually replace Douglas fir in all but the driest sites providing succession is not interrupted by disturbance. Some stands on the east side of Ross Lake contained ponderosa pine.

The stands of this cover type ranged from relatively open timber (50 percent canopy closure) to closed (100 percent canopy closure). The more open stands tended to be on dryer or rockier soils. The understory species composition and structure were also variable. Shrubs usually dominated the understory and included salal, Oregon grape, mountain box, vine maple, ocean spray, wild rose, serviceberry, and huckleberry. The herbaceous understory was usually much less prominent than the shrub layer and was composed of broadleaf herbaceous plants (e.g., hawkweed), several grass and sedge species, ferns (e.g., sword fern and deer fern), and often an extensive mat of mosses (e.g., stairstep moss).

Our field measurements confirmed the structural variability of this type (Appendix Tables C-6 and C-7). Douglas fir, the dominant tree species, was, however, found in virtually every stand, and it usually had the largest canopy cover and was sometimes the only conifer species in the sample plot. The wide range of stand age was reflected in the variability of the number of large trees and snags. The average number of large trees per hectare was 96 (compared with 161 for Old Growth Conifer Forests) with a coefficient of variation of 145.7 percent in 20 samples. The average number of large snags was 4.8 (compared with 29.3 for Old Growth Conifer Forests) and the coefficient of variation was 267.1 percent in 20 samples. These features show that Closed Canopy Conifer was a transitional stage between young and Old Growth Conifer Forest.

Successional changes noticeably affected this habitat type. There were 822 acres of other cover types that changed to Closed Canopy Conifer between the pre-impoundment period and 1987. Over 80 percent of the new acres of Closed Canopy Conifer came from the maturing of Regeneration Conifer stands. Other types, including Open Canopy Conifer, Shrub, and Exposed Rock, changed to Closed Canopy Conifer as seedlings established and trees grew larger, increasing the canopy cover to greater than 50 percent. Some stands of Closed Canopy Lodgepole also changed to Closed Canopy Conifer as other conifer species (especially Douglas fir) became more numerous, matured, and overtopped lodgepole pine. Only 29 acres (0.9 percent) of the pre-impoundment area of Closed Canopy Conifer type changed to Old Growth Conifer.

Development also affected this cover type. Several areas were converted to industrial and other developments associated with the hydroelectric project such as transmission line rights-of-way, housing areas, roads, campgrounds, and resorts.

Open Canopy Conifer Forest: Open Canopy Conifer Forest decreased from 728 acres (4.6 percent of the Study Area) before the dams to 157 acres (4.7 percent of the nonreservoir area) in 1987 (Table 3-8). This cover type represented similar proportions of the area of all three basins under both pre- and post-impoundment conditions (Tables 3-9 through 3-11). This reduction represents a 78 percent loss of acreage.

The Open Canopy Cover type, defined as having 10 to 50 percent conifer tree cover, is commonly found on rocky slopes and dry promontories with shallow soils. The most common tree species is Douglas fir, but in several locations on the east side of Ross Lake ponderosa pine may be present or even dominant. The understory varies with the substrate. On steep rocky slopes with a Douglas fir overstory, a heavy cover of mosses such as Rhacomitrium canescens is often prominent, sometimes supporting a number of spring ephemerals such as wild onions, monkey flowers, and candy flowers. In places with deeper soils, kinnikinnick forms extensive low shrub mats. Stands dominated by Douglas fir on deeper soils are interspersed with a heavy cover of large shrubs such as willows, mountain balm, bittercherry, Oregon grape, mock orange, serviceberry, and several other species. Stands dominated by ponderosa pine often have a sparse shrub understory but well developed grass and forb understories. These stands are more typical of the east slopes of the Cascades because they have bluebunch wheatgrass, Lomatium, larkspur, and balsamroot. The presence of such stands may be partly attributed to the rain shadow effect of the Pickett Range to the west. Some stands may be partly maintained by fire. For example, Agee et al. (1986) documented that repeated fires have maintained one open, ponderosa pine stand with a grass understory located north of Lightning Creek.

The field sampling confirmed the reported features of this habitat type (Appendix Tables C-6 and C-7). Tree density was much lower than in Closed Canopy Conifer ($\bar{x}$ = 170 vs 1,380 trees per hectare). Tree canopy cover averaged 39 percent compared to over 90 percent for Closed Canopy Conifer Forest. The number of shrub stems was high and variable, and the percent of herbaceous cover was about five times higher than in Closed Canopy Conifer Forests. These results show that the more open overstory promoted the development of well formed shrub and herbaceous understories.

About 26 percent of the area of Open Canopy Conifer Forest changed to Closed Canopy Conifer because of succession. About 0.3 percent of Regeneration Conifer, 3.9 percent of Shrub, and 13 percent of Exposed Rock acres changed to Open Conifer. These changes, along with those caused by various development activities and the inundation of the reservoirs resulted in an overall reduction in the amount of Open Canopy Conifer habitat by 570 acres (78 percent).

Regenerative Conifer Forest: Regenerative Conifer Forests decreased from 1,525 acres (9.7 percent of the Study Area) to 194 acres (5.8 percent of the nonreservoir area) between the pre- and post-impoundment periods (Table 3-8). Approximately 88 percent of the pre-impoundment acreage of this type was in Ross Basin (most of it became established following the 1926 fire), 11 percent was in Diablo Basin, and 1 percent was in the Gorge Basin (Tables 3-9 through 3-11). About 70 percent of the acreage of the Regenerative Conifer Forest in Ross and Diablo basins and 20 percent in Gorge basin was inundated by the reservoirs. Stands of this cover type currently occur in the Ross basin in areas cleared during the last stage of construction for Ross Dam. This cover type also occupied some of the transmission line rights-of-way and highway rights-of-way in the Diablo and Gorge basins.

Douglas fir was usually the dominant species of this cover type, but western hemlock and western red cedar were co-dominants on cool, moist sites, and lodgepole pine was present on some drier sites. The community structure varied. Regenerative Conifer Forests usually had a dense tree canopy and a poorly developed understory. On some drier, more open sites on the east side of Ross Lake, Douglas fir formed an open canopy with a well developed shrub layer including willow, serviceberry, mountain box, bittercherry, oceanspray, kinnikinnick, and other shrubs.

Field sampling results showed that the tree canopy cover was high (81 percent) and the density of conifer trees in Regenerative Conifer Forests was higher than any other type except Closed Canopy Lodgepole Pine (Appendix Tables C-6 and C-7). High tree density typifies young conifer forest.

This habitat type changed almost completely through succession between pre-impoundment conditions and 1987. Over 99 percent of the type changed to Closed Canopy Conifer and the rest changed to Open Canopy Conifer. The majority of the forested area above pool that was cleared between 1948 and 1951 had trees large enough by 1987 to be classified as Closed Canopy

Conifer and some had made this transition by 1978. Of the original 1,525 acres of Regeneration Conifer in the Study Area, the 450 acres above the reservoir pools changed into other types or were developed.

<u>Lodgepole Pine Forest</u>: Lodgepole Pine Forests including closed canopy, open canopy, and regeneration types, decreased from 973 acres (10 percent of the Study Area) before the dams to 186 acres (5.6 percent of the nonreservoir area) in 1987 (Table 3-8).

Diablo Basin originally had 265 acres and Ross Basin had 709 acres of Lodgepole Pine Forest (Tables 3-9 and 3-10). Gorge Basin had none (Table 3-11). The Lightning Creek delta in the Ross Basin supported extensive Lodgepole Pine stands. A large area on the south side of the Skagit River in Diablo Basin was named "Jack Pine Flat" on old USFS maps; Jack Pine is an alternate common name for lodgepole pine. In 1987, forests dominated by lodgepole pine were on dry sites in the Diablo area and along the southeastern portion of Ross Basin. These even-aged stands developed following fire, as evidenced by an occasional remnant Douglas fir towering above the pine canopy.

Lodgepole Pine Forests are typically dense with a closed tree canopy and little understory development. Where the soils are shallow, the stands are more open. With the right combination of soil and light, typical understory plants include salal, kinnikinnick, or prostrate juniper. The field sampling showed that Lodgepole Pine stands were densely stocked ($\bar{x}$ = 2,834 stems per ha) and had relatively open canopies ($\bar{x}$ = 53 percent canopy cover) (Appendix Tables C-6 and C-7).

Succession changed 18 percent of the Closed Canopy Lodgepole stands to Closed Canopy Conifer stands over the life of the project. We estimated that all of the regeneration stage lodgepole would have changed to Closed or Open Canopy Lodgepole within about 30 years.

Broadleaf: Broadleaf Forests were not common above the riparian zone before the dams were built (Table 3-8). Ross Basin had only two small patches totaling 3 acres (Table 3-9). Diablo Basin had three patches totaling 37 acres (Tables 3-10). There are now approximately 90 acres in the Study Area, an increase of about 44 percent. This increase is probably due to disturbance directly or indirectly associated with the reservoirs.

Broadleaf sites sampled during the field program were characterized by moderate densities of deciduous trees and shrubs and had an average tree canopy cover of about 88 percent (Appendix Tables C-6 and C-7). In general, Broadleaf Forests were dominated by black cottonwood, paper birch, red alder, bigleaf maple, or combination of these species. These species are not shade-tolerant, and they will gradually be replaced by conifers. This successional trend was evident at the sample sites, where western red cedar and western hemlock were growing in the understory. Additional understory species included vine maple, thimbleberry, Oregon grape, bracken fern, star-flowered Solomon's seal, and starflower.

Mixed Conifer/Broadleaf Forest: Upland Mixed Forest increased from 0 to 112 acres following construction of the dams (Table 3-8). About 58 percent of this type was in Ross Basin, 20 percent in Diablo Basin, and 22 percent in Gorge Basin (Tables 3-9 through 3-11).

These forests were dominated by a mixture of broadleaf and coniferous trees. Douglas fir, western hemlock, western red cedar, red alder, bigleaf maple, paper birch, and black cottonwood were typical species. Although some of the Mixed Forest communities in the Study Area were transitional stages between broadleaf and conifer-dominated forest communities, most developed at Ross after clearing the timber in Ruby Basin and are relatively young stands.

Mixed stands sampled during the field program were characterized by a low to moderate density of shrubs and trees, about 90 percent tree canopy cover, and the presence of some large trees and snags (Appendix Tables C-6 and C-7). Since none of this type occurred before the dams were built, no examples were available to characterize succession. Studies of succession in western Washington indicate that Mixed Forest would change to Closed Canopy Conifer Forest over time (Franklin and Dyrness 1973). We assumed that this type remained constant over the life of the project since it was not originally present in the Study Area.

Regenerative Broadleaf/Mixed Forest: Regenerative Broadleaf/Mixed Forests increased from 4 to 83 acres following construction of the dams (Table 3-8). The regeneration stage of Broadleaf or Mixed forests was difficult to distinguish on the project aerial photos with any degree of accuracy; therefore, they were considered as one type.

Young forests dominated by Douglas fir, western hemlock, western red cedar, red alder, bigleaf maple, willows, paper birch, and black cottonwood grew within the area cleared in Ross Basin between 1,600 ft and 1,725 ft elevation. Vegetation at these sites was very dense, with a well-developed shrub layer in openings beneath the tree canopy. Regenerative Broadleaf/Mixed Forests were essentially absent before the dams were built, but are now present in Ross Basin.

Depending on species composition, succession would lead either to Broadleaf Forest or Mixed Broadleaf/Conifer. No examples of succession were available in the Study Area. Succession was assumed not to occur for this type, since it originally represented a very small proportion of the Study Area.

Nonforested Upland Habitats

Nonforested habitats have less than 10 percent tree cover. The nonforested upland habitats include Shrubland, Avalanche Track, Grassland, Exposed Rock, and Talus types.

Shrub: About 90 percent of the 362 pre-impoundment acres of upland Shrubland cover type was inundated by the reservoirs (Table 3-8). The upland Shrub cover type occupied 2.3 percent of the pre-impoundment Study Area and 0.15 percent of the nonreservoir areas in 1987. Most of it was located on the dry gravelly delta of Lightning Creek, an area known as "The Little Sahara" by early settlers. Here, the shrub form of bittercherry, which grows primarily on the lower east slopes of the Cascade Mountain range, was a dominant species. Bittercherry stumps are still present on the delta, but visible only when the reservoir level is low. Other important species included mountain balm, serviceberry, mock orange, hazelnut, and willow. These same species currently occur now in adjacent shrub areas. Herbaceous understory cover was probably a mixture of grasses and forbs.

The structural characteristics of Shrubland habitat in the Study Area, as determined from field measurements, included a high shrub density (over 38,000 stems/ha), a moderately open shrub canopy (50 percent canopy closure), and relatively low herbaceous cover (25 percent cover) (Appendix Tables C-6 and C-7).

The influence of succession was relatively small over the life of the project. Over 90 percent of the observed Shrubland habitat area was unchanged, while approximately 5 percent changed to Closed Canopy Conifer and 4 percent to Open Canopy Conifer. Consequently, the Shrubland habitat in the Study Area was probably at a climax stage in succession.

Avalanche Tracks: Avalanche Tracks are steep, shrub-covered slopes that are subject to avalanches in winter. Tree cover is low because the trees are pruned by avalanches. There were 25 acres of this type before the dams and 4 acres in 1987 (Table 3-8). Vine maple, hazelnut, and Sitka alder are the common dominants in Avalanche Tracks. The herbaceous layer is generally sparse, although mosses may form a continuous cover over the cobble and boulder substrate. Successional change would be expected to be very slow and not observable in the period since the dams have been in place. We assumed succession was constant in this type.

Grassland/Meadow: Grass-dominated areas were uncommon (9 acres) before the dams were built, and they currently occupy about the same amount of area (Table 3-8). One such Grassland community exists on a dry, west-facing slope in the area south of Jack Point in Ross Basin. Dominants in the community include bluebunch wheatgrass, pinegrass, and arrowleaf balsamroot. Additional cover is provided by several species with restricted distributions west of the Cascade crest, including meadow deathcamas, swale desert-parsley, and microsteris.

The Grasslands in the Study Area appear to be maintained by fire. In the absence of fire they would be expected to be invaded by shrubs and trees and eventually become forested.

Exposed Rock and Talus: These two cover types are both characterized by having sparse tree, shrub, and herbaceous cover. Rock and Talus each occupied less than 1 percent of the Study Area both before and after the dams (Table 3-8). The Exposed Rock areas were outcrops of bedrock, while the Talus slopes were piles of broken rock. Both types may have a heavy cover of mosses and lichens, but Talus slopes often appear entirely barren except for widely scattered trees or other vascular plants in small pockets of soil. The amount of herbaceous cover on Talus slopes depends on effective moisture, which varies according to aspect, size of rocks, and location.

Succession changed 17 percent of Exposed Rock and 39 percent of Talus slopes to forest during the life of the project (Table 3-7). This is probably an overestimate of the amount of change that would be expected in the future. Some of these areas may not be capable of supporting forest cover until more soil builds up. Our sample may have been biased by unknown pre-impoundment disturbances of sites which promoted tree development.

Riparian Habitats

Riparian habitats are distinguished from upland habitats by their close association with streams and rivers. Riparian habitats were defined in our study as habitats adjacent to water courses where seasonally wet soils influence plant composition (Roberts 1983). The outer boundary of riparian habitat was distinguished on aerial photographs by the topographic break separating the river bottomlands (pre-impoundment period) from the uplands. The location of this break was associated with recognizable changes in the photo-image characteristics of the vegetation. The area between the river and the topographic break represented the area of riparian habitat in our study.

Approximately 98 percent of the original 4,965 acres of riparian habitat in the Study Area was inundated by the Skaget Hydroelectric Project (Table 3-8). Riparian habitat covered almost 32 percent of the Study Area before the dams were constructed. Most of the riparian habitat was in the Ross Basin, except for 22 acres at Diablo and 28 acres at Gorge Basins (Tables 3-9 through 3-11). The broad valley bottom coupled with the meandering Skagit River were responsible for the extensive area of riparian habitat in the Ross Basin. The narrow valleys of Gorge and Diablo were less suitable for supporting riparian vegetation. The Study Area currently has over 100 acres of riparian vegetation, which are primarily associated with Big Beaver Creek at Ross and Thunder Arm at Diablo.

Eight riparian habitat types were identified in the Study Area. These types are individually described below, and we assumed that their successional patterns paralleled those described earlier for the upland types.

Riparian Old Growth Conifer: Approximately 63 percent, or 3,106 acres, of the riparian habitat was old growth forest (Table 3-8). This type was originally widespread throughout the Study Area but particularly large, extensive areas of it were in the northern half of the Ross Basin. These areas were undoubtedly very impressive because the western red cedar they supported possibly reached 60 m in height and some may have been 2,000 years old with diameters of 3 to 4.5 m (Franklin and Dyrness 1973). The best representatives of Riparian Old Growth Conifer Forests are currently in Big Beaver Valley. Field sampling at these sites indicate that the Riparian Old Growth Conifer stands in the Study Area were dominated by cedar and occasionally western hemlock, which together formed a closed canopy over a sparse understory. The understory consisted of vine maple, yew, enchanter's nightshade, mountain wood-fern, and foam flower. Devil's club, salmonberry, and red-twig dogwood thickets grew in pockets of saturated soil or along intermittent drainages. The study area currently contains about 21 acres of small remnant stands of Riparian Old Growth Conifer habitat.

Riparian (Closed and Open) Canopy Conifer: Approximately 13 percent or 642 acres of riparian habitat was mature Riparian Conifer Forest (Table 3-8). This habitat type was scattered throughout the Study Area but generally in smaller patches than Riparian Old Growth Conifer. Compared to Riparian Old Growth Conifer the mature Riparian Conifer stands had less structural diversity, smaller but still large trees, and fewer logs and snags because of its younger age. The Study Area currently has 62 acres of Riparian Conifer Forest, all associated with Thunder Arm at Diablo.

Riparian Broadleaf: Approximately 11 percent or 551 acres of the original riparian habitat was Broadleaf Forest (Table 3-8). Prior to the creation of Ross Lake, there was a large stand of riparian forest near the Canadian border that was dominated by black cottonwood. Black cottonwood stands also grew downstream along bends in the river and around sloughs and oxbow lakes. Stands dominated by red alder also grew along the river, but these were restricted to Diablo Basin and the southern portion of Ruby Basin. The understory in Riparian Broadleaf Forest is often dense and contains thickets of salmonberry and devil's club. Lady fern, foam flower, false lily-of-the-valley, and many additional herbaceous species may also be present. There are currently 20 acres of Riparian Broadleaf Forest in the Study Area.

Riparian Mixed Conifer/Broadleaf: Approximately 9 percent or 450 acres of the original riparian habitat was Mixed Conifer/Broadleaf Forest (Table 3-8). This forest type was widely scattered in small patches on bends of the Skagit River. This type probably represents a successional stage between Riparian Broadleaf and Riparian Conifer forests. The plant community structure and composition are similar to Riparian Broadleaf Forest except for the addition of red cedar and western hemlock. There are currently no representatives of this type in the Study Area.

Riparian Regeneration Conifer: The Study Area originally contained one, 25-acre patch of Riparian Regeneration Conifer Forest (Table 3-8). Larger amounts of this type were present on the areas burned in 1926 but these stands had advanced to older successional stages by 1937, the base year for our study. These stands were probably composed of western red cedar and western hemlock with some Douglas fir in drier sites. There are currently no representatives of this type in the Study Area.

Riparian Shrub: Riparian Shrub represented 196 acres or 4 percent of all original riparian habitat in the Study Area (Table 3-8). It all occurred in Ross Basin. Streamside thickets dominated by redosier dogwood, twinberry, willow, and salmonberry grew along the banks of the Skagit River before it was flooded by Ross Lake. These communities often covered large areas on river bends and around oxbows, where the plants would colonize sediments deposited by the river. The Study Area currently has one, 2-acre patch along the Diablo Reservoir.

Wetland Habitats

Wetlands were defined as areas dominated by plants adapted to growing on seasonally saturated soils (Cowardin et al. 1979). The wetlands in the Study Area were small ($\leq$ 20 acres), shallow ($\leq$ 6 ft) water bodies termed palustrine wetlands. Lacustrine wetlands (> 20 acres) were not represented in the Study Area. The reservoirs do not fit these definitions of wetlands, so they will be treated separately in a later section of this report.

Approximately 98 percent of the original 570 acres of wetlands in the Study Area was inundated by the Skagit Hydroelectic Project (Table 3-8). Wetlands covered about 4 percent of the Study Area before the dams were constructed. All of the wetland habitat was in the Ross Basin. Diablo and Gorge basins were largely steep, rocky canyons not suitable for wetlands. The wetlands in Ross Basin were primarily distributed in the northern portion of the bottomlands where the Skagit River meandered through a wide valley. The Study Area currently has about 11 acres of wetlands including 9 acres at the lower end of Big Beaver Valley and 2 acres at Roland Point along Ross Lake.

Seven wetland types were identified in the Study Area. These types are individually described in the following sections. We assumed that succession would not have significantly influenced the wetland types over the life of the project. Rates of change between successional stages are typically very slow for wetlands (Cowardin et al. 1979).

<u>Wet Meadow/Marsh (Palustrine Emergent)</u>: Wet Meadows and Marshes were not common in the upper Skagit Valley. These herb-dominated wetlands originally comprised 1 percent or 7 acres of the wetlands in the Study Area (Table 3-8). Two small marshes existed in Ruby Basin. The Marshes currently in Big Beaver Valley are sedge-dominated communities that are probably similar to the Marshes inundated by Ross Lake.

<u>Bog (Palustrine Moss)</u>: Bogs represented 1 percent or 8 acres of the original wetland habitat in the Study Area (Table 3-8). Two Bogs existed near the confluence of Lightning Creek and the Skagit River prior to the creation of Ross Lake. Many unusual or uncommon plant species grow only in Bogs, including sundews, sphagnum moss, and several sedges. Bog clubmoss, a sensitive species in Washington State, grows in the Bogs of Big Beaver Valley, and may have also grown in the Ross Basin Bogs. There are currently no Bogs in the Study Area.

dendroideum is a forb found in the understory of mature conifer forests. These species may have occurred in similar habitats in the inundation area of Ross Lake.

3.3.2 Wildlife Habitat Evaluation

The HEP was used to determine the net effect of the Skagit River dams on wildlife. The net effect was determined by comparing AAHUs for the ten evaluation species "with-the-project" and "without-the-project" for Gorge, Diablo, and Ross reservoirs. The results of this analysis show that the dams had a negative impact on all ten evaluation species (Table 3-12). Losses were highest for Mule Deer, Marten, and Black-capped Chickadee; moderate for Yellow Warbler, Pileated Woodpecker, and Beaver; and lowest for Ruffed Grouse, Red-tailed Hawk, Osprey, and American Dipper. Under conditions "without-the-project," the Study Area provided high quality habitat (HSI = 0.66 to 1.00) for the Beaver, Pileated Woodpecker, Yellow Warbler, and Marten; moderate quality (HSI = 0.33 to 0.65) for the Black-capped Chickadee, Mule Deer, Osprey, and American Dipper; and low quality (HSI = 0.01 to 0.32) for Ruffed Grouse and Red-tailed Hawk (Figure 3-5). Habitat quality under conditions "with-the-project" was generally lower because of the amount of habitat lost. The effect of the dams on the evaluation species is described below.

3.3.2.1 Yellow Warbler

The Yellow Warbler was chosen as an evaluation species because it represents birds that reproduce in shrubs and make extensive use of wetlands. Optimal habitat for Yellow Warblers are wet areas with abundant shrubs or small trees such as thickets, marshes, and willow swamps (Bent 1953; Salt 1957; Schroeder 1982). Preferred foraging and nesting habitats are wet areas dominated by willow and alder (Morse 1966). Hydrophytic shrubs are most often used for nesting and wetlands dominated by shrubs have been reported to have high breeding densities of Yellow Warblers (Bent 1953). Riparian forests are also used but breeding densities tend to be low (Von Velzen 1981).

TABLE 3-12

NET IMPACT OF SKAGIT RIVER PROJECT ON WILDLIFE HABITAT[1/]

Evaluation Species	Gorge Reservoir			Diablo Reservoir			Ross Reservoir		
	AAHUs Without Project	AAHUs With Project	Net[2/] Change	AAHUs Without Project	AAHUs With Project	Net[2/] Change	AAHUs Without Project	AAHUs With Project	Net[2/] Change
Yellow Warbler	26	16	- 7	15	17	2	3261	621	-2645
Pileated Woodpecker	22	15	- 7	557	282	-275	3416	783	-2633
Black-capped Chickadee	334	250	-84	831	406	-425	6303	2046	-4525
Marten	331	242	-89	977	486	-491	8537	2461	-6076
Ruffed Grouse	12	14	2	190	67	-123	1351	779	- 572
Mule Deer	179	125	-54	544	241	-303	8546	2603	-5943
Beaver	---	---	---	38	24	- 14	1121	200	- 921
American Dipper	15	4	-11	50	12	- 38	---	---	---
Red-tailed Hawk	35	38	- 3	62	36	- 26	840	330	- 510
Osprey	138	98	-40	341	184	-157	4007	1222	-2785

1/ Total net change in AAHUs was not calculated because the life-of-project (total years the project is licensed by FERC, including temporary extensions) was different for Gorge (69 yr), Diablo (60 yr), and Ross (51 yr) reservoirs.

2/ Prior differences between this table and individual species tables are due to rounding.

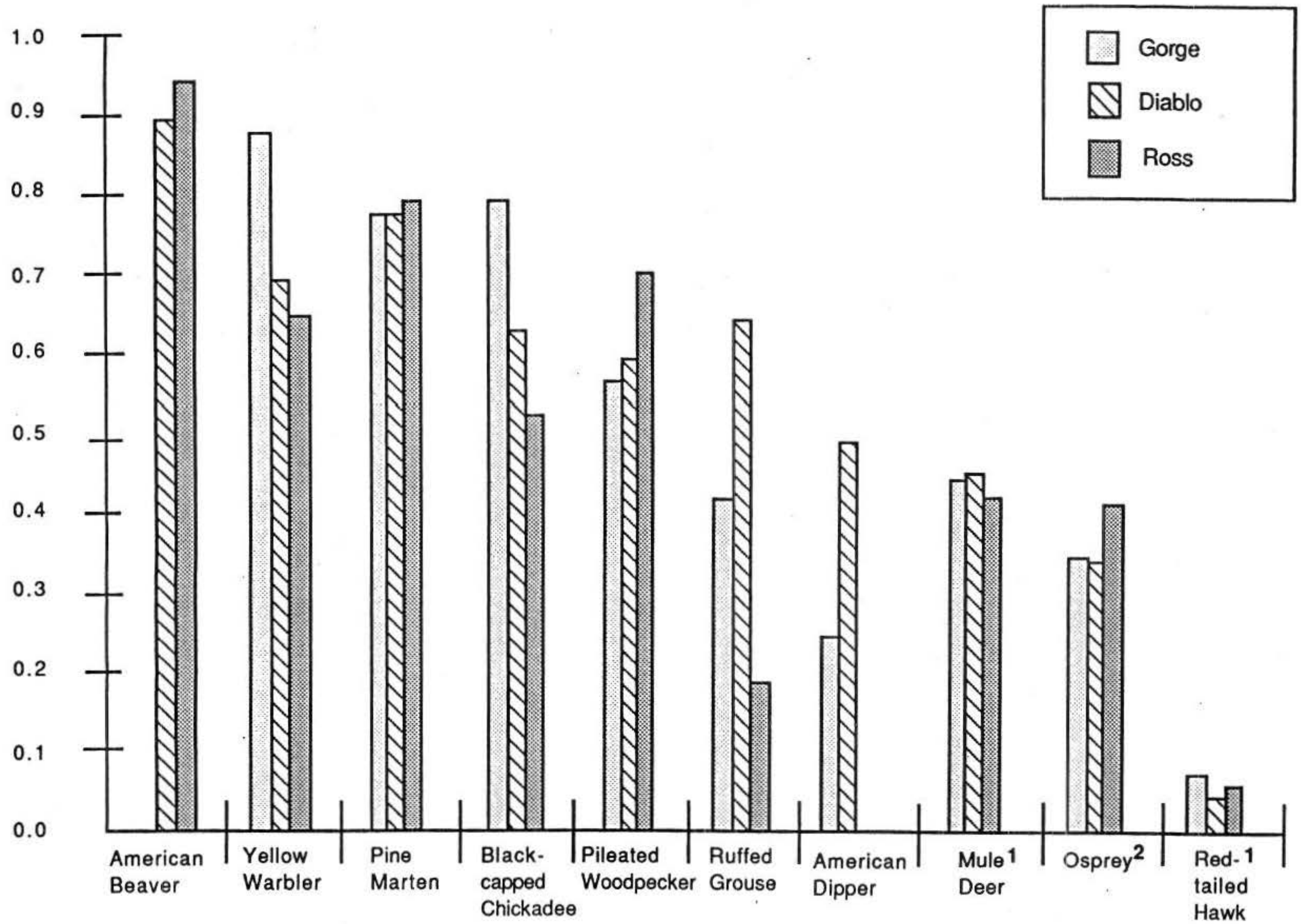


Figure 3-5. Habitat Quality in the Skagit Study Area for Pre-impoundment Conditions

1 forage HSI (cover HSI = 1.00)

2 reproduction HSI

The HEP team decided to evaluate all riparian and palustrine forest and shrub cover types as habitat for the Yellow Warbler. The Study Area provided moderate quality (HSI = 0.52 to 0.65) habitat for Yellow Warbler (Table 3-13). Habitat quality was highest at Gorge (HSI = 0.87 to 0.89), intermediate at Diablo (HSI = 0.64 to 0.69), and lowest at Ross (HSI = 0.51 to 0.65). Habitat quality was similar under "with-the-project" and "without-the-project" conditions for Diablo and Gorge but not for Ross. Habitat quality at Ross was highest under "without-the-project" conditions because of the larger amount of moderate quality Riparian Old Growth Conifer.

A total of 11 cover types on the Study Area provided Yellow Warbler habitat (Table 3-13). All 11 types were represented at Ross, 4 at Diablo, and 3 at Ross. Palustrine habitat quality was consistently higher than riparian habitat quality except for Riparian Closed Canopy Conifer Forest which was optimal at all three reservoirs. Habitat quality was low to moderate in the other riparian types. Palustrine habitat was only present in Ross. Shrub Swamp was the most important palustrine type because it provided large amounts of moderate quality habitat for the Yellow Warbler. The primary factor responsible for less than optimal Yellow Warbler habitat on the Study Area was a poorly developed hydrophytic shrub layer.

There was a net loss of 2,644 AAHUs for the Yellow Warbler in the Study Area (Table 3-13). This included losses of 7 AAHUs at Gorge, 2,639 AAHUs at Ross, and a gain of 2 AAHUs at Diablo. The net gain was due to an increase in riparian habitat adjacent to Thunder Arm at Diablo. The net losses were primarily due to the inundation of large portions of moderate to high quality riparian Old Growth and Closed Canopy Conifer forests.

3.3.2.2 Pileated Woodpecker

The Pileated Woodpecker was selected as an evaluation species because it represents cavity-nesting birds and denning mammals. It is one of the few species in the Study Area that requires snags, diseased trees, and dense

TABLE 3-13

SUMMARY OF HSI VALUES AND AAHUs FOR THE YELLOW WARBLER[1/]

Habitat Type	Without Project HSI	Without Project AAHUs	With Project HSI	With Project AAHUs	Net Change AAHUs
Riparian Old Growth Conifer Forest					
Gorge	0.66	7.28	0.66	4.05	- 3.23
Diablo	0.66	13.35	0.66	13.28	- 0.07
Ross	0.56	1723.04	0.35	340.69	- 1382.35
Riparian Closed Canopy Conifer Forest					
Gorge	1.00	16.56	1.00	13.21	- 3.35
Diablo	1.00	1.36	1.00	1.33	- 0.03
Ross	1.00	624.72	1.00	95.78	- 528.94
Riparian Open Canopy Conifer Forest[2/]					
Ross	0.52	8.35	0.52	0.58	- 7.77
Riparian Regenerative Conifer Forest[2/]					
Ross	0.52	4.00	0.52	0.64	- 3.36
Riparian Mixed Conifer/Broadleaf Forest					
Diablo	--	--	0.31	1.63	1.63
Ross	0.32	143.99	0.31	29.04	- 114.95
Riparian Broadleaf Forest					
Diablo	--	--	0.33	0.51	0.51
Ross	0.50	275.78	0.50	55.37	- 220.41
Riparian Shrub					
Gorge	0.52	1.71	0.52	1.53	- 0.18
Ross	0.52	112.81	0.28	16.38	- 96.43
Palustrine Conifer Forest[3/]					
Ross	0.69	26.04	0.69	5.03	- 21.01
Palustrine Mixed Forest					
Ross	0.69	30.93	0.69	6.97	- 23.96
Palustrine Broadleaf Forest					
Ross	0.81	26.36	0.81	11.97	- 14.39
Palustrine Shrub Swamp					
Ross	0.74	284.75	0.74	58.85	- 225.90
Average HSI/Total AAHUs					
Gorge	0.87	25.55	0.89	18.80	- 6.75
Diablo	0.69	14.71	0.64	16.75	2.04
Ross	0.65	3260.77	0.51	621.32	- 2639.45
Study Area	0.65		0.52		

1/ Reproductive life requisite.

2/ No current representative of this cover-type; applied values for Riparian Shrub.

3/ No current representatives of this cover-type; applied values for Palustrine Mixed Forest.

forest stands to meet all life requisites (Schroeder 1983a). Optimal habitat for the Pileated Woodpecker is mature, dense, productive forests, either coniferous or deciduous (Bock and Lepthien 1975). Pileated Woodpeckers forage on carpenter ants and other wood-boring insects (McClelland 1979; Bull 1981) in areas that contain high numbers of logs and snags and dense canopies (Bull and Meslow 1977). Preferred logs for foraging are greater than 0.3 m in length and 18 cm in diameter; preferred snags are greater than 51 cm dbh. Pileated Woodpeckers excavate their nest in large snags (Bull 1981).

The HEP team decided to include all riparian and upland forested habitats except Lodgepole Pine in the evaluation of the Pileated Woodpecker. The Study Area provided moderate quality (HSI = 0.50 to 0.69) habitat for Pileated Woodpecker (Table 3-14). Habitat quality was highest at Ross (HSI = 0.47 to 0.70), intermediate at Diablo (HSI = 0.57 to 0.59), and lowest at Gorge (HSI = 0.56 to 0.57). Habitat quality was comparable under "with-the-project" and "without-the-project" conditions at Diablo and Gorge but not at Ross. Habitat quality at Ross was highest under "without-the-project" conditions because of the larger amount of high quality Riparian Old Growth Conifer Forest.

Six cover types provided Pileated Woodpecker habitat in the Study Area (Table 3-14). All six of these types were represented at Ross and Diablo, and four at Gorge. Habitat quality was low to moderate (HSI = 0.02 to 0.68) for all types except Riparian Closed Canopy Conifer and Old Growth Conifer forest. Riparian Closed Canopy Conifer Forest provided optimal quality at all Reservoirs, while Old Growth Conifer Forest was high (HSI = 0.91) in quality only at Ross. Upland and riparian Broadleaf and Open Canopy Conifer forests had no value (HSI = 0.00) for Pileated Woodpeckers in the Study Area because large snags were absent from these types. The primary factors responsible for less than optimal Pileated Woodpecker habitat were small diameter snags or few snags.

TABLE 3-14

SUMMARY OF HSI VALUES AND AAHUs FOR THE PILEATED WOODPECKER[1/][2/]

Habitat Type	Without Project HSI	Without Project AAHUs	With Project HSI	With Project AAHUs	Net Change AAHUs
Old Growth Conifer Forest					
Diablo	0.36	36.05	0.36	34.97	- 1.08
Ross	0.91	879.98	0.91	302.41	- 577.57
Closed Canopy Conifer Forest					
Gorge	0.00	0.00	0.00	0.00	0.00
Diablo	0.61	509.48	0.61	232.59	- 276.89
Ross	0.02	75.82	0.02	27.87	- 47.95
Mixed Conifer/Broadleaf Forest					
Gorge	---	---	0.00	0.00	0.00
Diablo	---	---	0.68	3.41	3.41
Ross	0.23	0.67	0.23	3.85	3.18
Riparian Old Growth Conifer Forest					
Gorge	0.50	16.59	0.50	13.24	- 3.35
Diablo	0.50	10.13	0.50	10.08	- 0.05
Ross	0.54	1676.89	0.00	323.21	- 1353.68
Riparian Closed Canopy Conifer Forest					
Gorge	1.00	5.61	1.00	1.98	- 3.63
Diablo	1.00	1.39	1.00	1.34	- 0.05
Ross	1.00	624.72	1.00	95.78	- 528.94
Riparian Mixed Conifer/Broadleaf Forest					
Diablo	---	---	0.00	0.00	0.00
Ross	0.35	157.49	0.00	30.20	- 127.29
Average HSI/Total AAHUs					
Gorge	0.57	22.21	0.56	15.22	- 6.99
Diablo	0.59	557.02	0.57	282.38	- 274.64
Ross	0.70	3415.58	0.47	783.31	- 2632.28
Study Area	0.69		0.50		

1/ Reproduction/Food/Cover Life Requisites

2/ The following habitats were measured but not included in this table because each HSI = 0.00: Riparian and Upland Open Canopy Conifer and Riparian and Upland Broadleaf

There was a net loss of 2,921 AAHUs in the Study Area for Pileated Woodpecker (Table 3-14). This included losses of 7 AAHUs at Gorge, 282 at Diablo, and 2,632 at Ross. These losses primarily resulted from the inundation of large amounts of moderate to high quality, mature and old growth forests.

3.3.2.3 Black-capped Chickadee

The Black-capped Chickadee was chosen as an evaluation species because it represents birds that reproduce in small cavities and forage from the ground to the top of the forest canopy. Most of the year-round food supply for the Black-capped Chickadee is associated with trees. Optimum habitats are forests with 50 to 75 percent tree canopy closure and overstory trees at least 15 m tall (Schroeder 1983b). Black-capped Chickadees can only excavate cavities in soft, rotten wood, and their preferred nesting sites are snags between 10 and 25 cm (Schroeder 1983b).

The HEP team decided to evaluate all forested cover types as Black-capped Chickadee habitat. The Study Area provided moderate quality (HSI = 0.54 to 0.65) habitat for Black-capped Chickadee (Table 3-15). Habitat quality was highest at Gorge (HSI = 0.77 to 0.79), intermediate at Diablo (HSI = 0.63), and lowest at Ross (HSI = 0.53 to 0.65). Habitat quality was generally similar under "with-the-project" and "without-the-project" conditions for all three reservoirs.

A total of 18 cover types in the Study Area provided Black-capped Chickadee habitat (Table 3-15). All 18 of these types were present at Ross, 11 at Diablo, and 6 at Gorge. The HSIs for habitats at all three reservoirs varied from 0.00 to 1.00. Habitat quality was consistently high in 6 types, moderate in 1 type, low in 6 types, and variable in 5 types. Riparian Closed Canopy Conifer Forest was optimal quality while riparian and upland Mixed and Broadleaf forest types were high in quality. Riparian Old Growth Conifer and the Palustrine forest types were the

TABLE 3-15

SUMMARY OF HSI VALUES AND AAHUs FOR THE BLACK-CAPPED CHICKADEE[1/]

Habitat Type	Without Project HSI	Without Project AAHUs	With Project HSI	With Project AAHUs	Change AAHUs
Old Growth Conifer Forest					
Diablo	0.37[2/]	37.37	0.37[2/]	36.24	- 1.13
Ross	0.78[2/]	751.79	0.78[2/]	256.56	- 495.23
Closed Canopy Conifer Forest					
Gorge	0.78[3/]	283.14	0.78[3/]	202.59	- 80.55
Diablo	0.77[3/]	638.92	0.77[3/]	291.68	- 347.24
Ross	0.58[2/]	2586.96	0.58[2/]	950.97	- 1635.99
Open Canopy Conifer Forest					
Gorge	1.00	30.93	1.00	29.74	- 1.19
Diablo	0.28[2/]	14.66	0.28[2/]	8.17	- 6.49
Ross	0.58[3/]	359.64	0.58[3/]	132.14	- 227.50
Mixed Conifer/Broadleaf Forest					
Gorge	0.78[3/]	1.76	0.78[3/]	3.79	2.03
Diablo	---	---	0.80[3/]	4.03	4.03
Ross	0.92[3/]	2.67	0.92[3/]	15.26	12.59
Broadleaf Forest					
Diablo	0.81[3/]	29.94	0.81[3/]	7.38	- 22.56
Ross	0.86[2/]	3.92	0.86[2/]	13.13	9.21
Regenerative Conifer Forest					
Gorge	0.22[2/]	1.86	0.22[2/]	1.83	- 0.03
Diablo	0.22[2/]	9.47	0.22[2/]	3.70	- 5.77
Ross	0.22[2/]	99.42	0.22[2/]	145.52	46.10
Regenerative Mixed Forest					
Ross	0.53[2/]	0.57	0.53[2/]	5.04	4.47
Riparian Old Growth Conifer Forest					
Gorge	0.00[2/]	0.00	---	0.00	0.00
Diablo	0.00[2/]	0.00	0.00[2/]	0.00	0.00
Ross	0.16[2/]	492.30	0.00[2/]	97.00	- 395.30
Riparian Closed Canopy Conifer Forest					
Gorge	1.00	16.59	1.00	12.28	- 4.31
Diablo	1.00	1.37	1.00	1.34	- 0.03
Ross	1.00	624.72	1.00	95.49	- 529.23
Riparian Open Canopy Conifer Forest[4/]					
Ross	0.58[3/]	9.31	---	0.65	- 8.66
Riparian Mixed Broadleaf/Conifer Forest					
Diablo	---	---	1.00	1.53	1.53
Ross	0.95[3/]	429.28	0.95[3/]	86.51	- 342.77
Riparian Broadleaf Forest					
Diablo	---	---	0.78[3/]	3.81	3.81
Ross	0.84[3/]	461.66	---	92.69	- 368.97
Riparian Regenerative Conifer Forest[4/]					
Ross	0.22[2/]	1.69	0.22[2/]	0.27	- 1.42

TABLE 3-15 (continued)

SUMMARY OF HSI VALUES AND AAHUs FOR THE BLACK-CAPPED CHICKADEE[1/]

Habitat Type		Without Project		With Project		Change
		HSI	AAHUs	HSI	AAHUs	AAHUs
Palustrine Mixed Forest						
	Ross	0.13[2/]	5.83	0.13[2/]	1.31	- 4.52
Palustrine Broadleaf Forest						
	Ross	0.07[2/]	2.28	0.07[2/]	1.07	- 1.21
Palustrine Conifer Forest[4/]						
	Ross	0.13[2/]	4.91	0.13[2/]	0.95	- 3.96
Lodgepole Pine Forest						
	Diablo	0.39[2/]	98.93	0.39[2/]	32.68	- 66.25
	Ross	0.73[2/]	465.57	0.73[2/]	135.31	- 330.26
Forest Campground[5/]						
	Gorge	---	---	0.78	0.20	0.20
	Diablo	---	---	0.77	15.34	15.34
	Ross	---	---	0.58	15.81	15.81
Average HSI/Total AAHUs						
	Gorge	0.79	334.29	0.77	250.43	- 83.86
	Diablo	0.63	830.65	0.63	405.90	- 424.75
	Ross	0.53	6302.51	0.64	2045.68	- 4256.83
	Study Area	0.54		0.65		

1/ Different components of the same habitat are required to meet the food and reproduction requirements of the Black-capped Chickadee. These life requisites were analyzed seperately and the lowest (most limiting) is reported for each habitat.

2/ Reproduction HSI

3/ Food HSI

4/ No current representatives of this habitat-type; applied values for comparable upland type.

5/ Assigned HSI of Mature Closed Canopy Forest lowest in quality. The primary factor responsible for low quality Black-capped Chickadee habitat on the Study Area was a low number of suitable-sized snags for nesting.

There was a net loss of 5,034 AAHUs in the Study Area for the Black-capped Chickadee (Table 3-15). This included a loss of 84 AAHUs from Gorge, 425 AAHUs from Diablo, and 4,525 AAHUs from Ross. These losses were primarily due to inundation of the upland and riparian forest habitats by the reservoirs.

3.3.2.4 Marten

The Marten was chosen as an evaluation species because it represents carnivores dependent on small mammals that inhabit mature coniferous forests. The Marten consumes a wide variety of food items such as berries and invertebrates but voles are the single most important food (Koehler and Hornocker 1977; Soutiere 1979). Optimal habitat for Marten includes mature upland and riparian coniferous and mixed forests with at least 50 percent tree canopy closure (Koehler and Hornocker 1977; Allen 1982). Since Marten use decayed stumps, logs, and snags as winter cover sites, downfall is also an important component of Marten habitat (Clark and Campbell 1976).

The HEP team decided to evaluate all mature upland and riparian coniferous and mixed forests as Marten habitat (Table 3-16). The Study Area provided high quality (HSI = 0.78) habitat for Marten. Habitat quality was virtually the same at all three reservoirs (HSI = 0.77 to 0.79). In addition, habitat quality was similar under "with-the-project" and "without-the-project" conditions at each reservoir.

Nine forested cover types on the Study Area provided Marten habitat (Table 3-16). All nine types were represented at Ross, eight at Diablo, and five at Gorge. Habitat quality was consistently moderate to high (HSI = 0.57 to 1.00) in all types except in upland and riparian Open Canopy Conifer forests at Ross (HSI = 0.28 to 0.71). Habitat quality was particularly

TABLE 3-16

SUMMARY OF HSI VALUES AND AAHUs FOR THE MARTEN 1/

Habitat Type	Without Project HSI	Without Project AAHUs	With Project HSI	With Project AAHUs	Net Change AAHUs
Old Growth Conifer Forest					
Diablo	0.83	83.52	0.83	81.01	- 2.51
Ross	0.83	799.02	0.83	274.58	- 524.44
Closed Canopy Conifer Forest					
Gorge	0.78	283.50	0.78	202.85	- 80.65
Diablo	0.81	674.60	0.82	307.97	- 366.63
Ross	0.77	3447.80	0.77	1267.26	- 2180.54
Open Canopy Conifer Forest					
Gorge	0.71	22.02	0.71	21.18	- 0.84
Diablo	0.57	29.80	0.57	16.60	- 13.20
Ross	0.28	174.87	0.28	63.67	- 111.12
Mixed Conifer/Broadleaf Forest					
Gorge	0.67	2.97	0.67	3.25	0.28
Diablo	---	---	0.79	3.98	3.98
Ross	0.78	2.26	0.78	12.92	10.66
Lodgepole Pine Forest					
Diablo	0.67	169.96	0.67	56.14	- 113.82
Ross	0.64	406.26	0.64	120.66	- 285.60
Riparian Old Growth Conifer Forest					
Gorge	0.87	9.76	0.87	3.44	- 2.82
Diablo	0.87	17.62	0.87	17.53	- 0.09
Ross	0.90	2769.18	1.00	558.26	- 2210.92
Riparian Closed Canopy Conifer Forest					
Gorge	0.84	13.97	0.84	11.15	- 2.82
Diablo	0.84	1.15	0.84	1.13	- 0.02
Ross	0.84	526.01	0.84	80.65	- 445.36
Riparian Open Canopy Conifer Forest 2/					
Ross	0.28	4.49	0.28	0.31	- 4.18
Riparian Mixed Conifer/Broadleaf Forest					
Diablo	---	---	0.93	1.50	1.50
Ross	0.90	406.78	0.93	82.28	- 324.5
Average HSI/Total AAHUs					
Gorge	0.77	332.22	0.77	241.87	- 90.35
Diablo	0.77	976.64	0.79	485.85	- 490.79
Ross	0.79	8536.67	0.78	2460.59	- 6076.08
Study Area	0.78		0.78		

1/ Winter Cover Life Requisite

2/ No current representatives of this habitat-type; applied values for comparable upland type.

TABLE 3-17

SUMMARY OF HSI VALUES AND AAHUs FOR THE RUFFED GROUSE[1/], [2/]

Habitat Type	Without Project HSI	Without Project AAHUs	With Project HSI	With Project AAHUs	Net Change AAHUs
Closed Canopy Conifer Forest					
Gorge	0.00	0.00	0.00	0.00	0.00
Diablo	0.00	0.00	0.00	0.00	0.00
Ross	0.09	419.27	0.09	154.10	- 265.17
Broadleaf Forest					
Diablo	0.00	0.00	0.00	0.00	0.00
Ross	0.36	1.63	0.36	5.45	3.82
Lodgepole Pine Forest					
Diablo	0.61	154.23	0.61	50.94	- 103.29
Ross	0.07	42.09	0.07	12.50	- 29.59
Regenerative Conifer Forest					
Gorge	0.82	7.07	0.82	10.07	3.00
Diablo	0.82	35.30	0.82	13.79	- 21.51
Ross	0.82	378.26	0.82	500.52	122.26
Regenerative Mixed Broadleaf/Conifer Forest					
Ross	0.83	0.90	0.83	7.87	6.97
Shrubland					
Diablo	0.04	0.00	0.04	0.02	0.02
Ross	0.04	13.91	0.04	3.53	- 10.38
Riparian Closed Canopy Conifer Forest					
Gorge	0.16	2.61	0.16	2.08	- 0.53
Diablo	0.16	0.21	0.16	0.21	0.00
Ross	0.16	98.08	0.16	15.04	- 83.04
Riparian Mixed Conifer/Broadleaf Forest					
Diablo	---	---	1.00	1.62	1.62
Ross	0.65	292.49	1.00	60.71	- 231.78
Riparian Regenerative Conifer Forest[3/]					
Ross	0.82	6.31	0.82	1.02	- 5.29
Riparian Shrubland					
Gorge	0.64	2.09	0.64	1.87	- 0.22
Ross	0.45	97.63	0.97	18.72	- 78.91
Average HSI/Total AAHUs					
Gorge	0.42	11.77	0.50	14.02	2.24
Diablo	0.64	189.74	0.64	66.58	- 123.16
Ross	0.18	1350.56	0.30	779.46	- 571.10
Study Area	0.20		0.30		

1/ Fall to Spring Cover

2/ The following habitat types were measured but not included in this table because each HSI = 0.00: Old Growth Conifer, Open Canopy Conifer, Mixed Conifer/Broadleaf, Riparian Old Growth Conifer, Riparian Open Canopy Conifer, and Riparian Broadleaf forests.

3/ No current representatives of this habitat-type; applied HSIs from comparable upland type.

= 0.18 to 0.30). Habitat quality was similar under "with-the-project" and "without-the-project" conditions for Diablo and Gorge but not for Ross. Habitat quality was highest for Ross under "with-the-project" conditions because of the reduced amount of low quality upland and riparian Closed Canopy Conifer.

Ten cover types on the Study Area were available as Ruffed Grouse habitat (Table 3-17). All ten of these types were represented at Ross, seven at Diablo, and four at Gorge. Habitat quality was consistently high (HSI = 0.82 to 1.00) in three types, low (HSI = 0.00 to 0.16) in four types, and variable (HSI = 0.07 to 0.61) in three types. The riparian and upland Regenerative forests and the Riparian Mixed type had the highest habitat quality values. Lodgepole Pine quality was the most variable among the reservoirs. The lowest habitat quality was in the older-aged types where stem density was low.

There was a net loss of 638 AAHUs in the Study Area for Ruffed Grouse (Table 3-17). This included losses of 67 AAHUs from Diablo, 571 AAHUs from Ross, and a gain of 2 AAHUs at Gorge. These losses were primarily due to inundation of forest habitats by the reservoirs.

3.3.2.6 Mule Deer

The Deer was selected as an evaluation species because it represents mammals that are multi-cover users, and it is an important game species in the Study Area. The Deer in the Study Area are an intergrade mix of Mule Deer and Black-tailed Deer. The Mule Deer model was selected to evaluate all deer on the Study Area, since it best reflected the habitats and conditions of the Upper Skagit. Mule Deer feed on a variety of vegetation but, in general, browse is preferred and consumed more than forbs or grasses. Mule Deer require three kinds of cover: forage, hiding, and thermal. Stands of conifer or dense evergreen shrubs 244 to 490 m across provide optimal cover for Mule Deer (Thomas et al. 1976). The interspersion of forage and cover areas affects the quality of Mule Deer wintering habitat as does the road density and the average depth of snow. Optimal Deer winter range is assumed to be 60 percent forage and 40 percent cover (USFWS 1982).

The HEP team decided to include all terrestrial cover types except the palustrine, rock, developed, and aquatic types for evaluating Deer use of the Study Area. Because Deer use different cover types to fulfill their food and cover requirements, the proportion of the area meeting each of these life requisites is important. The area of each cover type available to Deer is used to weight the HSIs and each reservoir is evaluated as a single unit. In addition, the HEP team agreed that slope influenced Deer use of an area. The team decided that slopes greater than 80 percent had no value as forage or cover habitat, and slopes between 40 and 70 percent had a forage value half that of lower slopes (see Appendix F). These modifications to the model were derived from a study in Oregon that found Deer differentially use various slopes (Ganskopp and Vavra 1987). The HEP team also decided that the low density of roads in the Study Area and the generally low snow cover would have no significant influence on Deer habitat quality.

The Study Area provided optimal quality cover habitat and moderate quality (HSI = 0.47 to 0.59) forage habitat for the Mule Deer (Table 3-18). Cover habitat quality was optimal at all three reservoirs. Forage habitat quality was variable at Ross (HSI = 0.47 to 0.67) and virtually identical at Diablo and Gorge (HSI = 0.47 to 0.49). Cover habitat quality was optimal under both "with-the-project" and "without-the-project" conditions at all reservoirs. Forage habitat quality was comparable under "with-the-project" and "without-the-project" conditions for Diablo and Gorge but not for Ross. Forage habitat quality at Ross was higher under "without-project" conditions because of a larger amount of cover types that individually provided high quality forage.

A total of 20 cover types on the Study Area provided forage habitat for the Mule Deer and 18 of these also provided cover habitat (Appendix F). A total of 19 cover types were represented at Ross, 13 at Diablo, and 9 at

TABLE 3-18

SUMMARY OF HSI VALUES AND AAHUs FOR THE MULE DEER

Habitat Type	Without Project HSI	Without Project AAHUs	With Project HSI	With Project AAHUs	Net Change AAHUs
Forage 1/					
Gorge	0.44	178.76	0.49	125.33	- 53.43
Diablo	0.45	544.58	0.47	241.26	- 303.32
Ross	0.67	8546.13	0.47	2602.66	- 5943.47
Study Area	0.59		0.47		
Cover 1/					
Gorge	1.00	419.41	1.00	290.80	- 128.61
Diablo	1.00	1187.56	1.00	497.24	- 690.33
Ross	1.00	12386.99	1.00	4056.85	- 8330.14
Study Area	1.00		1.00		

1/ Because habitat quality for forage was more limiting (lower HSI) than it was for cover in the Study Area, the AAHUs for the food life requisite were used in this study to evaluate the impact of the Project on Deer.

Gorge. The types providing the highest and lowest quality habitat for Mule Deer cover were the same for all three reservoirs. Optimal cover habitat was provided by all upland and riparian coniferous and mixed forest types with closed canopies. Nonforested types had the lowest quality (HSI = 0.33 to 0.51) cover habitat. The quantity of Mule Deer cover habitat available at all three reservoirs was greater than the optimal 40 percent.

The types providing the highest and lowest quality forage habitat varied between reservoirs. The HSIs of forage habitat at Ross ranged from 0.21 to 0.96. Shrublands had the highest forage quality and Old Growth Conifer Forests had the lowest. The HSIs of forage habitat at Diablo ranged from 0.05 to 0.70. Riparian Old Growth Conifer Forests had the highest forage quality and Open Canopy Conifer Forests had the lowest. At Gorge the HSIs for forage habitat ranged from 0.28 to 0.70. Riparian Old Growth Conifer had the highest forage quality and Closed Canopy Conifer had the lowest. The quantity of forest habitat available for Mule Deer at all three reservoirs was greater than the optimal 60 percent, since many habitat types provided both forage and cover. In general, forage habitat quality throughout the Study Area was limited by the quantity of shrubs palatable to Deer.

Since forage habitat quality was more limiting (lower HSI) in the Study Area than was cover habitat quality, the AAHUs for the food life requisite were used to evaluate the impact of the project on Deer. There was a net loss of 6,299 AAHUs in the Study Area for Deer that included losses of 53 AAHUs from Gorge, 303 AAHUs from Diablo, and 5,943 AAHUs from Ross (Table 3-18). These losses resulted primarily from the large reduction of acreage in the Study Area due to flooding by the reservoirs.

3.3.2.7 Beaver

The Beaver was chosen as an evaluation species because it serves as an indicator of the losses in riverine, riparian, and palustrine habitats that occur when a free-flowing river in a broad, flat valley is replaced

Table 3-19

SUMMARY OF HSI VALUES AND AAHUs FOR THE BEAVER[1/]

Habitat Type	Without Project HSI	Without Project AAHUs	With Project HSI	With Project AAHUs	Net Change AAHUs
Wet Meadow/Marsh	0.87	6.17	0.87	1.19	- 4.98
Palustrine Shrubland	0.96	369.40	0.93	76.28	- 293.12
Palustrine Broadleaf Forest	0.96	31.24	0.83	13.11	18.13
Palustrine Mixed Forest	0.96	43.03	0.96	9.70	- 33.33
Palustrine Conifer Forest[2/]	0.96	36.24	0.96	7.00	- 29.24
Pond	0.93	50.17	0.93	7.48	- 42.69
Riverine					
Ross	0.93	584.65	0.89	84.94	- 499.71
Diablo	0.89	38.35	0.90	23.62	- 14.73
Average HSI/Total AAHUs					
Diablo	0.89	38.35	0.90	23.62	- 14.73
Ross	0.94	1120.90	0.91	199.71	- 921.19
Study Area	0.94		0.91		

1/ Food Life Requisite

2/ No current representative of this habitat type; applied values for Palustrine Mixed Forest

TABLE 3-20

SUMMARY OF HSI VALUES AND AAHUs FOR THE AMERICAN DIPPER[1/]

Habitat Type	Without Project HSI	Without Project AAHUs	With Project[2/] HSI	With Project[2/] AAHUs	Net Change AAHUs
Riverine, < 1% Gradient					
Gorge	0.10	4.34	0.10	1.57	- 2.77
Diablo	0.10	2.43	0.10	0.08	- 2.35
Riverine, 1-6% Gradient					
Gorge	0.60	10.61	0.60	2.13	- 8.48
Diablo	0.60	47.23	0.60	12.23	- 35.00
Average HSI/Total AAHUs					
Gorge	0.24	14.96	0.19	3.70	- 11.25
Diablo	0.48	49.66	0.43	12.31	- 37.35
Study Area	0.48		0.43		

1/ Food Life Requisite

2/ HSIs were only for tributaries

Because foraging habitat was more limiting at Gorge and Diablo than was reproductive habitat, the AAHUs for the food life requisite were used to evaluate the impact of the project on the American Dipper. There was a net loss of 48 AAHUs for the Dipper in the Study Area which included losses of 11 AAHUs from Gorge and 37 AAHUs from Diablo (Table 3-20). These losses were the result of the conversion of Riverine habitat to reservoirs that are too deep and slow moving to provide forage habitat for the American Dipper.

3.3.2.9 Red-tailed Hawk

The Red-tailed Hawk was chosen as an evaluation species because it represents avian predators that feed on small mammals. The Red-tailed Hawk requires a mosaic of forested and nonforested habitats to meet its life requisites (USFWS 1980d). Optimal feeding habitats are open areas with at least a moderate cover of relatively low (8 to 46 cm) herbaceous vegetation and a few tall perch trees (Schnell 1968; Craighead and Craighead 1956). Preferred nest sites are trees greater than 51 cm dbh. (Belyea 1976). For an area to provide optimal Red-tailed Hawk habitat, at least 70 percent should provide feeding habitat and 15 percent nesting habitat.

The HEP team decided to evaluate all open areas, including Open Canopy Conifer Forests, as feeding habitat for the Red-tailed Hawk. All mature forest types were evaluated as nesting habitat. However, because the Red-tailed Hawk uses different cover types to fulfill its life requisites, the proportion of the area meeting each life requisite is important. Therefore, the area of each cover type available to the Red-tailed Hawk was used to weight the HSIs. Each reservoir was evaluated as a single unit.

The Study Area provided optimal quality nesting habitat and low quality (HSI = 0.06) feeding habitat for the Red-tailed Hawk at all three reservoirs (Table 3-21). Feeding habitat was comparable under "with-the-project" and "without-the-project" conditions for Ross and Diablo but not for Gorge. Feeding habitat quality at Gorge was slightly greater under "with-the-project" conditions because of a larger proportion of high quality Exposed Rock and Rock Talus.

A total of 10 cover types on the Study Area provided nesting habitat for the Red-tailed Hawk and 8 cover types provided feeding habitat (Appendix F). Only two habitats, upland and riparian Open Canopy Conifer forests, met both life requisites. A total of 16 cover types were represented at Ross, 12 at Diablo, and 8 at Gorge. The HSIs of nesting habitat quality ranged from 0.35 to 1.00 at Ross and 0.66 to 1.00 at Diablo. At both of these reservoirs upland and riparian Old Growth Conifer and Closed Conifer forests consistently provided optimal nesting quality. Riparian Mixed Forests had the lowest quality at Ross and Open Canopy Conifer Forests had the lowest quality at Diablo. At Gorge the HSIs of nesting habitat quality ranged from 0.00 to 1.00. Optimal habitat was provided by riparian and upland Closed Canopy Conifer forests as well as Riparian Old Growth Conifer Forests. Open Canopy Conifer Forests had an HSI of 0.00.

At Ross optimal feeding habitat for the Red-tailed Hawk was provided by Grasslands and Agriculture. Palustrine Marsh had the lowest quality (Appendix F). Rock Talus and Exposed Rock had the highest quality (HSI = 0.75) and Open Canopy Conifer Forests had the lowest (HSI = 0.49 to 0.58) at Gorge and Diablo. Although the quality of the individual cover types available to the Red-tailed Hawk for feeding was high, these types represented only 5 to 8 percent of the Study Area. The primary factor responsible for the low quality of Red-tailed Hawk feeding habitat was the low amount of area.

Because food habitat quality was more limiting on the Study Area than was reproductive habitat quality, the AAHUs for the food life requisite were used to evaluate the impact of the project on the Red-tailed Hawk. There was a net loss of 532 AAHUs for the Red-tailed Hawk in the Study Area, which included a loss of 26 AAHUs from Diablo, 510 AAHUs from Ross, and a gain of 4 AAHUs at Gorge (Table 3-21). These losses resulted primarily from the reduction in the amount of nonforested habitat in the Study Area due to flooding.

TABLE 3-21

SUMMARY OF HSI VALUES AND AAHUs FOR THE RED-TAILED HAWK

Habitat Type	Without Project HSI	Without Project AAHUs	With Project HSI	With Project AAHUs	Net Change AAHUs
Feeding 1/					
Gorge	0.07	34.91	0.24	38.47	3.57
Diablo	0.04	61.57	0.10	35.74	- 25.83
Ross	0.06	840.21	0.06	330.26	- 509.95
Study Area	0.06		0.06		
Reproduction 1/					
Gorge	1.00	435.75	1.00	328.94	- 106.81
Diablo	1.00	1051.65	1.00	558.59	- 493.06
Ross	1.00	11190.46	1.00	3266.33	- 7924.13
Study Area	1.00		1.00		

1/ Because habitat quality for food was more limiting (lower HSI) than it was for reproduction, the AAHUs for the food life requisite were used to evaluate the impact of the Project on the Red-tailed Hawk.

3.3.2.10 Osprey

The Osprey was chosen as an evaluation species because it represents avian predators that feed on fish. The Osprey requires forested habitat adjacent to clear open water to meet its life requisites. Optimal feeding habitats are lakes and rivers with clear water and shorelines with at least six trees per kilometer suitable for perching in close proximity to the water (USFWS 1984). Trees suitable for perching are snags, dead topped trees, or open crowned trees that allow easy access for take-off and landing (Airola 1983). Preferred nesting sites are large broken or flat-topped trees or snags within 76 m of water (Shimanoto and Airola 1981).

The HEP team decided to evaluate all Riverine and Lacustrine (reservoir) areas as feeding habitat for the Osprey. All mature coniferous forest were evaluated as nesting habitat. However, because the Osprey uses different habitats to meet its life requisite, the proportion of the area meeting each life requisite is important. Therefore, the area of each cover type available to Osprey was used to weight the HSI and each reservoir was evaluated as a single unit. The Study Area provided high quality (HSI = 0.84 to 0.92) feeding habitat and moderate quality (HSI = 0.40) nesting habitat for the Osprey (Table 3-22). Feeding habitat was highest at Ross and Diablo (HSI = 0.85 to 0.96) and lowest at Gorge (HSI = 0.20 to 0.29). Nesting habitat was highest at Ross (HSI = 0.41) and low at both Gorge and Diablo (HSI = 0.22 to 0.36). Feeding and nesting habitat was similar under "with-the-project" and "without-the-project" conditions at all three reservoirs.

Feeding habitat for the Osprey consists of waterbodies (rivers or reservoirs) and adjacent cover types within 60 m of the shoreline. The riverine, lacustrine, and six adjacent forest types on the Study Area provided feeding habitat for the Osprey (Appendix F). All six forest types were represented at Ross, five at Diablo, and two at Gorge. At Ross and Diablo, the Lacustrine and Riverine areas in conjunction with all the shoreline cover types consistently provided high quality (HSI = 0.82 to 1.00) feeding habitat for the Osprey. At Gorge, however, habitat quality was variable (HSI = 0.20 to 0.94). Shorelines with Open Canopy Conifer Forests had optimal quality and shorelines with Closed

Canopy Conifer Forests had low quality. The primary factor responsible for low quality Osprey feeding habitat on the Study Area was lack of large trees suitable for perching within 60 m of the shoreline.

Six cover types on the Study Area provided nesting habitat for the Osprey (Appendix F). All six were represented at Ross and the HSIs ranged from 0.37 to 0.91. Upland and riparian Open Canopy Conifer forests had the highest quality and upland and riparian Old Growth Conifer forests had the lowest. Six cover types at Diablo provided Osprey nesting habitat and the HSIs ranged from 0.30 to 0.90. Open Canopy Conifer Forests had the highest quality and upland and riparian Closed Canopy forests had the lowest. Only four cover types on Gorge provided nesting habitat for the Osprey and the HSIs ranged from 0.00 to 0.37. Riparian Old Growth Conifer Forests had the highest quality while Open Canopy Conifer Forests always had an HSI of 0.00. The primary factor responsible for low quality Osprey nesting habitat in the Study Area was the lack of an adequate number of large trees or snags suitable for nesting.

Because reproductive habitat quality was more limiting on the Study Area than was feeding habitat quality, the AAHUs for the reproduction life requisite were used to evaluate the impact of the project on the Osprey. The net loss of Osprey nesting habitat on the Study Area was 2,982 AAHUs (Table 3-22). This loss included 40 AAHUs at Gorge, 157 AAHUs at Diablo, and 2,785 AAHUs at Ross. These losses were the result of the inundation of a large amount of mature conifer forest habitat by the project.

3.3.3 Wildlife Species of Special Concern

3.3.3.1 Threatened or Endangered Species

Three species potentially inhabit the Study Area that are listed by the federal government as threatened or endangered in Washington: peregrine falcon, grizzly bear, and bald eagle. These species are discussed below, but they were not incorporated into the HEP analysis because the USFWS recommends that threatened or endangered species be treated separately from the HEP.

The peregrine falcon is the only federally-listed endangered species in Washington State. There have been no peregrine falcon sightings recently reported in the North Cascades National Park (Bjorklund 1987a). Two peregrine falcon sightings were, however, confirmed near the town of Marblemount in 1981-1982, which is approximately 18 miles west of Gorge Reservoir. One active peregrine nest was reported in the vicinity of Ross Reservoir by WDW employee Fred Doppler in 1976-77. The paucity of information for this species in the Study Area did not allow an evaluation of project impacts to be reliably made.

The grizzly bear is a threatened species in Washington. The last confirmed sighting of a grizzly bear in the North Cascade National Park was in 1964, when a carcass was found in Fisher Basin. Fisher Basin drains into Thunder Arm which is a tributary of Diablo Reservoir. Approximately 20 to 30 unconfirmed sightings of grizzly bears have been reported since 1964 but their reliability is uncertain (Bjorklund 1987b). Little information exists for grizzly bear habitat requirements and population demographics in the North Cascades (Almack 1986); therefore, effects of the project on bear habitat or population could not be estimated.

The bald eagle is also a threatened species in Washington. A small proportion of the estimated 300 eagles which winter along the Skagit River inhabit the Study Area. Eagles occur along the river from November through April, when they feed on seasonally abundant stocks of salmon, particularly chum salmon. The eagles do not nest along the river, since most of the population summers in Alaska.

In the case of the bald eagle, as for the two species above, there are no data available in the Study Area before the dams were constructed to provide a basis for assessing impacts. It is, however, unlikely that the hydroelectric projects significantly impacted (i.e., reduced the viability of the regional population) the bald eagle, since few salmon probably passed above the site of Gorge Dam before construction (see Section 4.0). The steep gradient of the river at this site greatly reduced the capacity of salmon to inhabit the Upper Skagit River and, therefore, support a bald eagle population similar to that found below Gorge Dam.

3.3.3.2 Osprey

The Osprey is the only other species of special concern addressed in this report. An estimated 260 to 290 pairs of Osprey summer in Washington State. Approximately 58 percent occur in western Washington where they nest along lakes, reservoirs, Puget Sound islands, and some rivers. The number of Osprey pairs recently nesting in the Study Area ranges from four (1986) to eight (1987). All of the nests occurred on Ross Lake, although at least one nest is known to be outside the Study Area on the Thunder Arm tributary of Diablo Lake.

Osprey production in the Study Area is close to that reported for northwestern Washington. Production in the Study Area was estimated by North Cascade NPS personnel (Bjorklund 1987a) to be 0.5 young per active nest in 1986 and 1987. This compares to 0.8 young per nest that was reported for 22 active nests surveyed by WDW in Region IV (i.e., the region overlapping the Study Area) during 1985. Osprey use of the Study Area before construction of the dams is not known.

3.4 DISCUSSION

3.4.1 Project Impacts to Unusual Plant Communities and Species

The upper Skagit Valley, especially in the Ross Lake area, has a unique set of geographic and topographic features that affect the vegetation. The lower valley is west of the Cascade Range crest and the vegetation is typical of the Western Hemlock Zone (Franklin and Dyrness 1973) for western Washington. The upper valley is in a rain shadow of the Pickett Range and several Cascade peaks that lie to the west, and the vegetation is characteristic of vegetation of the eastern Cascade Range. Consequently, these plant communities are unusual because they include elements of both east and west Cascades vegetation.

The Study Area contained a complex of habitats that would be unique today. A mosaic of riparian, wetland, and upland habitats originally formed the valley bottom. Old growth cedar, Douglas fir, and western hemlock dominated the forested components of these habitats. This diversity of habitats and age structure are seldom found today, except where protected by the NPS or other federal service organizations. If the Skagit Hydroelectric Project had not been authorized for construction, Ross Basin probably would have been part of the area designated a "Primitive Area" by the federal Government in 1935. This designation would have protected Ross Basin from development and preserved the area's ecological character.

Within the original complex of habitats there were several particularly unusual plant communities. One was located in an area known as the "Little Sahara." It was dominated by shrubs (described in Section 3.3.1.2), and its dry appearance was unmatched in the valley. No similar areas exist today in the Study Area. Other unusual plant communities in the study area were wetlands. There were seven types of wetlands representing a wide range of successional stages. These wetlands may also have contained species with east-Cascade affinities. For example, a genetic variety of bur-reed has been found in Big Beaver Valley wetlands that is otherwise found only east of the Cascades (Vanbianchi and Wagstaff, in press).

The Skagit Project dams, especially Ross Dam, impacted a unique complex of communities. These communities included some unusual combinations of plant species, and some rare species; but, as far as is known, no species now recognized as threatened or endangered would have been expected. Because of the isolation of the area until the inundation by the dams and the eventual protection of the area within the National Park System, there are still remnants of some unusual plant communities. However, the majority of the unusual communities are gone.

3.4.2 Project Impacts on Wildlife

The major impact of the Skagit River Hydroelectric Project on wildlife was the loss of habitat. Prior to construction of the Skagit Hydroelectric Project, habitat in the Study Area was 56 percent upland forest, 30 percent riparian, 5 percent riverine, 4 percent nonforested, 4 percent wetland, and less than 1 percent developed. The project inundated approximately 12,400 acres which included most of the riverine, riparian, and wetland habitats in the upper Skagit Basin.

The loss of upland and riparian forests in the Study Area impacted the Pileated Woodpecker, Black-capped Chickadee, Mule Deer, Marten, Ruffed Grouse, and Osprey. Old Growth Conifer Forests are important to these species, particularly the Pileated Woodpecker. This species depends heavily on large diameter trees and snags in mature and Old Growth Conifer Forests to complete its life cycle. The quantity of this habitat type was substantially reduced by the project. The project flooded over 93 percent of the original 4,164 acres of Old Growth Conifer Forest in the Study Area, leaving only relatively small patches. There were 7 AAHUs of Pileated Woodpecker habitat lost from Gorge, 275 AAHUs from Diablo, and 2,633 AAHUs from Ross.

Closed Canopy Conifer Forests were utilized by all six of the forest species, particularly the Marten. This species requires a dense tree canopy for cover and depends on the small mammals in this habitat for food. The project did not impact the quality of this habitat for Marten, but it did substantially reduce the quantity. Over 64 percent of the Closed Canopy Conifer Forest, coupled with a high loss of other mature forest types, resulted in a reduction of 89 AAHUs of Marten habitat from Gorge, 491 AAHUs from Diablo, and 6,075 AAHUs from Ross.

Open Canopy Conifer Forests were available to all six of the forest species but its value was marginal except for the Osprey. Osprey used this habitat for nesting and for perching along the shores of Diablo and Ross reservoirs. The reduction of Open Canopy Conifer Forest as well as the losses in other mature conifer forest types resulted in a loss of 40 AAHUs from Gorge, 157 AAHUs from Diablo, and 2,785 AAHUs from Ross.

Broadleaf and Mixed forests were also used by the six forest species but these cover types provided particularly high quality habitat for the Black-capped Chickadee. This species requires tall trees and a moderately dense tree canopy for cover, and relatively small snags for reproduction. The small amount of

Broadleaf Forest decreased only slightly by the project and the small amount of Mixed Forest actually increased. Nonetheless, the loss of other forest types resulted in a reduction of 84 AAHUs of Black-capped Chickadee habitat from Gorge, 425 from Diablo, and 4,525 from Ross.

Regenerative Conifer and Regenerative Mixed forests on the Study Area were only used by three of the forest species. These cover types provided only low quality habitat for the Black-capped Chickadee but were particularly important to the Ruffed Grouse and Deer. The high stem density characteristic of regenerative forests resulted in some of the best quality habitat available on the Study Area for Ruffed Grouse. The reduction in acreage of regenerative forests resulted in a net loss of 123 AAHUs of Ruffed Grouse habitat from Diablo and 572 AAHUs from Ross. The Ruffed Grouse gained 2 AAHUs at Gorge.

The Shrublands in the Study Area were primarily used by Deer. This cover type had a dense canopy of shrubs palatable to Deer, which provided some of the best quality forage habitat on the Study Area. The high losses of Shrublands combined with the reduction of Regenerative Conifer and Mixed forests and Riparian Old Growth Conifer contributed to the net loss of 53 AAHUs of Deer habitat from Gorge, 303 AAHUs from Diablo, and 5,943 AAHUs from Ross.

The nonforested terrestrial cover types on the Study Area (Rock Talus, Exposed Rock, Grasslands, and Agriculture) were used primarily by the Red-tailed Hawk as foraging habitat. The amount of this habitat available on the Study Area was relatively small under pre- and post-impoundment conditions. Nonetheless, the reduction in nonforested cover types as well as Open Canopy Conifer and Shrublands resulted in a net loss of 3 AAHUs of Red-tailed Hawk forage habitat from Gorge, 26 AAHUs from Diablo, and 510 AAHUs from Ross.

Wildlife impacted by the loss of Riverine habitat, associated wetlands, and riparian types were the Yellow Warbler, Beaver, and American Dipper. The Riverine habitat was represented almost entirely by the Skagit River and was important habitat for the Beaver and American Dipper. In the area now occupied by Ross Reservoir, the gradient of the river and the characteristics of the adjacent cover types provided nearly optimal Beaver habitat quality but poor

American Dipper habitat quality. The Riverine habitat at Gorge and Diablo provided moderate quality feeding habitat for the American Dipper but poor Beaver habitat quality. The loss of nearly all Riverine habitat in the Study Area coupled with the inundation of most of the wetlands resulted in net losses of 921 AAHUs of Beaver habitat from Ross and 14 AAHUs from Diablo. American Dipper habitat was reduced by 38 AAHUs from Diablo and 11 AAHUs from Gorge.

The Yellow Warbler predominantly used the riparian and palustrine forest and shrub cover types. With the exception of Riparian Closed Canopy Conifer Forests, the palustrine cover types on the Study Area provided higher quality habitat for the Yellow Warbler than did the riparian types. Habitat quality was generally limited by the lack of a well-developed hydrophytic shrub layer. The large reduction in the amount of riparian area and the virtual elimination of palustrine cover types on the Study Area resulted in a loss of 10 AAHUs of Yellow Warbler habitat from Gorge and 2,640 AAHUs from Ross. The project actually increased the riparian area at Thunder Arm on Diablo which resulted in a gain of 2 AAHUs for the Yellow Warbler.

In summary, the project area originally provided relatively high quality habitat for six of the species we evaluated and their associated guilds. The quality was derived from a diversity of habitats having well developed and complex structures. The development of the reservoirs substantially reduced the diversity and area of habitat. This change represented the most significant impact to the wildlife habitat.

4.0
FISHERIES STUDIES

4.0 FISHERIES STUDIES

4.1 HISTORICAL ANADROMOUS AND RESIDENT FISH INFORMATION

4.1.1 Introduction

The purpose of this section is to summarize historical information describing: 1) potential barriers to the migration of anadromous salmonids and 2) the species composition of resident fish in the Upper Skagit River system prior to construction of the Skagit Hydroelectric Project. The Upper Skagit River is defined as the basin area located upstream of the Cascade River up to the United States/Canadian border.

4.1.2 Methods

All historical information covering the Upper Skagit River area that could be located in published and unpublished documents was reviewed for this report. This included the following:

- History books
- Historical resource analyses
- Historical biological surveys
- Miscellaneous papers and records
- News articles
- Transcribed and untranscribed interviews
- Personal interviews
- Archived agency material (i.e., correspondence, records, notes, sketches, and maps)
- Archived personal papers
- Historical Indian tribal information
- Maps

Repositories and other locations searched included the following:

- The Washington State Library, Washington Department of Fisheries, and Washington State Archives in Olympia

- Federal Archives and Records Center, and U.S.F.S. files in Seattle
- University of Washington libraries (Map Room, Manuscripts, Government Publications, Pacific Northwest Collection, Science Reading Room, Fish and Ocean Sciences, Forestry), and University of Washington Fisheries Research Institute Publications
- NPS at Sedro Woolley
- The Skagit Tribes Cooperative
- The Upper Skagit Tribes.

In the following sections the most relevant and informative historical accounts on fish passage are presented first. Important correspondence and other records describing state/federal agency and Seattle City Light interpretations of anadromous fish impacts, Seattle City Light's responsibilities for mitigation, and politics of the time are given second. The latter papers are critical to understanding the assumptions and actions of that time and are discussed in chronological order. Our interpretation of the historical records concerning anadromous fish passage and further clarification of some confusing accounts are provided in the summary. Also, a narrative of resident fish (trout) occurrence and a complete annotated bibliography are provided.

Excerpts from references inside quotation marks are exact quotes, including the spelling even though the spelling may be different than what is customary today; the (sic) notation applied by historians is not used here. Square brackets [like this] contain explanations and interpretations that are not a part of the quote.

4.1.3 Results and Discussion

4.1.3.1 Anadromous Fish

Historical Accounts

The earliest account that provides an accurate description of potential barriers to anadromous fish on the Upper Skagit River comes from Henry Custer's journal (from the 1859 boundary survey of the 49th parallel;

Custer 1866). While negotiating the Upper Skagit River in a canoe, Custer noted that the Skagit took on the character of a canyon below Big Beaver Creek near the Ruby Creek confluence, ..."we rapidly enter the beginning of a canon...The river flows here between rocky banks, with a swiftness & impetuosity which even makes my expert Indian canoe men feel more or less uncomfortable." Downstream of the Ruby Creek confluence, apparently in the vicinity of the Rip Raps, the party beached the canoe and climbed the rock river bank to investigate downstream and Custer wrote, ..."within a distance of only 100 yards from our harbor, we found the River forming a small perpendicular fall of some 12-15 feet which, if we had dashed over it, would have engulfed the whole party and sent us inevitably to our last accounts...We found that we were only a few hundred steps from the east fork [Ruby Creek]...It joins the Skagit by breaking through a high rocky ledge..." Exploring the immediate area on foot, Custer described Ruby Creek from the top of a canyon about 150 feet above the water, "...in the dissy chasm below where the waters were dashing and roring in their onward cours."

An early USFS publication (Greelev 1920) extolled the wildlife and scenic virtues of the Upper Skagit area for outdoor users. The following narrative could pertain to possible fish passage, "Just below Big Beaver Creek the river gains momentum and is literally turned on edge as it passes between the frowning walls of Canyon Diablo, a narrow cleft scarcely 10 feet across, with sheer walls rising upward 150 feet. At low water the canyon may be penetrated by boat." Greelev wrote, "Emerging from this defile, the river spreads out into a great rock-walled pool, rushing over the rocks and down into the broadening valley in a series of foaming rapids 7 miles in extent." [Refers to the Gorge Canyon area.]

Jenkins (1984), recounts his impressions as a Skagit Valley resident and employee of City Light during the construction of all three dams. Describing Gorge Canyon, "...the wild gorge of the Skagit begins, just beyond the flat where the hydro village of Newhalem now stands...The

A NPS history of the North Cascades by Thompson (1970) contains a reference to the character of the Upper Skagit River, "Between Ruby Creek and Newhalem, the Skagit flowed through narrow, steep canyons." A later NPS study (Luxenberg 1986) contains more information:

"The Skagit River...flowed freely, quietly...until it reached Ruby Creek...From there its waters were compressed and violently forced through narrow, rock-walled canyons and gorges."

"A short distance above Goodell's Landing...The river...passes through the great Box Canyon [Diablo Dam area], and there is no bottom lands at all on either bank. The great towering mountains come right down to the water's edge."

In several transcribed interviews (e.g., Davis N.D.; Davis 1970), an Upper Skagit homesteader, roadhouse operator at Cedar Bar (Cedar Bar was the location of the Davis' ranch/roadhouse, just below Stetattle Creek, see Figure 4-1), USFS and City Light employee Glee Davis gave firsthand information on fish passage in the Skagit and its tributaries. Concerning possible access into Big Beaver Creek, Davis describes a series of falls which confirm Custer's observations of lower Big Beaver. In support of other accounts, Davis stated that there were, "...always lots of rainbow trout, all the way up the river." Davis said that steelhead never went above where the Gorge Powerhouse is, and that salmon never made the rapids above there, "...a half a mile above the power plant [Gorge]...an awful lot of rapids...Salmon never make a place like that. ...not one fall after another." Davis was sure there were never any salmon above that point, "Never an indication of them. I saw one right near the powerhouse once. Fact they...gave up mostly below Newhalem Creek. They'll spawned out buy the time they had got up...around the mouth of Goodell Creek would be the last good spawning ground." Concerning spawning grounds, Davis states further that if passage were possible, "...it would be good spawning grounds from at the mouth of Ruby on up the Skagit."

In an archaeological study, Collins (1974) wrote that most Upper Skagit Indians subsisted off harvests of anadromous salmonids and used salmon products in trade with tribes east of the mountains. Hence, their salmon fishing villages and camps were located in reaches of the river where significant runs of salmon occurred, and there were no salmon above Goodell, according to Collins (she provided no reference for this statement). The Upper Skagit Indians had only one semi-permanent village above Goodell (Collins 1974). Pertaining to the Indian families or groups of families that lived above Goodell (some Upper Skagits and most of the Thompsons), Grabert and Pint (1978) stated in their archaeological and cultural inventory of the area that, "Although salmon played an important role in [their]...subsistence not ascend the Skagit gorge...Their salmon fishing was done outside the Park Complex." The authors deduced that, "Fishing, however, may not have been the major food source of the prehistoric peoples who utilized the North Cascades area that it was for people in more favored locales" [e.g., lower rivers and coastal areas]. The first biological survey of the Skagit River system was performed by University of Washington fishery biologists in 1920 (Smith and Anderson 1921). In characterizing the main channel of the Skagit above Ruby Creek, Smith and Anderson described extensive log jams and stated, ..."No salmon have ever been seen in this part of the Skagit river, but it is well stocked with rainbow trout and Dolly Vardens. Game fishing is unusually good in this part of the river."

Referring to the 14 river miles between Ruby Creek and Gorge Creek, the biologists stated that the channel, "...runs through the most rugged country drained by the river. The banks in many places are abrupt precipices. Through this region the Skagit boils and foams for the greater part of the distance. While no single fall or rapid observed would form an unsurmountable barrier to the upward migration of salmon, yet the continued series of low falls and rapids seem to have proved effective in stopping the run of salmon through this part of the river. Those living in this region who have given close attention to the movement of fish have never seen salmon more than one mile above the City of Seattle Camp [refers to the Falls Creek area about one mile above Newhalem]. Rainbow trout and Dolly Vardens are very abundant in this part of the river and afford excellent fishing."

Pertaining to some Upper Skagit tributaries, Smith and Anderson (1921) reported that Big Beaver Creek had 300 feet of falls within 1.25 miles of its mouth which completely obstructed the passage of fish. Ruby Creek had Dolly Varden and trout. Thunder Creek was blocked by falls and had no fish Stetattle Creek had rainbow but was too small for game fish (steelhead) and had obstructing falls at 1.5 miles upstream Goodell Creek represented the farthest upstream utilization for salmon; this stream contained rainbow, spring chinook, a few pink, and chum.

Throughout their report, Smith and Anderson (1921) discuss the serious degradation of the anadromous fishery by 1920 and describe some of the causes. A portion of the author's narrative about Goodell Creek is an example, "A few humpback, silver and dog salmon visit the stream, but the numbers are insignificant compared with the numbers reported to visit this stream in earlier years. This is the farthest branch of the Skagit from its mouth in which salmon run...The condition at present shows almost utter depletion so far as spring, silver, and humpback salmon are concerned." Smith and Anderson's observations of declining salmon resources during the first quarter of this century is supported by a USFS (1964) study of the North Cascades. The study recounts salmon exploitation by the commercial fish industry through fishing practices and mass production in processing. This study also discusses impacts to salmonids through environmental degradation in the early days by logging practices (clear cutting, road building, cedar bolt camps), fires, and mineral developments (especially the Azurite mine at the head of the Skagit).

A survey of the Upper Skagit River was conducted by the USGS in 1915 to identify the potential for hydropower development (Herron 1916). This report contains five foot contour interval maps of the Skagit River and of lower Ruby and lower Big Beaver creeks. These maps do not identify barriers or falls, but could be utilized to determine stream flow characteristics and, hence, the theoretical possibilities for anadromous fish passage.

Agency Investigations

By the mid-1930s, when fish and wildlife mitigation for hydropower developments was becoming a more prevalent issue, the State began putting demands on City Light for compensation from the Skagit projects. After Diablo Dam was constructed, much of the concern was being raised over low flow problems as opposed to blockage of migratory fish. Concerning the latter issue, however, the State and City Light had no official documentation of pre-impoundment anadromous fish conditions above Newhalem.

A couple of unofficial Washington State Department of Fisheries (WDF) reports provide information gleaned from fact-finding trips to the Upper Skagit. Chapman (1936) reported on several interviews of Upper Skagit residents. A Marblemount homesteader, Frank Pressentin, told Chapman that before the dam was put in at Newhalem a few steelhead used to go up as far as Stetattle Creek and Reflector Bar, but he thought that no salmon ever went through Gorge Canyon. He said, however, that City Light varied the depth of the river to such an extent that the spawning of the salmon as far down as Marblemount was seriously interfered with. Ed O'Brien, who was familiar with the Upper Skagit, also said that he never knew of any salmon upstream of Newhalem. Otto Pressentin of Birdsview (about 5 miles below Concrete) asserted, "...there were never any salmon above the Newhalem gorge and that he knew because he had been there looking for them." In a search of the U.S. Fisheries Bureau's Birdsview Hatchery records, the manager could find no report of salmon being found above the Newhalem Dam site before the dam was built. In line with these rather consistent recounts, Tommy Thompson, the local USFS Ranger since the 1910s stated, "No salmon above Goodell Creek, which empties near Newhalem and only a few steelhead. The steelhead used to spawn in Stetattle Creek to a small extent in former years but never went above Reflector Bar at the Diablo Dam site."

Chapman took his investigation to British Columbia. Tom Scott, a 30 year employee with the Dominion Fisheries Board said that "...neither salmon nor steelhead ever come up into the B.C. part of the Skagit." Recounts by Bob Robertson, a long-time British Columbia Skagit River resident, confirms the agency's statement. Chapman found no controversy in summarizing his interviews, "The consensus of opinion appeared to be that even before the City Light of Seattle began construction on their dams on the Skagit the salmon run ended at Goodell Creek and the steelhead run at Stetattle Creek, which is above the Newhalem Dam [Gorge dam] site."

Ten years later, two State employees performed an inspection of two miles of the Skagit River between the Gorge Powerhouse and Gorge Dam (Smoker 1949). Smoker reported, "...at a much lower stage the channel would not be worth much as far as providing spawning area for salmon species. About 1/8 mile above the Gorge-power house a swift rapids area extending about 75 feet was observed which probably serves as the upstream terminus of all anadromous salmonids. In a conversation with the train-man who has been making daily trips up the river for many years, he stated that he has seen salmon and steelhead attempt this barrier but to the best of his knowledge only a few steelhead have ever made it."

"Above this first barrier the stream has a cascade nature and no spawning beds occur. There are a few beds of large rocks about the size of base-balls" [suitable for chinook and steelhead spawning given acceptable stream velocity and water depth]. An unspecified distance further upstream, Smoker observed "...at least two other falls or rapids which would serve as impassable barriers. According to the train conductor and several other employees they have never seen a salmon or steelhead as far up as the gorge intake dam. The conductor reported that although the entire flow at the Gorge Dam at times is taken through the Gorge powerhouse intake, the main channel of the Skagit River does not completely dry up, but is kept alive by smaller tributaries."

Agency Correspondence

During the development period for the City Light's hydroelectric projects, the City had meetings and correspondence with a number of government agencies. These correspondence often contain theories, threats, agreements, and general politics, which should be interpreted with caution. Prior to writing permits, the FPC sought comments from the local USFS districts. In 1920, miscellaneous USFS correspondence discussed Special Use Permit requirements for a $10,000 fish hatchery as mitigation for Gorge Dam disrupting the Skagit salmon runs. A proposed hatchery located on a side stream at Newhalem near the proposed Gorge Powerhouse was considered. Later the City and the USFS agreed that the loss of the salmon run would be inconsequential, and the hatchery plans were canceled. This short-lived mitigation project is also referenced in Pitzer's (1978) history of the Skagit hydro developments.

C. Park (USFS Supervisor, Bellingham) in a 1926 letter to the District Forester (Portland), summarized feedback from local USFS personnel pertaining to an FPC amendment for the Diablo/Ruby dams; included were comments on anadromous fish, "I see no advantage in requiring ladders to take care of the fish coming and going. The steelhead trout seldom if ever get as far as Gorge Creek, because of natural obstruction and falls in the river about a mile below Gorge Creek, where the City's diversion dam is run." Over the early history of the Skagit projects, the USFS was legally able to, and did, defer fishery issues to the state agencies.

Not unlike today, the statements between state agencies and the developer often had political murmurs concerning preconstruction conditions and ultimate responsibilities. In relation to the Upper Skagit projects, the State was very belated in demanding mitigation basically because there was not a major loss of migratory fish habitat and there were no quantitative data on predevelopment fishery conditions. After the construction of Diablo Dam, the foremost mitigation issue was the destruction of the existing fishery, downstream from the dams to the confluence with the Cascade River. Habitat was impacted by rapid, daily fluctuations in river discharge. The predevelopment fish passage issue and the low flow issue are both presented here because these two affairs are not readily isolated in the historical records on mitigation. In Smoker's (1949) report, he stated that the fluctuation of river flow due to power peaking demands would be alleviated in 1952 when the Ross powerhouse and the Gorge Dam developments were to be completed. Ross Reservoir was actually filled by 1953 and the Gorge Dam rebuild (a higher, concrete dam) completed by 1960-61.

A conference was held in the City Engineer's office on August 12, 1927, before Diablo Dam was started, to determine what steps, if any, were necessary to safeguard resident and migrating fish. A City Light memorandum on this conference with State fish and game personnel summarized the meeting with rather disjointed statement, "Mr. Mayhall [of Fisheries] thinks no fish go above Gorge. There may be a small number of early run [probably spring chinook, given their swimming ability and other comments about chinook above Newhalem]...Ross [Lighting Superintendent] says steelhead have been caught at Newhalem. The river will be dry at times below the Gorge dam." Mayhall said the City should, "... subsidize a hatchery that would meet all criticism...[stemming] from destruction of the fishing industry...trout eggs would be brought in [for the hatchery]." The next day the City sent a letter to the State Department of Fish and Game (the agency separated into two departments in 1932) giving official notice of the construction of Diablo Dam. To implement full cooperation of the City and State, City Light requested the requirements of the "Fisheries Industry."

Milo Bell, an engineer who consulted for or was employed by the State, characterized his impressions to C. Pollock (Supervisor of Fisheries) from a trip to the Skagit projects while Diablo Reservoir was filling (Bell 1930). Bell observed that with water retention at Diablo (to fill the reservoir), there was less flow for the Gorge powerplant and all available water below the Diablo Powerhouse was diverted into the Gorge Powerhouse tunnel by the Gorge diversion dam (i.e., little or no spill). Therefore, there was a wide fluctuation in water level below the Diablo Powerhouse and Gorge Canyon was nearly dry (in places); seepage water occurred only in a small area of river bed and resident fish were "practically exterminated." Bell commented about great bars being alternatively covered and uncovered by the regulation at Diablo Dam and speculated that there were thousands of small fish left stranded in pot holes or upon the banks due to these fluctuations. He observed large flocks of birds feeding in those areas. [Bell was probably referring to juvenile, resident trout or whitefish in the Cedar and Reflector Bar areas.]

Bell further asserted that given the seasonal low flow conditions in the tributaries plus, "...lowering of the Skagit [caused] a delta area over which the small upper streams spread, and would in some cases, make the ascent into the streams from the main river hard for the migrating salmon..." Bell also stated that the area above Newhalem had become lost to migrants and that attempts of migrants to pass Newhalem should be prevented because river flow fluctuation would exterminate them. [It is assumed that in the first statement (in quotes), Bell is referring to the Skagit River below Newhalem since there were no suitable salmonid spawning habitats in the Skagit or its tributaries between Newhalem and Gorge Dam (Smith and Anderson 1921; early resident observations); and there was evidence of low flow problems even below the Gorge Powerhouse (Chapman 1936 interview of F. Pressentin). As to the character of the Skagit above Gorge Dam to Diablo Dam, Bell made the confusing comment that the channel, "...was apparently favorable to migrating fish if they were able to ascend the canyon between these points, which is not at all favorable for spawning purposes or as a migrating channel." Bell could only define mitigation responsibilities by saying, "Past records will show how much spawning area has been destroyed but regardless of this there will be a loss due to the power regulations which should be compensated for."

Additional comments by Bell (1934) from another visit to the Upper Skagit are available from a July 6, 1934 letter to WDF. Bell stated, "At this time Mr. Russell of the U.S. Bureau of Fisheries was of the opinion that there would be considerable loss of Chinooks in the canyon [Gorge Canyon] when the river went dry."; and the river was "dry" below Gorge Dam during Bell's visit. In an attempt to instill one viewpoint on predevelopment fish passage, Bell wrote, "I understand that it had been customary for salmon to ascend through the canyon and spawn in the neighborhood of Reflector Bar which is below the present Diablo Dam." Bell gave no reference for this statement. Bell continued, "However, with the construction of the Gorge Dam in 1924 [1920] salmon were unable to make the canyon above this dam as there was no provision made in it for fish migration. If Chinook salmon or steelhead trout still ascend as far as the Gorge Dam they would either be forced out of the canyon or trapped and perish as the section of the river between the Gorge Dam and the Gorge Powerhouse goes practically dry in the low water season or when the river is regulated from the Diablo reservoir." Bell pointed out that due to rapid river fluctuations induced by power regulation, fingerlings were trapped in pools and subjected to predatory birds or to drying up. It is not clear if Bell was referring to resident trout between Gorge Dam and Diablo Powerhouse or to salmon and trout below Newhalem. The latter seems to be the case given that Bell's next statement must be meant to include the Skagit below Newhalem, "In a river the size of the Skagit the destruction of fish life by power operations can not be estimated."

In a January 1936 letter to the State, City Light said they would welcome a conference to discuss commercial and game fisheries in the Skagit River. The letter repeats information from the August 12, 1927 conference when State fisheries personnel Pollock and Mayhall stated there were no salmon spawning above, "Falls Creek...about a mile above the Gorge plant." Falls Creek was not specifically mentioned in the City Light Engineer's MEMO from August 12, 1927. The 1936 letter continues, "It was understood at that time [August 12, 1927] that "...any provision to take care of salmon...at Diablo or Gorge...would be entirely useless, because no salmon had been known at those points." The City expressed a desire to, "...preserve our fisheries...keeping up the wonderful trout fishing..." Thus, City Light wanted to operate under the statements made by the State in 1927 (no migratory fish habitat loss) and to just proceed with enhancement of the resident trout fishery in the reservoirs.

An important conference, to supposedly settle fishery mitigation responsibilities, was finally held between the State and City Light on February 10, 1936. The City reiterated statements of record (from the previous year and from the August 12, 1927 conference with the State), "...that the city had done no damage by building Diablo dam or Gorge intake." And that, "...no provision for taking care of fish was made in connection with Diablo dam."

In a change from the previous policy stand on Upper Skagit migratory fish impacts, at this 1963 conference the State began pressuring City Light to acquiesce to the State's current concepts on fishery impacts. A City Light MEMO recorded the meeting, "Mr. Brennan [Dir. Commercial Fish. Div.] stated that his records would show unquestionable damage to the fish run [i.e., anadromous fish blockage], especially the steel head, and Mr. Bell called attention to the damage to small fish on the way down stream, because of extreme fluctuations in the stream due to regulating the stream for operation of the power plant." Continuing, the fishery agencies said that undoubtedly the State could win a case and quoted Mr. Ross' (City Light Superintendent) long record of cooperation, and care to maintain and increase wildlife.

Further discussion centered on the location for a fish hatchery. Then, to bolster their argument, the State gave examples of other utilities who paid large amounts of money and that the City should do its part. The City said it did not want a law suit nor will it dodge responsibility, but the City, "...would like definite facts and recommendations..."

The chronology of correspondence now leads to more formal agency type letters. Referring to the February 10, 1936 conference, a joint WDF and Washington Department of Game (WDG) letter (February 27, 1936) to City Light said the, "...following facts were ascertained:

1. The construction of the Canyon and Diablo dams has not seriously hindered the spawning migrations of the Chinook salmon.
2. The runs of steelhead into Stetattle Creek and into the dam area have been destroyed."

Item (3) of the joint letter discusses the impacts to spawning salmonids, their eggs and fry due to daily fluctuations of the river below the dams. Apparently the State could not include data with these statements and declared it was, "...impossible to accurately ascertain the definite loss in any one year...it is a definite fact that an abnormal depletion has occurred in the upper Skagit during past years and the condition of other streams tributary to the Skagit River cannot biologically have an effect on this area."

WDF and WDG requested that the City build a fish hatchery and rearing ponds, and provide annual operation and maintenance funds (based on a 1923 law). Then, upon compliance, WDF and WDG would release the City from any further responsibility in preserving the fish life of the Skagit River.

In response to the above letter, City Light prepared a rather piquant response on March 3, 1936. The City concurred with item (1). However, pertaining to item (2) the City asserted, "Your finding that runs of steel-head into Stetattle Creek and the dam area [presumed to mean Diablo Basin] have been destroyed, is directly contrary to the conclusions of that conference. It is also contrary to all experience and observation by City of Seattle representatives since 1917."

"Steel head have been reported at Bacon Creek, and at Newhalem Power House just above Newhalem Creek. Numbers of fish-carcasses, reported to be those of spawned humpback salmon, have been observed in Goodell Creek for years past,- and this condition still continues. But if you have any proof, that will withstand court questioning, of steel head runs into Stetattle Creek, we shall be glad indeed of a chance to study it."

Continuing, ..."Statement made at the February 10th. conference, that steel head had been caught in the area above Diablo dam-site, is also directly contrary to all known experience. An opinion, dated February 19th., from Regional Director of fisheries Fred J. Foster, states:

> 'It is at this time the general opinion among ichthyologists that the rainbow and the steel head are one and the same fish. ' "

Adding, ..."Thousands of rainbow trout have been caught above Diablo dam site. But if you have definite proof of even one steel head (sea-run rainbow) ever having been caught in that area, we most respectfully urge that you will submit it to us at an early date."

Issue resolution dealing with the specific loss of anadromous fish habitat seems to have died at this point, or at least no other records were located. Ten years later, daily fluctuations in river level were continuing to negatively impact fish habitat and was still an unsettled issue. Concerning Seattle's permit application for additional construction on Ross Dam in 1946, the FPC chairman suggested that it would be acceptable for the City to maintain a minimum flow equivalent to the natural minimum flows in the Skagit River. A September 30, 1946, USFWS Intraagency letter (from the local Portland district to the Director in

Chicago) declared opposition to the FPC chairman's suggestion, "... with the utmost vigor..." and that such a condition, "...would spell doom of many salmon runs and resident trout populations." Passing over the details of the river level regulation issue in this letter, to anadromous fish passage responsibilities at Ross Dam, the author refers to previous records (including Smith and Anderson 1921) and states, "...there were no salmon above Goodell Creek, ...and locals have never seen salmon more than one mile above Newhalem." Thus, "...neither the State of Washington nor this office believes there is any need for the construction of fishways on either Ross Dam or on the two dams located farther downstream. Existing fish populations in the affected area above the dam are resident in type, and considered non-migratory."

A joint letter from the directors of WDF and WDG to the FPC (December 30, 1946) also addressed the minimum flow requirements to reduce fish losses. Pertaining specifically to the third step in rising Ross Dam, the directors expressed no objection, "...in fact...greatly desire the construction of the Ross Dam to a [greater] height and in a manner so that it can be used to control floods of the Skagit River in lieu of a special flood control dam planned by the USCOE [U.S. Army Corps of Engineers] at Faber [which would have severe fishery impacts]." They add, "...Ross Dam is not in any way related to the migratory fish of the Skagit river and the impounded water behind the dam greatly augment[s] the game fish in the area."

A legal contract between the Seattle City Light, the WDF and WDG was finally drawn up in late 1946. In discussing the Skagit River project's impacts to fisheries, the agreement declared that construction of the three dams has caused, "...destruction of the salmon, steelhead and cutthroat trout runs to a small extent in the area above the Gorge Dam and to a considerable extent in the portion of the Skagit River extending downstream from the Gorge Dam to the confluence of the Cascade River..." Concerning predevelopment conditions, the agreement stated that very few spring chinook salmon ever spawned above the site of Gorge Dam; and that some steelhead spawned above the site of Gorge Dam. Thus, the contract related that, "The construction of fishways over said dams would be impracticable in the opinion of the Director of fisheries." The rest of the document delineates various salmonid species between the Gorge Dam and Marblemount, the condition of daily artificial fluctuation of the river's flow, and the associated impacts to specific juvenile and adult salmonid species.

The City would be required to provide $55,000 for a fish hatchery at Marblemount and to maintain a minimum flow of 1000 cfs with fines assessed for every violation of the minimum flow.

Anadromous Fish Passage Summary

Based on the historical accounts and agency correspondence, the following conclusions can be made:

1) A small number of steelhead trout probably returned to the Reflector (and presumably Cedar) Bar area(s) and lower Stetattle Creek.
2) Some chinook salmon (probably spring) returned to the Falls Creek area about one mile above the Gorge Powerhouse at Newhalem.
3) Possibly, a very small number of spring chinook salmon returned to the Cedar/Reflector Bar areas.
4) Rainbow trout were present throughout the Skagit River and any accessible tributary.

Some points made in the correspondence between State agencies and City Light should be clarified. Milo Bell's two letters (1930, 1934) made references to stranded young fish, great river bars being flooded and dried by the fluctuating water level, and potential restrictions to returning salmon. Most of the accounts are not documented and many of the descriptions are too obscure to ascertain what reach of the river or what fish species are discussed. According to his July 1934 letter, Bell said the riverbed was dry at times below Gorge Dam. This account is inconsistent with the City Light train conductor's repeated observations that the main channel was kept alive by tributaries even though the Skagit's entire flow was often diverted to the Gorge intake (Smoker 1949).

The joint WDF and WDG letter of February 27, 1936 declared that the Stetattle Creek and dam area (probably Reflector Bar) steelhead runs had been destroyed. Davis and other long-time area residents who lived on Cedar Bar stated that steelhead never went above the Gorge Powerhouse (several transcribed interviews). Smith and Anderson (1921) reported that Stetattle Creek was too small and insignificant for game fish. Other reports allude that a few steelhead made the journey through Gorge Canyon to spawn on the Reflector Bar and in the lowermost portion of Stetattle Creek. So, perhaps the State was correct but they certainly exaggerated the severity of the steelhead loss for political reasons just as City Light might have overly minimized the impact.

Although all the area residents said there were no salmon above Newhalem ("to the best of their knowledge"), there are enough reports in agency correspondence to theorize that some strong swimming, early run (presumably spring chinook) salmon ventured about a mile above Newhalem. Since there were no suitable spawning areas in this reach, these fish were evidently trying to reach spawning areas at Reflector or Cedar Bar. There were probably limited periods when flow conditions were negotiable by these salmon.

One of the very few and the only federal fishery agency reference to chinook salmon above Newhalem is from Bell's 1934 letter. Bell declared that Mr. Russell of the U.S. Bureau of Fisheries said there would be a considerable loss of chinook in the canyon (presumably Gorge Canyon) when the river went dry. Apparently, the Bureau of Fisheries believed there were chinook more than a mile above Newhalem. The statement "considerable loss" can be interpreted as many fish or a high percentage of a few fish given the nonobjective nature of these letters.

Another theory for consideration, that has not been alluded to in any of the extant records, is that once the Gorge diversion dam blocked anadromous fish in 1920, some remaining chinook residualized and continued to feed and reproduce in the short, habitable section of river between Diablo Canyon and Gorge Reservoir. If any such fish developed, they were probably wiped out by rapid fluctuations in the river after Diablo Dam was built in 1929.

A 1964 report by the Wild Rivers Study Team includes a rather propitious WDG narrative summarizing the condition of the Upper Skagit fisheries, "At present, the fishing at Diablo and Ross is very, very good. These two dams are very rare examples of structures which did little to injure fishery production, as normally it is impossible to secure power from a river without hurting the fishery. But the river bank in this section is steep, and before being dammed at these sites, the Skagit boiled and foamed downstream. Bottom and shores are rocky and covered with immense boulders in some spots. Little vegetation or insect life could be found on the stream bottom. Prior to the construction of the dams the continued series of falls and rapids seemed to discourage salmon from journeying upstream. And this was not a large spawning area for the steelhead. The dams, of course, in no way aid migratory fish, but serve to establish unusual conditions which now support resident fish."

4.1.3.2. Upper Skagit River Resident Fish Analysis

Species Composition and Distribution

The species composition and distribution of salmon was previously discussed to the extent that historical accounts and data were available. Since nonanadromous salmonids were only minimally considered, trout species composition and distribution is summarized here. As with anadromous salmonids, there was no quantitative information for Upper Skagit River trout; and most records refer to trout in very general terms.

A USFS (1964) fish and wildlife study on the Washington Cascades also states that there were no records from the "early times" pertaining to sport fish. This report asserts that one can assume all accessible trout habitat was fully stocked by natural migrations. All landlocked and high mountain lakes (those above 2499 ft) that were inaccessible due to falls or obstacles in outlets, were barren. Similarly, Smith and Anderson (1921) indicated that all accessible habitats in the Upper Skagit area were stocked with trout. The sport fishery was not materially damaged by the exploitation of the fisheries in the early 1900s; however, environmental degradation from logging and mining practices would have affected resident trout populations.

The question remains as to speciation. Smith and Anderson (1921) provided the only early biological survey before reservoirs were a dominate feature in the Upper Skagit habitat. Again, the speciation and density of trout was reported in very qualitative terms. Smith and Anderson recorded Dolly Varden and resident rainbow trout throughout all habitable reaches of the Skagit River mainstem. Big Beaver Creek was obstructed to fish due to the series of falls (described previously by Smith and Anderson, and Davis (1970) interview); above the falls, the progeny from Forest Ranger Thompson's planted cutthroat trout were reported to be, "...unusually beautiful fish..." The lower reaches of Big Beaver Creek became accessible as Ross Lake filled (Seattle City Light 1973). Smith and Anderson reported a dam (from mining operations) about four miles up Ruby Creek, that Ruby Creek was an excellent trout stream, and some Dolly Vardens were caught at the mouth. Thunder Creek and Lake were blocked by falls and barren of fish (stocked by Thompson in the 1920s). Stetattle Creek was described as a rough, precipitous stream that was, "... well stocked with rainbow trout below the falls (at 1.5 miles)." A few trout were planted above the falls in 1919; and, "The stream is too small to be worthy of much consideration from the standpoint of game fish." This last statement seems to contrast with the implied severity in the joint WDF and

WDG letter of October 2, 1936 to Seattle City Light asserting destruction of the Stetattle Creek steelhead run. Smith and Anderson gave no further species definition as to "trout" other than occasionally saying "rainbow trout" instead.

General Historical Accounts

Upper Skagit Indians, explorers, miners, and homesteaders reported abundant trout in the Upper Skagit and its tributaries. Archaeological studies of the Upper Skagit Indians indicated they caught only resident fish in the mountains above the Skagit gorge, on their hunting or social trips to eastern Washington. The Upper Skagit and Thompson Indians had hunting camps in the area currently under Ross Lake (Collins 1974; Grabert and Pint 1978).

After reaching the Skagit in the vicinity of Little Beaver Creek, Henry Custer of the 1859 boundary survey, recounted, "Our Indians were engaged in fishing and the result was a fine mess of black speckled trouts, which seem to be in abundance in the river [Skagit] wherever its water are deep and the currents low. These fish are truly delicious..." (Custer 1866). Although black speckled trout could be either cutthroat or rainbow, the habitat description is more appropriate for cutthroat. A surgeon/ naturalist on the original boundary survey submitted a detailed report to the Commissioner (Archibald Campbell) on new species of salmonidae (Baker 1900). This report as part of Campbell's final report was lost to history. Members of other boundary survey teams mentioned catching trout. An isolated stream, near the boundary, in the vicinity of the Pickets was named Dolly Varden Creek (Stanley 1970; International Boundary Commission 1937). An Upper Skagit prospector's journal contains routine entries about catching trout for lunch while on the trail between his claim on Slate Creek and the lower Skagit Valley (Melville N.D.).

Glee Davis, the roadhouse operator at Cedar Bar, said that there were, "...always lots of rainbow trout. All the way up the river." The Davis family used to catch many 14 to 18 inch rainbow; he remembered his mother catching the largest at 20.5 inches (Davis 1970). A Forest Service promotional booklet (Greelev 1920) professes the main Upper Skagit River and its tributaries, including Ruby, Lightning, Big and Little Beaver Creeks to be, "...filled with rainbow, Dolly Varden, black-spotted [cutthroat?], and steel-head [the only publication mentioning steelhead and possibly implying their existence, by the tributaries named, in the Skagit above the canyons] trout, and offer unsurpassed fishing."

Later, pertaining to compensation for the original Ross Lake flooding in British Columbia, the Deputy Minister of Lands asserted that, "At present the Skagit River in British Columbia is one of the best fishing streams in the Province..." and expressed concern that flooding and fluctuating water levels would damage the resource (Melrose 1948); other indications were that the resident fishing would be improved. For example, while discussing the effects of hydroelectric developments in the Washington Cascades, a general fish and wildlife study related the enhanced sport fishery created in reservoirs (USFS 1964).

Trout Planting

Given the early trout planting operations of the USFS in the Upper Skagit (pre-1920s) it is important to note locations of this stocking activity to know which waters were devoid of various trout species. Forest Ranger Tommy Thompson transported 20,000 cutthroat trout fry by pack mules to the barren waters above the falls in Big Beaver Creek (circa 1916). Thunder Creek was stocked in a similar manner (1917-1918). Thompson and other USFS personnel planted Thunder and McGuire lakes and Panther Potholes in about 1937; early planting of Lake Chelan trout in Thunder Lake was unsuccessful). Based on a memo from the Skagit County Game Warden to Seattle's mayor, apparently Diablo Lake and various creeks of the Upper Skagit were being planted with, "...very fine blooded trout...from Montana..." for several years prior to, and an indefinite period after, 1932 (McKenna 1932). Brown Wiseman was responsible for planting millions of trout in the barren high lakes and streams of the North Cascades. This was a personal endeavor by Wiseman and his associates. Wiseman provided a record of planting and restocking activities from 1927 to the 1950s (Dwelley 1975; Wiseman N.D.).

physical data for the American tributaries to Ross Lake including stream gradient profiles, spawning areas, accessible stream area, and barriers to trout passage. Both reports have detailed fishery surveys and associated data from the Canadian Skagit River. An analysis is included for potential environmental impacts from the construction and flooding periods and projects for fishes and the fishery.

4.2 RESIDENT FISH POPULATIONS

4.2.1 Introduction

The development of Gorge, Diablo, and Ross dams resulted in major alterations of resident fish habitat in the mainstem Skagit River and tributaries in the area inundated by these dams. Free-flowing stream reaches were changed to lake-like reservoirs. No analyses have been performed to determine if this change resulted in a significant difference in fish populations. Therefore, this evaluation was undertaken to compare resident fish populations between pre-impoundment[1/] and post-impoundment periods. Although numerous fish species exist in the area, the primary focus of this evaluation was on catchable size (greater than about 150-200 mm) trout[2/] because of their importance in the sport fishery. By developing population estimates for catchable trout in both the pre-impoundment and post-impoundment periods, a general comparison of the effects of impoundment on resident fish populations was established.

1/ Pre-impoundment includes the time period when all tributaries in the study area were free flowing and no reservoirs existed. Post-impoundment will be referred to as the period of time after all three reservoirs became operational. No analyses were performed for the interim period during construction and filling of each reservoir.

2/ In this report, the term "trout" applies to all species historically found in the study area. These include rainbow, eastern brook, and cutthroat trout and Dolly Varden char.

The study area for this evaluation was the area encompassed by the inundation zones of Gorge, Diablo, and Ross reservoirs (for the Ross Dam Reservoir, only that portion in the United States was considered). Information on resident fish populations in this area ranges from little or none for the pre-impoundment period to more substantial information for the post-impoundment period. Although no population estimates are available for pre-impoundment conditions, it is known that resident species included rainbow, cutthroat, and eastern brook trout and Dolly Varden char (City of Seattle 1973). The rainbow and cutthroat populations were supplemented through stocking programs. Eastern brook trout are not native to this area and were introduced.

Rainbow trout were the primary sportfish in the post-impoundment period. According to the City of Seattle (1973), approximately 97 percent of the fish caught in Ross Lake during 1972 were rainbow.

4.2.2 Methods

Various methods were used to estimate catchable trout populations between the two periods. No attempt was made to estimate abundance by species because the pre-impoundment species composition and relative abundance were not known. The assumptions and methods for deriving these estimates are as follows.

4.2.2.1 Post-impoundment Resident Fish Population Estimate Methods

The existing catchable trout population estimates were based on studies conducted in 1971 and 1972 in Ross Lake and the Skagit River system above Ross Lake (City of Seattle 1973). These studies estimated the total trout population of fish exceeding 200 mm through the use of tagging and recapture of the tags in creel surveys. The study results provided a population estimate for all of Ross Lake and the Skagit River upstream of the lake. These estimates were reduced to an estimate of catchable size trout in the United States portion of Ross Lake. This density estimate (number of fish/acre) was then extrapolated to the surface areas of Diablo and Gorge reservoirs in order to estimate their trout population. The steps involved in using these study results to develop an estimate of resident fish populations in the study area were the following:

1) The population estimate for the study area was developed by estimating the percentage of fish from the total population estimate for the Ross Lake and upper Skagit River that were in Ross Lake only. This was done by using creel survey results for the region (City of Seattle 1973). The trout population in the United States portion of Ross Lake was assumed to be proportional to the ratio of United States surface area to total Ross Lake surface area.

2) The trout population sizes in Diablo and Gorge reservoirs were determined by assuming that the density of trout per unit surface area in Ross Lake was identical to the other reservoirs.

4.2.2.2 Pre-impoundment Resident Fish Population Estimates

The lack of information about pre-impoundment populations presents a large degree of uncertainty about the reliability of any one estimating method. Therefore, three different methods were used to obtain a range of estimates.

Method 1 was based on 4 years (1977-1980) of post-impoundment data on catchable trout biomass from 25 streams in the Skagit River drainage (Phillips et al. 1981). It was assumed that the post-impoundment data from the Skagit River tributaries provided a reasonable estimate of the biomass in the mainstream Skagit River and tributaries prior to impoundment. There are potential biases in making this assumption. To minimize these, adjustments were made in the analysis. The steps involved in calculating the estimate using Method 1 were as follows:

1) To account for current fishing pressure in the tributaries, which possibly reduced the biomass density of catchable trout, the maximum average biomass density of the 4 years of data from the 25 streams was used. The overall comparison examined catchable size trout only. Therefore, just the biomass data of age 1+ and older rainbow trout and cutthroat trout were considered. Cutthroat trout were included because they may have been present in the pre-impoundment streams, and they represent catchable trout production.

2) The total surface area (m^2) of all inundated mainstem and tributary streams in the study area was then multiplied by the maximum average biomass density to estimate the total catchable trout biomass. This step did not consider varying qualities of stream habitat in trout production. Instead, it assumed that current tributary biomass per unit surface area equaled that for all inundated streams.

3) In order to compare pre- and post-impoundment catchable size fish populations, the total biomass estimate for pre-impoundment reservoir streams was divided by the 1971-72 (City of Seattle 1973) average catchable size fish (weight) to obtain an estimate of the number of pre-impoundment catchable trout.

Method 2 was based on estimates of juvenile steelhead abundance in fully seeded streams in western Washington. Juvenile steelhead were used because the current sport fishery in Ross Lake is based on rainbow trout (97 percent of sport catch in 1972; City of Seattle 1973), which is the same species as steelhead except that rainbow are nonanadromous whereas steelhead are anadromous. Although historical fish populations may not have had such a high proportion of rainbow trout, this method was based mostly on information about catchable size rainbow trout in Ross Lake.

In systems with steelhead, very few fish of catchable size are found. The reason for this is that steelhead migrate to sea in the spring, mostly at age 2 and a few at age 3 (Wydoski and Whitney 1979), leaving very few older age classes (ages 2-4) in streams during the summer (Bjornn 1978). Therefore, estimates of rainbow trout population were based on age 2 steelhead abundance with modifications to estimate catchable size trout. A description of the exact methods used follows.

1) A method developed by Johnson and Cooper (1986) was used to estimate steelhead parr[1/] (mostly age 1 steelhead) abundance. This method estimates steelhead parr abundance by mainstem river slope categories. The use of slope categories accounts for habitat differences that affect steelhead parr density. Average parr density of the three slope categories (0.00-0.25, 0.25-0.50, and 0.50-1.0 percent stream slope) in Johnson and Cooper (1986) was used to estimate parr production in stream sections with less than 1 percent slope, for the pre-impoundment Skagit River mainstem. The pre-impoundment slope data taken from maps were only categorized into whole slope categories (i.e., 1, 2, or 3 percent slope) so the finer slope gradations presented by Johnson and Cooper (1986) were averaged.

2) The parr density from Johnson and Cooper (1986) for mainstem sections with stream gradients of 1 to 3 percent slope was used for the corresponding gradient zones in the pre-impoundment Skagit River mainstem.

3) The steelhead parr density value for Skagit River tributaries reported by Gibbons et al. (1985) was used for pre-impoundment tributaries that were inundated after the reservoirs were filled.

1/ Parr is used here to mean juvenile steelhead present in a stream during their final summer before they migrate to sea as smolts the following spring.

5) These density values were then multiplied by the corresponding pre-impoundment stream areas. The total estimated steelhead parr production was then summed separately for the mainstem and tributaries for each of the three reservoir areas.

6) Steelhead parr are too small (i.e., less than 6 inches, 150 mm) to be considered catchable trout. Therefore, the resulting parr values were converted, with the use of overwinter survival rates, to number of two year old trout. Two year old steelhead, which are commonly smolts, approach catchable size (average smolts from Skagit River tributaries were 161 mm average length; Phillips et al. 1981).

   Overwinter survival rates for one year old parr to two year olds are variable. DeShazo (1985) used a survival rate of 40 percent for steelhead parr to smolt on major Washington tributaries or the Columbia River. Everest et al. (1987) found overwinter steelhead parr survival rates ranging from 40 to 70 percent on a tributary to the Willamette River, Oregon. Thurow (1985) suggested values of 30 to 40 percent would be expected for steelhead on the Salmon River, Idaho. Based on these rates, an overwinter survival of 50 percent was assumed.

7) Based on the assumed overwinter survival rate, the estimated number of steelhead parr was reduced by 50 percent. The resulting number was equivalent to age 2 rainbow trout. However, the estimated number of age 2 fish was probably equivalent to all older age groups that may have been present in the pre-impoundment streams. The reason for this is that streams which have steelhead typically have very few older age groups, while streams without steelhead have a range of rainbow trout older than age 2 (Bjornn 1978). Therefore, we believe the estimate resulting from Method 2 would be a reasonable approximation of most catchable size fish in the pre-impoundment streams.

Method 3 uses the estimated number of trout from Method 2, and the average biomass of those fish as the basis for developing a population estimate. The steps in this method were the following:

1) The average biomass of steelhead smolts (age 2 and greater) from Johnson and Cooper (1986) was multiplied by the estimated number of trout from Method 2 to estimate total rainbow trout biomass. (This biomass value represents most of the catchable size steelhead in a steelhead system. Thus, it was assumed that it would also be equivalent to the total biomass of catchable trout.)

2) This biomass value was converted to an equivalent number of trout present in the existing reservoirs. To do this, the total biomass was divided by the average size of trout caught in Ross Lake during 1971 and 1972 (City of Seattle 1973).

4.2.3 Results

The post-impoundment calculations of estimated trout population in the three reservoirs ranged from 161,643 catchable trout in Ross Lake to 3,398 trout in Gorge Lake (Table 4-1).

The pre-impoundment estimate of fish population was based on three methods using the area of stream habitat that was inundated (Tables 4-2 and 4-3). The estimated catchable trout population in the three reservoirs varied from 4 to 27, but was probably closer to 8 to 27, times more than was estimated to have been present in the pre-impoundment streams (Table 4-4).

TABLE 4-1

ESTIMATED POST-IMPOUNDMENT CATCHABLE SIZE TROUT
POPULATIONS IN ROSS LAKE, DIABLO RESERVOIR, AND GORGE RESERVOIR

1. Population of catchable size trout in all of Ross Lake =
184,056 trout[a/] x 0.90[b/] = 165,650 trout

2. Population of catchable size trout in United States portion of Ross Lake =

$$165{,}650 \text{ trout} \times \frac{11{,}417 \text{ acres}}{11{,}700 \text{ acres}}^{\underline{c}/} = 161{,}643 \text{ trout}$$

3. Density of trout in Ross Lake =

$$\frac{165{,}650 \text{ trout}}{11{,}700 \text{ acres}} = 14.16 \text{ trout/acre}$$

4. Population of catchable size trout in Diablo Lake =

$$910 \text{ acres} \times \frac{14.16 \text{ trout}}{\text{acre}} = 12{,}886 \text{ trout}$$

5. Population of catchable size trout in Gorge Reservoir =

$$240 \text{ acres} \times \frac{14.16 \text{ trout}}{\text{acre}} = 3{,}398 \text{ trout}$$

---

a/ Average of 1971 and 1972 catchable size (greater than 200 mm) trout population in Ross Lake and the upper Skagit River (City of Seattle 1973).

b/ Percentage of total trout caught in Ross Lake and the Skagit River above Ross Lake that were caught in Ross Lake only during 1972 (City of Seattle 1973).

c/ The surface area of Ross Lake in United States waters (11,417 acres) and the total Ross Lake area (11,700 acres) at full pool.

8396a

TABLE 4-2

STREAM HABITAT AREA INUNDATED BY THE CONSTRUCTION OF ROSS, DIABLO, AND GORGE DAMS a/

Region	Stream Slope	Stream Area (acres)			
		Ross	Diablo	Gorge	Total
Skagit River Mainstem	<1 percent	549.76	24.26	43.42	617.44
Skagit River Mainstem	1-3 percent	4.32	35.63	17.69	57.64
Tributaries	--	66.77	17.27	0.00	84.04
Total		620.85	77.16	61.11	759.12

a/ Values are summaries of acreage data presented in Appendix F.

TABLE 4-3 (Continued)

ESTIMATED PRE-IMPOUNDMENT CATCHABLE SIZE TROUT
POPULATION IN ROSS LAKE, DIABLO RESERVOIR, AND GORGE RESERVOIR

Method 3

1. This method takes the results of Method 2 and converts them to average size trout in Ross Lake during 1971-72 with the formula:

$$\text{Estimated number of trout by Method 2} \times \frac{45\ \text{g}^{g/}}{\text{trout}} \times \frac{\text{trout}^{h/}}{302\ \text{g}}$$

2. The results average of these estimates are:

Ross	=	4,980
Diablo	=	1,074
Gorge	=	482

---

a/ The maximum average biomass of age 1+ and older trout in 25 Skagit River tributaries from 1977 to 1980 (Phillips et al. 1981).

b/ Average weight of fish caught in Ross Lake during 1971 and 1972 (City of Seattle 1973).

c/ Acres of inundated streams by reservoir (see Table 4-2).

d/ Reservoir is used to mean the pre-impoundment inundated stream areas in either Ross, Diablo, or Gorge lakes.

e/ Parr densities are from the slope categories for mainstem streams from Johnson and Cooper (1986) and Skagit River tributaries from Gibbons et al. (1985).

f/ Survival value of parr to 2-year-old trout was assumed to be 50 percent.

g/ Average weight of 2-year-old rainbow trout (steelhead smolts) (Johnson and Cooper 1986).

h/ Average weight of sport-caught trout in Ross Lake during 1971 and 1972 (City of Seattle 1973).

4.2.4 Discussion

The results indicate that the post-impoundment populations of catchable size trout increased substantially relative to pre-impoundment populations.

The fish population estimates were based on many assumptions. Thus, no confidence intervals were estimated. However, a short discussion of the quality of the various estimates will help explain the range and validity of the values.

4.2.4.1 Post-impoundment Methods

The post-impoundment estimates of the catchable fish populations for Ross Lake are probably very good. The main problem is they only include fish in excess of 200 mm (City of Seattle 1973). Catchable size fish down to 150 mm (6 inches) are not included because they appeared to be a small portion of the catch. We do not know the reliability of the estimate for Diablo and Gorge reservoirs, because these systems were not sampled. We can only assume that being in the same river system results in similar fish densities as Ross.

4.2.4.2 Pre-impoundment Methods

The pre-impoundment estimates of catchable trout have the greatest chance for error. Different assumptions used for each of the three estimation methods may have resulted in these estimates being low or high.

Method 1 (based on trout biomass of age 1 and older trout in Skagit river tributaries) resulted in a population estimate that was probably higher than the true pre-impoundment population. There were several potential reasons for this. First, the estimates were based on parr biomass in small streams. Past studies have shown that steelhead parr densities in small streams are typically higher than they are in mainstem rivers (Gibbons et al. 1985). The surface area of the mainstem Skagit River was more than 80 percent of the total stream area inundated by the three reservoirs. Therefore, the density factor used was probably high. Second, the biomass was for age 1 and older fish. Most age 1 fish are not of catchable size (i.e., less than 6 inches long), so the inclusion of this biomass probably elevated the estimate of catchable trout biomass. This bias is partially offset because very little of the total trout biomass during summer in small streams containing anadromous steelhead have fish older than age 1. Because steelhead migrate as smolts during the spring as age 2 fish, this estimate probably represents the biomass of the largest fish.

Method 2 did consider the effect of habitat quality on production. It was based on information from the literature about density of age 2 steelhead in fully seeded mainstem and tributary streams. Although this method considered habitat quality, it may have overestimated the number of catchable trout relative to present impoundment populations. The estimated number of fish was for those approximately 160 mm in length. These fish were considerably smaller than the fish estimated from the creel census in Ross Lake which averaged 293 mm (City of Seattle 1973). Also, the 1971 and 1972 Ross Lake population was for fish greater than 200 mm.

Another problem with using Method 2 for estimating the pre-impoundment population was that it did not estimate abundance of older catchable size classes which may have been present in pre-impoundment streams. However, in steelhead systems, most of the production of "catchable" size fish is from the age 2 smolts. Therefore, the resulting estimate of catchable fish using this method was probably higher than would have been present before impoundment. We believe this method, based on the reasons presented above, overestimates the pre-impoundment number of catchable trout.

Method 3 attempted to compensate for some of the problems in Method 2. The weight of the estimated number of fish from Method 2 was converted to "equivalent" size fish in Ross Lake. Method 3 produced the lowest estimated number of catchable trout for the pre-impoundment period. This estimate is probably too low because older fish were not included in the calculation.

While the three methods have biases, they provide our best estimate of the range of trout population size in the project area. The estimates of post-impoundment catchable trout populations ranged from 4 to 27 times, but were probably 8 to 27 times, higher than the pre-impoundment populations. Moreover, the estimates consistently show that there was a net gain in catchable trout resulting from the Skagit Hydroelectric Project.

5.0 SUMMARY

significant impact (i.e., reduced the viability of the regional population) on the bald eagle, since salmon were unavailable or scarce in the upper Skagit River above the site of Gorge Dam.

- Four osprey nests were in the Study Area in 1987. Osprey production in the Study Area was close to that reported for other areas in western Washington.
- Rainbow trout were present throughout the Skagit River and accessible tributaries prior to construction of the Skagit Hydroelectric Project. Post-impoundment catchable trout population estimates ranged from 4 to 27, but were probably between 8 and 27 times higher than pre-impoundment trout populations.
- Historical information indicates that the falls and rapids on the upper Skagit River discouraged anadromous fish from migrating above the current location of Diablo Dam. However, small numbers of chinook salmon probably spawned at the Falls Creek and Cedar/Reflector Bar areas. A small number of steelhead probably returned to the Reflector/Cedar Bar and lower Stetattle Creek areas.

6.0 REFERENCES

Bell, M. 1980. Letter from Milo Bell (Engineer, Washington Department of Fish and Game) to Chas. Pollock (Supervisor of Fisheries). September 14, 1930. Washington State Archives, WDF/WDG files, Skagit River, Accession No. 73-7-675 (surface waters), Box 1010-40.

Bell, M. 1934. Letter from Milo Bell (Interstate Fish Conservn. Commit.) to B. Brennan (WDF). July 6, 1934. Washington State Archives, WDF/WDG files, Skagit River, Accession No. 73-7-675 (surface waters), Box 1010-40.

Belyea, G.Y. 1976. A nesting study of the red-tailed hawk in southern Michigan. Ph.D. Diss., Michigan State Univ., East Lansing.

Bent, A.C. 1953. Life histories of North American wood warblers. U.S. Natl. Mus. Bull. 203. 734 pp.

Bjorklund, J. 1987a. Personal communication. National Park Service, Sedro Woolley, Washington. Telephone Conversation with J.J. Brueggeman (Envirosphere Co.), September 1986.

Bjorklund, J. 1987b. Personal communication. National Park Service, Sedro Woolley, Washington. Phone conservation with J.J. Brueggeman (Envirosphere Co.), October 1986.

Bjornn, J.C. 1978. Survival, production, and yield of trout and chinook salmon in the Lemhi River, Idaho. Idaho Cooperative Fisheries Research Unit, University of Idaho, Moscow, Idaho. 57 pp.

Bock, C.E., and L.W. Lepthien. 1975. A Christmas count analysis of woodpecker abundance in the United States. Wilson Bull. 87(3):355-366.

Brewer, L.W. 1980. The ruffed grouse in western Washington. Washington State Dept. Game, Biol. Bull. 16. 102 pp.

Colinvaux, P. 1973. Introduction to Ecology. John Wiley and Sons, Inc. New York.

Collins, J.M. 1974. Valley of the spirits. The Upper Skagit Indians of western Washington. Univ. of Wash. Press, Seattle, Washington. 267 pp.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service Biological Services Program, FWS/OBS-79/31.

Craighead, J.J., and F.C. Craighead, Jr. 1956. Hawks, owls, and wildlife. Dover Publ., Inc. New York. 443 pp.

Custer, H. 1866. Report of Henry Custer, assistant of reconnaissances made in 1859 over the routes in the Cascade Mountains in the vicinity of the 49th parallel. Typescript. UW PNWC. 54 pp.

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Science. 33:43-46.

Davis, G. 1970. Cy Hentges interview of Glee Davis (deceased), Upper Skagit homesteader, 1893. Transcribed. National Park Service, Sedro Woolley.

Davis, G. No date. Interview in late 1950s to early 1960s. USDI, NPS, Sedro Woolley, H-14 Area and Service History.

DeShazo, J. 1985. Steelhead production plans - Columbia River basin memorandum. Washington State Dept. of Game. Olympia, Washington.

Dwelley, C.M. 1975. How one man planted first trout in high lakes of North Cascades. Skagit Valley Herald, May 8, 1975. Mount Vernon, Washington. Pp. 8-9.

Everest, F.H., G.H. Reeves, J.R. Sedell, D.B. Hohler, and J. Cain. 1987. The effects of habitat enhancement on steelhead trout and coho salmon smolt production, habitat utilization and habitat availability in Fish Creek, Oregon, 1983-1986. Div. Fish and Wildlife, Bonneville Power Administration. Portland, Oregon. 128 pp.

Federal Energy Regulatory Commission (FERC). 1980. Skagit River basin, Washington, water resources appraisal for hydroelectric licensing. Off. of Elect. Power Reg., San Francisco Regional Office. 70 pp.

Franklin, J., and C. Dyrness. 1973. Natural vegetation of Oregon and Washington. Pacific Northwest Forest and Range Experiment Station. USDA Forest Service General Technical Report PNW-8. 417 pp.

Ganskopp, D., and M. Vavra. 1987. Slope use by cattle, feral horses, deer, and bighorn sheep. Northwest Science 61(2):74-81.

Gibbons, R.G., P.K.J. Hahn, and T.J. Johnson. 1985. Methodology for determining MSH steelhead spawning escapement requirements. Report No. 85-11. Washington State Dept. of Game. Olympia, Washington. 22 pp.

Grabert, G.F., and D.J. Pint. 1978. An archaeological reconnaissance and cultural resource inventory of the North Cascades Natural Recreation Area. USDI, NPS, CX-9000-7-0026. Reports on archaeology, No. 5, NPS, Sedro Woolley. 99 pp.

Greelev, W.B. 1920. In the open - the National Forests of Washington. USDA, USFS, Dept. Circular 138. 78 pp.

Gullion, G.W. 1970. Factors influencing ruffed grouse populations. Trans. N. Am. Wildl. Nat. Resour. Conf. 35:93-105.

Gullion, G.W., and F.J. Svoboda. 1972. The basic habitat resource for ruffed grouse. Proc. Aspen Symp., U.S. For. Serv. Gen. Tech. Rep. NC-1:113-119.

Hann, H.W. 1950. Nesting behavior of the American dipper in Colorado. Condor 52(2):49-62.

Herron, W.H. 1916. Profile surveys in 1915 in Skagit River basin, Washington. USDI, USGS Water Supply Paper 419. Government Printing Office, Washington, D.C. 8 pp.

Information Builders Inc. 1982. Focus User's Manual, 1982 Edition. Information Builders Inc., New York, New York.

Ingles, L.G. 1979. Mammals of the Pacific States. Stanford University Press. Stanford, California.

International Boundary Commission. 1937. Joint report upon the survey and demarcation of the boundary between the United States and Canada, from the Gulf of Georgia to the northwesternmost point of Lake of the Woods. USGPO, Washington, D.C. 477 pp.

Jenkins, W.D. 1984. Last frontier in the North Cascades. Tales of the wild Upper Skagit. Skagit County Historical Society, Mount Vernon, Washington. 176 pp.

Johnson, T.H., and R. Cooper. 1986. Snow Creek anadromous fish research. Report No. 86-18. Washington State Dept. of Game. Olympia, Washington. 164 pp.

Morse, D.H. 1966. The context of songs in the yellow warbler. Wilson Bull. 78(4):444-445.

Nelson, W., S. Cooley, and T. Juelson. 1980. High Ross wildlife mitigation study annual report and on-site mitigation plan. Washington Dept. of Game report to Seattle City Light.

Nelson, W., S. Cooley, C. Olson, T. Juelson, R. Vanbianchi, and J. Gilstrom. 1981. High Ross wildlife mitigation study, High Ross wildlife mitigation, compensation, and enhancement plan. Washington Dept. of Game report to Seattle City Light.

Phillips, C., R. Cooper, and T. Quinn. 1981. Skagit River salmonid studies, 1977-1981. Report No. 82-1. Washington State Dept. of Game. Olympia, Washington.

Pitzer, P.C. 1978. Building the Skagit: a century of Upper Skagit Valley history, 1870-1970. Lake Grove Printing Co., Lake Oswego, Oregon. 106 pp.

Rhodes, M.J., T.J. Cloud, and D. Haag. 1983. Habitat evaluation procedures for planning surface mine reclamation in Texas. Wildl. Soc. Bull. 11:222-232.

Roberts, L.D. 1983. Riparian habitat in the proposed Grey Rocks Reservoir. M.S. Thesis. Colorado State University, Fort Collins.

Salo, L.J. 1978. Characteristics of ruffed grouse drumming sites in western Washington and their relevance to management. Ann. Zool. Tenn. 15:261-278.

Salt, G.W. 1957. An analysis of avifaunas in the Teton Mountains and Jackson Hole, Wyoming. Condor 59:373-393.

Smith, V.E., and M.C. Anderson. 1921. A preliminary biological survey of the Skagit and Stillaguamish rivers. Univ. of Washington School of Fisheries for Washington Dept. of Fisheries and Game. 76 pp.

Smoker. 1949. Memorandum to Mr. Hurley. January 17, 1949. Presumably an unofficial report within WDF. Washington State Archives, WDF/WDG files, Skagit River, Accession No. 73-7-675 (surface waters), Box 1010-40.

Soutiere, E.C. 1979. Effects of timber harvesting on marten in Maine. J. Wildl. Manage. 43(3):850-860.

Stanley, G.F. 1970. Mapping the frontier. Charles Wilson's diary of the survey of the 49th parallel, 1858-1862, while secretary of the British Boundary Commission. Toronto, Canada. 182 pp.

Taber, R.D. 1972-1976. Biotic Survey of Ross Lake Basin. Reports for five time periods. College of Forest Resources, University of Washington reports to Seattle City Light.

Thomas, J.W. 1979. Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. U.S. Department of Agriculture. Forest Service. No. 553. 512 pp.

Thomas, J.W., R.J. Miller, H. Black, J.E. Rodiek, and C. Maser. 1976. Guidelines for maintaining and enhancing wildlife habitat in forest management in the Blue Mountains of Oregon and Washington. Trans. N. Am. Wildl. Nat. Resour. Conf. 41:452-476.

Thompson, E.N. 1970. North Cascades National Park and Lake Chelan National Recreation Area, history-basic data. Office of History and Architecture, Eastern Service Center. 301 pp.

Thut, R.N. 1970. Feeding habits of the dipper in southeastern Washington. Condor 72:234-235.

Thurow, R. 1985. Middle Fork Salmon River fisheries investigation, job completion report. Project F-73-R-6. Idaho Dept. Fish and Game. 100 pp.

Urich, D.L., and J.P. Graham. 1983. Applying habitat evaluation procedures (HEP) to wildlife area planning in Missouri. Wildl. Soc. Bull. 11:215-221.

U.S. Fish and Wildlife Service (USFWS). 1980a. Ecological services manual - habitat as a basis for environmental assessment. 101 ESM Division of Ecological Services, Dept. of Interior. Washington, D.C.

U.S. Fish and Wildlife Service (USFWS). 1980b. An ecological characterization of the Pacific Northwest Coastal Region. Vol. 3. Characterization atlas zone and habitat descriptions. Biological Services Program. FWS/OBS-79-13.

U.S. Fish and Wildlife Service (USFWS). 1980c. Habitat suitability index models: American dipper. USFWS. Fort Collins, Colorado. 9 pp.

U.S. Fish and Wildlife Service (USFWS). 1980d. Habitat suitability index models: red-tailed hawk. USFWS. Fort Collins, Colorado. 16 pp.

U.S. Fish and Wildlife Service (USFWS). 1982. Habitat suitability index model: mule deer. USFWS. Fort Collins, Colorado. 15 pp.

U.S. Fish and Wildlife Service (USFWS). 1984. Draft habitat suitability index model: osprey. USFWS. Sacramento, California. 8 pp.

U.S. Fish and Wildlife Service (USFWS). 1985. A users manual for HEP Accounting program for microcomputer users, version 2. Fort Collins, Colorado.

U.S. Fish and Wildlife Service (USFWS). 1987. A users manual for MICRO-HSI. Fort Collins, Colorado.

U.S. Forest Service (USFS). 1964. USFS fish and wildlife study of the North Cascade Mountains. USDA, USFS. 82 pp.

Vanbianchi, R., and S. Wagstaff (in press). Floristic survey of Big Beaver Valley. Washington Native Plant Society Occasional Papers.

Von Velzen, W.T. 1981. Forty-fourth breeding bird census. Am. Birds 35(1):46-112.

Wahl, J.R., and D.R. Paulson. 1971. A guide to bird finding in Washington. T.R. Wahl, Bellingham, Washington.

Wiseman, A.B. No date. Notes on fish planting activities. NPS, Gretchen Luxenberg files, Seattle, Washington.

Wydoski, R.S., and R.R. Whitney. 1979. Inland fishes of Washington. University of Washington Press, Seattle, Washington. 220 pages.

7.0

ANNOTATED BIBLIOGRAPHY OF THE UPPER SKAGIT RIVER FISHERIES

7.0 ANNOTATED BIBLIOGRAPHY OF FISHERIES RELATED LITERATURE FOR THE UPPER SKAGIT RIVER

The following references were examined for information on anadromous and resident fish occurrence and barriers to their passage in the Upper Skagit River. For each reference, the citation is followed by the library/repository location and call number, if applicable. The narrative for each reference may contain direct quotes.

The bibliography is organized into five sections. Section 7.1 contains state and city authored correspondence and reports. Section 7.2 has only correspondence of federal origin. All other references are in Section 7.3 (including federal reports). Section 7.4 has notes or findings for various archives and is intended to assist future investigators.

7.1 STATE AND CITY AUTHORED CORRESPONDENCE AND REPORTS

Bell, M. 1930. Letter from Milo Bell (Engineer, Washington Department of Fish and Game [WDFG]) to Chas. Pollock (Supervisor of Fisheries). September 14, 1930. Washington State Archives, WDF/WDG files, Skagit River, Accession No. 73-7-675 (Surface waters), Box 1010-40.

Milo Bell, an engineer who consulted for or was employed by the State, characterized his impressions from a trip to the Skagit projects, while Diablo Reservoir was filling (would be full by about year end, 1930). Bell observed that with water retention at Diablo (to fill the reservoir), there was less flow for the Gorge powerplant and all available water below the Diablo Powerhouse was diverted into the Gorge Powerhouse tunnel by the Gorge diversion dam (i.e., little or no spill). Therefore, there was a wide fluctuation in water level below the Diablo Powerhouse and Gorge Canyon was nearly dry (in places); seepage water occurred only in a small area of river bed and resident fish were "practically exterminated." Bell commented about great bars being alternatively covered and uncovered by the regulation at Diablo Dam and speculated that there were thousands of small fish left stranded in pot holes or upon the banks due to these fluctuations. He observed large flocks of birds feeding in those areas. [Bell was probably referring to juvenile, resident trout, or whitefish in the Cedar and Reflector Bar areas.] Bell believed that with fall rains and a full reservoir, the fluctuation problem would be reduced.

Bell further asserted that given the seasonal low flow conditions in the tributaries plus, "...lowering of the Skagit [caused] a delta area over which the small upper streams spread, and would in some cases, make the ascent into the streams from the main river hard for the migrating salmon..." Bell also stated that the area above Newhalem had become lost to migrants and that attempts of migrants to pass Newhalem should be prevented because river flow fluctuation would exterminate them. [It is assumed that in the first statement (in quotes), Bell is referring to the Skagit River below Newhalem since there were no suitable salmonid spawning habitats in the Skagit or its tributaries between Newhalem and Gorge Dam (Smith and Anderson 1921; early resident observations); and there was evidence of low flow problems even below the Gorge Powerhouse (Chapman 1936).] As to the character of the Skagit above Gorge Dam to Diablo Dam, Bell made the confusing comment that the channel, "...was apparently favorable to migrating fish if they were able to ascend the canyon between these points, which is not at all favorable for spawning purposes or as a migrating channel." Bell could only define mitigation responsibilities by saying, "Past records will show how much spawning area has been destroyed but regardless of this there will be a loss due to the power regulations which should be compensated for."

Bell, M. 1934. Letter from Milo Bell (Interstate Fish Conservn. Commit.) to B. Brennan (WDF). July 6, 1934. Washington State Archives, WDF/WDG files, Skagit River, Accession No. 73-7-675 (surface waters), Box 1010-40.

Comments by Milo Bell from another visit to the Upper Skagit. Bell stated, "At this time Mr. Russell of the U.S. Bureau of Fisheries was of the opinion that there would be considerable loss of Chinooks in the canyon [Gorge Canyon] when the river went dry."; and the river was "dry" below Gorge Dam during Bell's visit. In an attempt to instill one viewpoint on predevelopment fish passage, Bell wrote, "I understand that it had been customary for salmon to ascend through the canyon and spawn in the neighborhood of Reflector Bar which is below the present Diablo Dam." Bell gave no reference for this statement. Bell continued, "However, with the construction of the Gorge Dam in 1924 [1920] salmon were unable to make the canyon above this dam as there was no provision made in it for fish migration. If Chinook salmon or steelhead trout still ascend as far as the Gorge Dam they would either be forced out of the canyon or trapped and perish as the section of the river between the Gorge Dam and the Gorge Powerhouse goes practically dry in the low water season or when the river is regulated from the Diablo reservoir." Bell pointed out that due to rapid river fluctuations induced by power regulation, fingerlings were trapped in pools and subjected to predatory birds or to drying up. It is not clear if Bell was referring to resident trout between Gorge Dam and Diablo Powerhouse or to salmon and trout below Newhalem. The latter seems to be the case given that Bell's next statement must be meant to include the Skagit below Newhalem, "In a river the size of the Skagit the destruction of fish life by power operations can not be estimated."

Brennan, B., and B. McCauley. 1936. Letter from B. Brennan (Director, WDF) and B. McCauley (Director, WDG) to J.D. Ross (Superint. Dept. Lighting, Seattle), attention to W.J. McKeen (Acting Superint.). February 27, 1936. Washington State Archives, WDF/WDG files, Skagit River, Accession No. 73-7-675 (surface waters), Box 1010-40.

After referring to the 10 February 1936 conference between the State and City, this joint letter stated that the, "...following facts were ascertained:

Chapman recounted his visit with Frank Pressentin, an old-time area homesteader at Marblemount, "...before the dam was put in at Newhalem a few steelhead used to go up as far as Steattle Creek and Reflector bar which is at the Diablo Dam site, but to the best of his knowledge no salmon ever went through the gorge [Gorge canyon]. He said, however, that the City Light varied the depth of the river to such an extent that the spawning of the salmon as far down as Marblemount was seriously interfered with." While at Marblemount, Chapman went to see Sadie Sarblinge who had run a hotel there for many years. There was a beer party in progress and he could not obtain any information.

At Concrete, Chapman spoke with Ed O'Brien, "...who had been all through the Upper Skagit country many years before the City of Seattle began construction. "...he said that there were never any salmon beyond Newhalem that he knew of." Next Chapman went to see Otto Pressentin at the ferry above Birdsview. A life-long area resident, he said, "...that there were never any salmon above the Newhalem gorge and that he knew because he had been there looking for them." At the Birdsview Hatchery, Joe Kemmerich (of the U.S. Fisheries Bureau) said he had not been above Newhalem before construction started. Kemmerich researched the Bureau's records for Chapman. Kemmerich found one excerpt from a field trip by J.T. Hagen [this report was not found in the state or federal archives]. Chapman wrote that, "In none of his [Kemmerich's] records could he find a report of salmon being found above the Newhalem dam site before the dam was built." Kemmerich referred Chapman to, "...Tommy Thompson, who was born at Birdsview and had been a Forest Ranger at the Backus Station for 21 years, as a man who knew the situation well and whose word word I could rely upon. [Thompson also manned the Boundary Station until flooded by Ross Lake and developed quite a reputation as the caretaker/samaritan for the Upper Skagit residents, as well as, the federal lands]. I went back up the river and saw this man. His report was the same. No salmon above Goodell

Creek, which empties near Newhalem and only a few steelhead. The steelhead used to spawn in Steattle Creek to a small extent in former years but never went above Reflector Bar at the Diablo Dam site."

Chapman then went to Hope, British Columbia, and interviewed Tom Scott (30 years with Dominion Fisheries Board). Scott said, "...that neither salmon nor steelhead ever come up into the B.C. part of the Skagit." Chapman also spoke with Bob Robertson (Skagit River resident in B. C. for many years); Robertson said, "...that never in early years did he see a salmon or steelhead in the Skagit."

Chapman summarized his findings: "The concensus of opinion appeared to be that even before the City Light of Seattle began construction on their dams on the Skagit the salmon run ended at Goodell Creek and the steelhead run at Steattle Creek, which is above the Newhalem Dam [Gorge dam] site."

McKeen, W.J. 1936. Letter from W.J. McKeen (Acting Superint. of Lighting, SCL) to Miller Freeman (Chairman, Fish. Div., Wash. State Planning Council). January 31, 1936. Washington State Archives, WDF/WDG files, Skagit River, Accession No. 73-7-675 (surface waters), Box 1010-40.

In this letter to the State, City Light said they would welcome a conference to discuss commercial and game fisheries in the Skagit River. The letter repeats information from the August 12, 1927 conference when State fisheries personnel Pollock and Mayhall stated there were no salmon spawning above, "Falls Creek...about a mile above the Gorge plant." Falls Creek was not specifically mentioned in the City Light Engineer's MEMO from August 12, 1927. The 1936 letter continues, "It was understood at that time [August 12, 1927] that "...any provision to take care of salmon...at Diablo or Gorge...would be entirely useless, because no salmon had been known at those points." The City expressed a desire to, "...preserve our fisheries...keeping up the wonderful trout fishing..." Thus, City

Light wanted to operate under the statements made by the State in 1927 (no migratory fish habitat loss) and to just proceed with enhancement of the resident trout fishery in the reservoirs.

McKeen, W.J. 1936. Letter from W.J. McKeen (Acting Superint. Lighting) to B.M. Brennan (Director, WDF). March 3, 1936. Washington State Archives, WDF/WDG files, Skagit River, Accession No. 73-7-675 (surface waters), Box 1010-40.

This letter was a response to the February 27, 1936 joint WDF/WDG letter (Brennan and McCauley 1936). City Light concurred with item (1). However, pertaining to item (2) the City asserted, "Your finding that runs of steel-head into Stetattle Creek and the dam area (presumed to mean Diablo Basin) have been destroyed, is directly contrary to the conclusions of that conference. It is also contrary to all experience and observation by City of Seattle representatives since 1917. [The City was probably incorrect here since a few steelhead had been reported in the Stetattle Creek/Reflector Bar areas, presumably by the USFS and others (e.g., Thompson, USFS).]

"Steel head have been reported at Bacon Creek, and at Newhalem Power House just above Newhalem Creek. Numbers of fish-carcasses, reported to be those of spawned humpback salmon, have been observed in Goodell Creek for years past,- and this condition still continues. But if you have any proof, that will withstand court questioning, of steel head runs into Stetattle Creek, we shall be glad indeed of a chance to study it."

Continuing, ..."Statement made at the February 10th. conference, that steel head had been caught in the area above Diablo dam-site, is also directly contrary to all known experience. An opinion, dated February 19th., from Regional Director of fisheries Fred J. Foster, states:

> `It is at this time the general opinion among ichthyologists that the rainbow and the steel head are one and the same fish.'

height [greater] and in a manner so that it can be used to control floods of the skagit River in lieu of a special flood control dam planned by the USCOE at Faber." Continuing, "...Ross Dam is not in any way related to the migratory fish of the Skagit river and the impounded water behind the dam greatly augment the game fish in the area."

Morse, W. 1927. Letter from W. Morse (City Light) to C. Pollock (WDFG/Div. Fish.). August 13, 1927. Washington State Archives, WDF/WDG files, Skagit River, Accession No. 73-7-675 (surface waters), Box 1010-40.

The City sent a letter to the State Department of Fish and Game (the agency separated into two departments in 1932) giving official notice of the construction of Diablo Dam. To implement full cooperation of the City and State, City Light requested the requirements of the "Fisheries Industry" in this letter.

Nye, Gene D., and W. Dale Ward. 1966. Skagit River Fisheries, 1965. State of Washington Department of Fisheries, Statistics Section. 5 pp. Washington State Archives, WDF/WDG files, Skagit River, Accession No. 73-7-675 (surface waters), Box 1010-40.

This report is not directly relevant to the Upper Skagit fish and wildlife study and contains mostly sport and commercial catch data. One quote about the Upper Skagit below Newhalem, "The river section of 14 miles from Marblemount to Newhalem has been observed by Department employees as a prime spawning area."

Seattle City Light. 1936. Memorandum of conference between State and City personnel. February 10, 1936. Present: Miller Freeman (Chairman Fish. Div., Wash. State Planning Council), Bernard McCauley (Dir., WDG), Bertram Brennan (Dir., Commercial Fisheries Div.),

Milo Bell (Fish. Engineer); McKeen, Smith, and Moore (all SCL). Washington State Archives, WDF/WDG files, Skagit River, Accession No. 73-7-675 (surface waters), Box 1010-40

This memo is the only record located that summarized an important conference that was to supposedly (and finally) settle fishery mitigation responsibilities between the City and the State. The City reiterated statements of record (from the previous year and from the August 12, 1927 conference with the State), "...that the city had done no damage by building Diablo dam or Gorge intake." And that, "...no provision for taking care of fish was made in connection with Diablo dam."

In a change from the previous policy stand on Upper Skagit migratory fish impacts, at this 1936 conference the State began pressuring City Light to acquiesce to the State's current concepts on fishery impacts. A City Light MEMO recorded the meeting, "Mr. Brennan [Dir. Commercial Fish. Div.] stated that his records would show unquestionable damage to the fish run [i.e., anadromous fish blockage], especially the steel head, and Mr. Bell called attention to the damage to small fish on the way down stream, because of extreme fluctuations in the stream due to regulating the stream for operation of the power plant." Continuing, the fishery agencies said that undoubtedly the State could win a case and quoted Mr. Ross' (City Light Superintendent) long record of cooperation, and care to maintain and increase wildlife.

Further discussion centered on the location for a fish hatchery. "Mr. Brennan explained that the Fisheries Department considered that a hatchery on the Sauk would be the best means of restoring the salmon in the Skagit river. Reluctance was expressed by Glen Smith to the city's building and maintaining an establishment so far away from its own works and apparently so little connected with any damage it may have caused. He suggested that a hatchery on Goodell Creek might serve the purpose. The representatives of the State, however, insisted that Goodell Creek would not be satisfactory for a hatchery, and that it should go on the Sauk River."

Then, to booster their argument, the State gave examples of other utilities who paid large amounts of money and that the City should do its part. The City said it did not want a lawsuit nor will it dodge responsibility, but the City, "...would like definite facts and recommendations..."

Smoker. 1949. Memorandum to Mr. Hurley. January 17, 1949. Presumably an unofficial report within WDF. Washington State Archives, WDF/WDG files, Skagit River, Accession No. 73-7-675 (surface waters), Box 1010-40.

This memo covers an inspection with Phil Stewart, Engineer (WDG) of two miles of channel between Gorge Powerhouse and Gorge Dam on January 11, 1949; and concerns the proposed Gorge Dam developments, i.e., the first Gorge Dam rebuild (to a greater height)for the 30 year old wooden diversion structure.

Smoker wrote: "At the time of inspection there were at least several thousand second feet flowing in the stream, but it was obvious that even at a much lower stage the channel would not be worth much as far as providing spawning area for salmon species. About 1/8 mile above the Gorge power house a swift rapids area extending about 75 feet was observed which probably serves as the upstream terminus of all anadromous salmonids. In a conversation with the train-man who has been making daily trips up the river for many years, he stated that he has seen salmon and steelhead attempt this barrier but to the best of his knowledge only a few steelhead have ever made it."

"Above this first barrier the stream has a cascade nature and no spawning beds occur. There are a few beds of large rocks about the size of base-balls [acceptable for chinook and steelhead spawning if

This is a summary of the legal contract between the City and the State concerning fishery impacts on the Skagit River. The document first lists "facts", e.g.:

> FACTS: (1) constructed three dams "...destruction of the salmon, steelhead and cutthroat trout runs to a small extent in the area above the Gorge Dam and to a considerable extent in the portion of the Skagit River extending downstream from the Gorge Dam to the confluence of the Cascade River."

The next major section was titled: "Action to be Taken for the Protection of Fish Life in that Portion of the Skagit River Affected by the Construction of Ross, Diablo and Gorge Dams." And stated:

1. "Very few spring chinook salmon ever spawned above the site of the Gorge Dam. Some steelhead spawned above the site of the Gorge Dam. The construction of fishways over said dams would be impracticable in the opinion of the Director of fisheries. Large annual runs of chinook, silver and pink salmon and steelhead and cutthroat trout have utilized that area of the Skagit River lying between the Gorge Dam and Marblemount, Washington and its tributaries for the perpetuation of their kind. Small runs of chum and dog salmon have done likewise. In addition, there is probably an indigenous trout population not dependent on anadromous steelhead and cutthroat trout for its maintenance."
2. stated that the City has artificially fluctuated the flow...each day with few exceptions.

Continuing:

3. "A definite observed daily mortality to young salmon and trout...at low flow...damage reaches its peak during the gravel emergence stage of the young fry, January 1st to June 1st, extending...for steelhead, to a later date."
4. "...definite observed mortality of adult pink and chum...at low flow...and some mortality may occur in adult chinook, silver and steelhead although no kills have been observed."

Regarding mitigation for fish losses due to river level regulation, the letter stated that the law requires replacement in kind or financial compensation (cites supporting laws). Discussing resident trout, are fish protective facilities needed at Ross Dam? Letter cites Smith and Anderson (1921): "no salmon above Goodell Creek, locals have never seen salmon more than one mile above Newhalem." So, the USFWS concluded, "On the basis of these reports, neither the State of Washington nor this office believes there is any need for the construction of fishways on either the Ross Dam or on the two dams located farther downstream. Existing fish populations in the affected area above the dam are resident in type, and considered non-migratory."

Getting back to the fluctuation issue, the letter said, "The principal fish problem in the Skagit River has been created by the abrupt daily changes in the flow of the Skagit River, necessitated by lack of available storage." Some flow data are given, times, etc. (e.g., sudden change from 5000 cfs to 55 cfs). Continuing, "The 15 mile area extending upstream from the Cascade River to the Gorge dam is one of the principal spawning grounds for chinook, silver and pink salmon. Some chum salmon and steelhead and cutthroat trout also spawn in the same district. The rapid daily fluctuations of the river, according to investigations by the WDF, show that adult pink salmon are the most seriously affected, as many as 1900 being killed in one day when the river was dropped to a minimum flow of 295 cfs. The most serious mortality is brought about in the spring of the year by the stranding of salmon and cutthroat fry, just emerging from the spawning nests. The limitation in the contract on the daily reduction of flow to 1000 cfs, which is noted in Mr. Fuquay's letter as above the normal minimum flow, is designed to keep the spawning beds in the main river channel completely covered with water at all times. As long as the stream bed is not exposed by rapidly receding water, the water fluctuation is of little or no consequence so far as fish life is concerned. Because of artificial regulation of the Skagit River, the original minimum flow no longer has any relation

to the adequate maintenance of fish population...the figure of 1000 cfs in the contract is the absolute minimum amount to be considered practical and still maintain the fish runs in the important spawning and feeding area below the Gorge Dam."

Statements summarized from the letter: Due to unnatural conditions, fish spawn in areas that would naturally be exposed (during spawning time); later regulated lowering would expose the spawn. Therefore, normal low flow has no relation in an artificially regulated system. City previously agreed to 1000 cfs low flow. Penalties provided in the contract are discussed. Then, conclusions and recommendations are given.

Kemmerich, A. 1946. Letter from Alphonse Kemmerich (Acting Regional Director, USFWS) to Milo Moore (Director, WDF). October 3, 1946. Washington State Archives, WDF/WDG files, Skagit River, Accession No. 73-7-675 (surface waters), Box 1010-40.

No relevant information. This is a cover letter for enclosed material covering items such as described under the USFWS September 30, 1946 intraagency letter.

Dater, P. 1926. Letter from P. Dater (District Forest Service Engineer) to C.H. Park (Forest Supervisor, Bellingham). April 22, 1926. Federal Archives and Record Center (FARC), Seattle, WA, Record Group 95, Mt. Baker-Snoqualmie, Accession 59-A540, Box 28217.

Letter displays the policy of deferring enforcement action, such as mitigation for fish and wildlife, to the State, "Ordinarily we require licensees to conform with State laws with respect to construction of fishways around dams or the building of hatcheries to take the place of a fishway. It is therefore not necessary for us in our report to the Commission to make special recommendation as to the construction of fishways or hatcheries but merely to make a requirement that the permittee shall build fishways or hatcheries as may be required by State law. Does this requirement in your judgment cover the needs in the Skagit situation?"

Granger, C. 1926. Letter from C. Granger (USFS, District Forester) to Executive Secretary, FPC. January 20, 1926. FARC, Seattle, WA, Record Group 95, Mt. Baker-Snoqualmie, Accession 59-A540, Box 28217.

Cover letter pertains to the FPC license change October 1, 1924 for the Skagit projects, with photos and topographic blue prints, etc. of the Diablo site. This letter was providing information from local USFS to FPC concerning possible constraints on the license (e.g., telephone line protection, etc.); no relevant fish or wildlife material.

U.S. Forest Service. 1920. Memorandum for engineering from USFS (Portland) to Park (USFS, Superintendent, Bellingham). March 8, 1920. FARC, Seattle, WA, Record Group 95, Mt.Baker-Snoqualmie, Accession 59-A540, Box 28217.

This letter seeks input for response to the City's Final Power Permit, amendment: to build 2 dams Diablo/Ruby instead of 1 (Ruby) to control flow for the later Gorge Dam rebuild (too narrow and too high a flow at Gorge to allow an economical rebuild to the desired scale without having total flow control).

The letter refers to obtaining a Special Use Permit for a $10,000 fish hatchery on a side stream, as mitigation for Gorge Dam. Excerpt:

> "Mr. Cecil (Dist. Forester) states after conference with City officials, that the City of Seattle does not desire to install a fish ladder under the Snoqualmie permit but will accept the alternative provided by State law, namesly [namely], to build a fish hatchery for the State Fish Warden."

7.3 GENERAL REFERENCES INCLUDING FEDERAL PUBLICATIONS

Baker, Marcus. 1900. Survey of the northwestern boundary of the United States, 1857-1861. Washington Dept. Interior, USGS Bulletin No. 174. 69 pp. UW PNWC, N 979.518 B17s.

A very abbreviated summary report on the 49th. parallel boundary survey in the Northwest. This document calls attention to what natural history information may have been published. The U.S. Boundary Commissioner's (A. Campbell) report, referred to by Baker, does not exist. On page 61: "Scientific Results," are reports to be included in the final report of the commission (by A. Campbell, Commissioner); some examples listed:

- Theodore Gill, report on fishes.
- George Suckley, report on salmonidae, ornithology, and mammals.
- Elliot Coues, report on birds, etc.
- John Torrey, report on botany.
- J.H. Richard, drawings for natural history reports.

Baker wrote, "Mr. George Suckley, M.D., assistant surgeon, United States Army, read before the New York Lyceum of Natural History, in June, 1861, a paper entitled "Notices of certain new species of North American salmonidae, chiefly in the collection of the Northwest Boundary Commission...I have prepared a copious synopsis of the species of American salmon and trout, to appear in the final report of the commissioner." (Annals Lyceum Nat. Hist. New York, vol.7, pp.314-318, 1861.)

No such reports were found (searched UW PNWC, Govt. Publications, and microfilm). The Commissioner's (Archibald Campbell, esq., commissioner of the United States) final report was never published, and probably was lost (see Thompson 1970, p. 47).

Columbia Provincial Government, Fish and Wildlife Branch. 1970. Effects of increased water storage levels in Ross reservoir on fisheries and wildlife, a preliminary report. 20 pp. FARC, Seattle, WA, Record Group 95, Portland, Oregon.

This report examines the High Ross effects on the Skagit Valley in Canada and stated that a more comprehensive document was to be prepared. Concerning resident trout, the document contains information (but no data) on the Skagit River, tributaries, and flooding effects (spawning area, food, etc.). Also included are material on higher reservoir and water fluctuation effects, public access, and fishing value. All information is qualitative.

Campbell, Archibald. No date. Northwest Boundary Commission - records relating to the first Northwest Boundary Survey Commission 1853-1869. U.S. National Archives Records Group 76. MF, 3 rolls. UW Microfilm, A1265.

Contains mostly items of correspondence in original handwriting; no obvious indication of any fish, wildlife, or flora reports as mentioned in Baker (1900).

Campbell, Archibald. 1890. Final report to the House of Representatives, September 16, 1890. H.M. 51-1, vol.16, no. 16, 1 p., fisch. 2775. Reference from UW Govt. Pub.

This appears to be just a letter (1 page), the final report was not published.

Collins, June M. 1974. Valley of the spirits. The Upper Skagit Indians of Western Washington. University of Washington Press, Seattle, Washington. 267 pp. UW PNWC, E99 S627 C64.

particularly the Columbia River area. There is no specific mention of the Skagit River in this report. Many and different species of salmon were defined at that time (versus current taxonomy).

Custer, Henry. 1866. Report of Henry Custer, Assistant of reconnanissances made in 1859 over the routes in the Cascade Mountains in the vicinity of the 49th parallel. Typescript. 54 pp. UW PNWC, F 891 C98 1866. [Also referenced via: Wasem, Robert (NPS, Sedro Woolley), October 5, 1871 letter to Gary Engmann (WDG, Seattle), for trout and Skagit rapids reference.]

The earliest account that provides an accurate description of potential barriers to anadromous fish on the Upper Skagit River comes from Henry Custer's journal. This journal contains information on rapids in the Upper Skagit area only because of the comprehensive nature of Custer's reporting. The prosaic nature of Custer's writing makes the document entertaining, as well as informative. While negotiating the Upper Skagit River in a canoe, Custer was probably describing Big Beaver Creek when he wrote, "...we passed the mouth of a large tributary from the West, forming a wide Ravine which extended to the foot of Main cascade Ridge." Custer continued, "From here the river bed assumes rapidly the Character of a Canon, its waters dashing forward with great impetuosity."

"After another 1/2 hour navigation, we rapidly enter the beginning of a canon...The river flows here between rocky banks, with a swiftness & impetuosity which even makes my expert Indian canoe men feel more or less uncomfortable. From the anxious looks they cast around, I conclude that it is time to look out for a secure harbor for our canoe. When we had reached a little eddy, in a convenient little nook of the roky River bank, forming a cosie little harbor, the Indians gave vent to a yell of satisfaction..."

Davis, Glee. 1970. Cy Hentges interview of Glee Davis (deceased), Upper Skagit homesteader, 1893. Transcribed. National Park Service, Sedro Woolley. NPS, Sedro Woolley, F897. W57 D39.

Glee Davis was an Upper Skagit resident from 1890-1929; his mother started the Cedar Bar road house (see Figure 1). Davis worked for the Forest Service and City Light. In interviews with the Park Service, Glee Davis gave firsthand information on fish passage in the Skagit and its tributaries. Excerpts from the interview follows (D = Davis, H = Hentges-interviewer) page 11:

H: Ah...before the area which is now Ross Lake was flooded, was there quite a falls entering...dropping out of the Beaver Valley?

D: Oh yes.

H: How...how great a drop was it?

D: Well ah...

H: 2 - 300 feet...400 feet?

D: It was a...in the neighborhood of...

H: 100 feet?

D: ...about 300. It was one fall after another.

H: Cascade then?

D: Yes.

H: Rather than a direct...

D: They were ah...well they were a high falls...yes. I would say ah...I'd never explored all of them but...couple of them I've seen. It'ld run ah...probably 60 feet...the direct drop.

H: Was it quite spectacular? Have you seen it...

D: Yes...

H: ...in the spring when the runoff was quite heavily? (or heavy).

D: Well...yes I've seen it ah...when it was ah...

H: Was that the only hanging ah...valley there or falls actually dropped out...Little Beaver wasn't a...a...

D: Well...it would...

H: Cause now they're...

D: ...it would be good spawning grounds from at the mouth of Ruby on up the Skagit...that...that

H: Yet you had trout up there...other trout?

D: Yea.

H: How'd they get up there?

D: Well ah...I suppose they ah...trout will go where salmon won't, of course, they ah...they'll...

H: Course, right, you'd mentioned that the salmon were pretty beat up and they might have gone...to the point where they had to start spawning.

D: Yea.

H: ...you know.

D: They'd spawned out by the time they had got up there.

H: Uh hum. That could have a lot to do with it.

D: They ah...in fact ah...up around the mouth of Goodell Creek would be the last good spawning ground. There was a beach on this side of the river at the ah...powerhouse. There 'as quite a beach there. Then from there on up you wouldn't hardly find a s...beach until you got to Ferry Bar. Then there was some beach in there. But ah...the ah...salmon were pretty well beaten up by the time they got...

More questions on wildlife, then questions of fishing.

H: Did...did you fish a lot?

D: Oh yes...

H: What's the largest fish you've pulled out of the creek or river?

D: Well my mother got the...

H: Legally or illegally you don't have to tell me. (laughs). I was just...

D: Oh...ah...well the largest rainbow I know of was...my mother caught it...was ah 20.5 inches. I remember...

H: 20.5 inches.

D: I never caught one quite that large but...we used to get them oh...ah 14 to 18 inches quite a lot.

H: How about steelhead or salmon?

D: They never ah...come up you see...

Davis, Glee. No date. Interview in late 1950s to early 1960s. USDI, NPS, Sedro Woolley, H-14 Area and Service History. NPS, Sedro Woolley; also referenced in: Roger Contor (NPS, Sedro Woolley) letter to Erwin Thompson (NPS, Washington, D.C.) September 25, 1969.

No additional material on fish passage or occurrence. Some relevant information for flora and wildlife.

Deutsch, Herman J. 1862. United States - Canadian boundary in the Pacific Northwest, surveying the 49th parallel, 1858-1861. Washington State Hist. Soc. 17 pp. UW PNWC, N 979.508 P19 No. 2.

Another report on the first boundary survey. No relevant material for the Upper Skagit River fish and wildlife study.

Dwelley, Charles M. 1975. How one man planted first trout in high lakes of North Cascades. Skagit Valley Herald, May 8, 1975, Mount Vernon, WA. p. 8-9. UW Manuscripts.

This article describes how A.B. (Brown) Wiseman, former Skagit County Commissioner, was responsible for planting millions of fish in the high lakes and streams of the North Cascades. There were approximately 50 plantings from 1927-1936. Some of the sites were listed, "Lakes included Sauk and Baldy, Monogram, Jordan Lakes, Watson Lakes, Anderson, Clear, Stilwell, Bear, LaRush, Martin, Ann, Lower and Upper Falls, Slide, Illabot, Jug, Lily Pad, and some replantings and restocking of water already holding fish. These ranged from the Cascade River watershed, south of the Skagit into the Illabot Lake district, some north of the Skagit and many in the Baker Lake area, into Whatcom county. Almost all were barren waters until

Wiseman and his crew brought fish....stocked streams of all sizes encountered along the route to the various lakes. Also, trips were made purposely to stock streams as near their source as possible, above high falls and, in larger streams, above each level of falls that would prevent fish from reaching them by migration. Those flowing into the Skagit River were Jackman (3 different plants above falls 1, 2 and 3), Diobsud, Illabot and Boulder."

Federal Energy Regulatory Commission. 1980. Skagit River basin, Washington, water resources appraisal for hydroelectric licensing. Off. of Elect. Power Reg., San Francisco Regional Office. Appraisal report. 70 pp. Washington State Archives. WDF/WDG files, Skagit River, dams.

Publication has general public relations material; good for summary hydrologic data, river profiles, etc. Also has an aerial photo of Diablo Dam that gives a good perspective of the existing (remaining) canyon. Content items: existing use report; potential hydrologic and hydropower developments; other resources; fish and wildlife information (no new material); river profiles; development map; dam picture (aerial) of Diablo Dam.

Grabert, G.F., and D.J. Pint. 1978(?). An archaeological reconnaissance and cultural resource inventory of the North Cascades Natural Recreation Area. USDI, NPS, CX-9000-7-0026. Reports on archaeology, No. 5. 99 pp. NPS, Sedro Woolley.

Archaeological study of the North Cascades for the National Park Service. Concerning wildlife the book reports that the Upper Skagit Indians hunted many small animals. Larger animals of importance were: mule deer, white tail deer, mountain goat, bighorn sheep. Other game included: beaver, mountain beaver, and Grizzly bear. The only information on flora were mentions of plants, seeds, and herbs for diet and medicinal uses. Camas bulbs were important in the spring and berries in the fall.

Regarding fishery topics, the authors state that salmon were usually caught in territorial spots where runs were large, generally these places were below Marblemount. They write, "Although salmon played an important role in the subsistence pursuits of the Thompson [lived in the Canadian Skagit to the U.S. Upper Skagit areas], Nooksack, and Upper Skagit, these fish did not occur in the surveyed area since they could not ascend the Skagit gorge [presumably, Diablo Canyon] or Chelan Falls. Their salmon fishing was done outside the Park Complex."

Considering trout, the Indians did have campsites (e.g., Hozomeen site) in the Ross Reservoir area and crossed the mountains on hunting trips or social journeys (throughout the year) to eastern Washington, they caught resident fish only. Due to the absence of salmon and relatively low densities of trout (vs. salmon in the lower rivers) in the upper hills and mountains the authors state, "Fishing, however, may not have been the major food source of the prehistoric peoples who utilized the North Cascades area that it was for people in more favored locales [coastal]."

Greelev, W.B. 1920. In The Open - The National Forests of Washington. USDA, USFS; Dept. Circular 138. 78 pp. UW Forestry, 634.9 Inl.

This is an early Forest Service public relations document that extolled the wildlife and scenic virtues of the Upper Skagit (and other areas in the then Washington National Forest). Page 41 refers to the Upper Skagit by saying, "Just below Big Beaver Creek the river gains momentum and is literally turned on edge as it passes between the frowning walls of Canyon Diablo, a narrow cleft scarcely 10 feet across, with sheer walls rising upward 150 feet. At low water the canyon may be penetrated by boat."

"Emerging from this defile, the river spreads out into a great rock-walled pool, rushing over the rocks and down into the broadening valley in a series of foaming rapids 7 miles in extent."

Greelev portrayed the fishing by saying, "The Skagit River, which crosses the line from British Columbia, forms with its tributaries the main drainage. For about 20 miles the stream flows south, between low wooded banks, through a comparatively broad valley. Here and there it forms deep, dark pools which tempt the ambitious angler. [Ambitious because of access difficulty.] ...The main upper Skagit River and its tributaries-including Ruby, Lighting, Big Beaver, and Little Beaver Creeks-are filled with rainbow, Dolly Varden, black-spotted, and steel-head trout [referring to rainbow, in general?], and offer unsurpassed fishing....Splendid fishing is offered by nearly all the streams on the Washington Forest."

Herron, William Harrison. 1916. Profile surveys in 1915 in Skagit River basin, Washington. Washington, D.C.: Govt. Printing Off., Dept. of Interior; USGS Water Supply Paper 419. 8 pp., 6 maps and 6 stream profiles. UW PNWC and Nat. Sci., N 979.73 H436p.

This is a report of a survey of the Upper Skagit River that was conducted by the USGS in 1915 to identify the potential for hydropower development. This report contains 5 foot contour interval maps of the Skagit River and of lower Ruby and lower Big Beaver Creeks. These maps do not identify barriers or falls, but could be utilized to determine stream flow characteristics and hence, the theoretical possibilities for anadromous fish passage. The report also includes survey information for the Suiattle and Sauk Rivers.

International Boundary Commission. 1937. Joint report upon the survey and demarcation of the boundary between the United States and Canada, from the Gulf of Georgia to the northwestern most point of Lake of the Woods. USGPO, Washington, D.C. 477 pp. UW PNWC, 973.58 In81j.

This report is a general discussion on survey work with no specific information on fish or wildlife. There were comments on:

- Grazing areas for pack trains,
- Game for food,
- Fish for food, etc.

Page 83 refers to creek/valley names; not far from Silesia Creek and Tamihi Mt. near Middle Creek is Dolly Varden Creek (cairn 50), with access via Chilliwack Lake. (Stream is noted here for name only.)

Jenkins, Will D. 1984. Last frontier in the North Cascades. Tales of the wild Upper Skagit. Skagit County Historical Society. Mount Vernon, Washington. 176 pp. UW PNWC, F 897 S52 J45 1984.

In this book, Jenkins recounts his impressions as a Skagit Valley resident and employee of City Light during the construction of all three dams. Describing Gorge Canyon, "...the wild gorge of the Skagit begins, just beyond the flat where the hydro village of Newhalem now stands... The vibrating roar of the wild Skagit was so loud here I found it difficult to make conversation without shouting..." Referring to Diablo Canyon, "Where the Diablo Dam...now stands, only a remnant of the deep and narrow gorge once known as Diablo Canyon remains. Diablo roared with the thunder of white water [for about 1000 feet]...spewing and boiling between vertical walls that, at one point in the choke of the bore, were estimated to be less than eight feet apart...a booming you could hear at a mile."

Jenkins gives an account of running Diablo Canyon in a canvas canoe during late July in 1920. Referring to the lower end of canyon (before porting the canoe upstream for the ride), "It was the only slack water in the river for many miles, and from a vantage point in the canoe we could look right up in to the maw of Diablo and see the white water bucking between the vertical bedrock walls. The outfall of the river where it burst from the narrow slot was a sort of steep sloping green waterfall that spilled and fanned out into the gentle basin...[at Reflector Bar]"

"From the cable suspension bridge that hung where Diablo Dam is now locked into the bedrock, the original Thunder Creek trail stretched away south toward Park Pass. And from the bridge you could look right down into the narrow gut of Diablo, where the river seemed to

be the whitest and the wildest." This could imply that the "serious" part of Diablo Canyon was/is below the dam site. Jenkins points out that, ..."you can see a good portion of the original gorge from a viewpoint on the high rim of the dam." A Federal Energy Regulatory Commission document (FERC 1980) contains an aerial photograph of this area.

After entering the river about 500 feet upstream of the bridge, the river was fast moving but reasonably smooth. "The distance from this place to the narrowest section of the canyon was around five hundred feet. There was another five or six hundred feet beyond the slot to the big eddy at the sprawling outfall of the river at Reflector Bar." Jenkins recalled the ride, "Paddles were useless in this frothing bore. We rode the bucking hummocks of wild water through the deep gloom of towering bedrock..."

Concerning the Ross Dam site, Jenkins described a 300 foot-plus sidewalls section containing, "...the deep slot of the Rip Raps in the wild canyon below the frothing junction of the Skagit and Ruby Creek where the towering bulk of Ross Dam now stands." Captions to pictures: page 106 Ruby/Skagit confluence (1920s), "The combined streams rush through the famed gorge of the Skagit."; page 125, "The outfall of Diablo Canyon was a fast drop of white water that spilled into a big eddy at Reflector Bar. The Skagit twisted and churned for a thousand feet between cliffs which, at one point, were a scant eight feet apart."; page 140, "The wild Skagit, a stretch of white water near Reflector Bar."

Luxenberg, Gretchen A. 1986. Historic Resource Study. North Cascades National Park Service Complex, Washington. Cultural Resources Div., Recreation Resources and Profes. Services, Pac. N.W. Region, NPS, USDI. 385 pp. NPS, Sedro Woolley; and SCL/Envirosphere files.

stated, "On the western slope of the mountains, the Fish and Game Department began stocking remote lakes with fish in the 1930's. Throughout the decade, trout were released primarily in Diablo Lake, providing good fishing grounds for sport fishermen." (From SCL 1937.)

McKenna, W.A. 1932. Letter from W.A. McKenna (Skagit County Game Warden) to John F. Dore (Seattle Mayor). September 21, 1932. NPS, Gretchen Luxenberg files, Seattle, Washington.

Pertaining to trout stocking in the City's reservoirs and the Upper Skagit area, "We have been planting the upper Skagit River for the last few years with very fine blooded trout and want to take a load in immediately as they have arranged for their pack horses at the upper end of the lake above the Power House, to be placed in various creeks. These are a very high grade trout, shipped in from Montana." McKenna requests a renewal for the Skagit River Railroad pass.

Melrose, G.P. 1948. Letter from G.P. Melrose (Dept. of Lands and Forests, Office of the Deputy Minister of Lands) to Farris & Co. [timber contractors in Canada?]. August 9, 1948. UW Manuscripts, Seattle Lighting Department files, Container Listings 33-2, Box 20, 3rd. file, clearing-timber sales in Ruby Reservoir, Canadian compensation correspondence.

In relation to the Step 3 phase of Ross Dam construction (raising) concerning compensation to British Columbia, Part 4 of the letter states, "At present the Skagit River in British Columbia is one of the best fishing streams in the Province and it is quite possible that the flooding of it and the raising and lowering of the level of the lake may have a very detrimental effect on the fishing." The Canadians had problems evaluating the fisheries worth and set the value on "lost fishery" at $150,000.

In the margin there is a pencil note by a SCL reviewer of the letter: "Will make fishing better. EL 3484 Lloyd Royal"; and other contrary comments.

Melville's Historical Journal. 1892-1893. Typescript. NPS, Sedro Woolley, 979.

Melville's journal of prospecting in Slate Creek area (upper Ruby Creek watershed); contains general material on the Upper Skagit.

- Wildlife: only comments on hunting; i.e., goat, grouse, deer, etc.
- Flora: general comments on pack animal grazing areas or lack of such areas along the Skagit trail.
- Fisheries: indirect mention of rapids; and notations of routinely fishing for trout while on the trail up and down the Skagit River.

Northwest Regional Task Group for consideration of the Wild Rivers Study Team. 1964. Draft - study report on the Skagit River and its Cascade, Sauk and Suiattle tributaries. State of Washington. 163 pp. Washington State Archives. WDF/WDG files, Skagit River - Stream Improvement.

This report by the Wild Rivers Study Team contains a short description, on page 97, of trout fishing in Ross Reservoir. "The reservoir offers excellent angling for rainbow, cutthroat, and Dolly Varden. Catches average over four fish per man, with many weight limits taken. Rainbows run from 12-22 inches in length, and some 5-pound rainbows are caught." Taken from The Skagit, WDG Bulletin, January-March 1961, the Study Team recounted a rather propitious WDG narrative summarizing the condition of the Upper Skagit fisheries:

"At present, the fishing at Diablo and Ross is very, very good. These two dams are very rare examples of structures which did little to injure fishery production, as normally it is impossible to secure power from a river without hurting the fishery. But the river bank in this section is steep, and before being dammed at these sites, the Skagit boiled and foamed downstream. Bottom and shores are rocky and covered with immense boulders in some spots. Little vegetation or insect life could be found on the stream bottom. Prior to the construction of the dams the continued series of falls and rapids seemed to discourage salmon from journeying upstream. And this was not a large spawning area for the steelhead. The dams, of course, in no way aid migratory fish, but serve to establish unusual conditions which now support resident fish."

Pitzer, Paul C. 1978. Building the Skagit: a century of Upper Skagit Valley history 1870-1970. Lake Grove Printing Co., Lake Oswego, Oregon. 106 pp. UW PNWC; and Seattle City Light files.

A short history of the Upper Skagit River area. Page 34 has some information pertaining to fluctuating river levels due to power peaking demands. In reference to the beginning of the dam construction era on the Skagit River Pitzer states that there were no EIS requirements or pressure from conservation groups in the 1910s, though there was some concern for wildlife. He states, "City Light had been told that their proposed dam at Gorge Creek would disrupt the Skagit salmon runs." For compensation a $10,000 fish hatchery was planned for a site near the proposed Gorge Powerhouse. "But later the City and Forest Service agreed that the loss of the salmon run would be in inconsequential, and plans for the hatchery were dropped..." [From USFS Memo. March 8, 1920. Mt. Baker MMS, also in this bibliography.] On page 92, Pitzer notes a changing USFS attitude on conservation since 1920s; that, "the Skagit dams had done more harm to fish runs than had been originally estimated." Pitzer mentions the 1946 WDF/WDG demand (agreement) for a minimum flow in the Skagit River below Gorge Dam [1000 cfs] and a $50,000 contribution to the construction of a hatchery at Marblemount and to maintain the facility for 9 years.

City of Seattle, Department of Lighting. 1973. The aquatic environment, fishes and fishery - Ross Lake and the Canadian Skagit River. Interim Report No. 2, Vol. 1. 378 pp. Vol. 2, 18 appendices. Washington State Dept. Game; and SCL files.

As part of the High Ross impact analysis, the Seattle City Light "aquatic environment series" provided the most information on resident fish. These "progress" reports culminated in the 1974 volumes (Interim No. 3, see below). Interim No. 2 is included because of some additional tributary information that was not repeated or expanded on in Interim No. 3. For both Interim Report 2 and 3 there are two volumes, Volume 1 contains text, narrative, and data, Volume 2 has appendices.

Fish species discussed were rainbow, Dolly Varden, and cutthroat. The report does not have specific data for habitat area. Included, however, is information on specific tributary habitat areas in terms of species, population size, etc. Basic data for American tributaries covers assessability, stream profiles, migration barriers, and potential spawning areas. A summary of the contents follows.

Vol. 1 text and data:

Introduction: history, study objectives, reports.

Present environment, Ross Lake (limnological data), tributaries (U.S. and Canada), drawdown river, Skagit River data.

Present state of fishes and fishery; history of stocks - Washington, B.C.; general fish sampling procedures; spawning data - rainbow, others.

Skagit River and tributaries; physical characteristics; methods; rainbow spawning time and location; spawning of other species.

Food and feeding; primary production; zooplankton; benthos; Skagit River system fauna, food utilized by trout.

Age, growth and condition.

The fishery; creel census/angler data.

Population size, movements, and mortality; tagging, population size estimates 1970-72, survival and mortality. Environmental projections; lake and tributaries - during construction, during flooding.

Projections for fishes and fishery; during construction, during and after the fill period, Ross Lake at stabilized conditions. Volume 2 appendices:

Ross Lake data; stream gradient profiles; map of Canadian Skagit; fish sampling; substrate/gravel samples; net sets; benthic samples; plankton samples; angler data; holding pen experiments; etc.

City of Seattle, Department of Lighting. 1974. The aquatic environment, fishes and fishery - Ross Lake and the Canadian Skagit River. Interim Report No. 3, Vol. 1. 207 pp. Vol. 2, 18 appendices. UW PNWC, QH541.5 W3 I57 1974, and SCL files.

The final volumes in the "aquatic environment series" progress type reports. The No. 3 volumes covers the same topics as described above for the No. 2 report although some of the contents are more abbreviated (see list of contents for Vol. 2, above). A few different topics/studies are: a preliminary genetic survey of rainbow and cutthroat; methods and data for fish sightings, gillnet sets, fry net sets, rainbow spawning, fry emergence, catch and sightings of adults and fry - locations; population size, movements, and mortality; update on tagging, comparisons of 1971, 1972, 1973; and more data on population size estimates, survival, and mortality.

This report references Interim Report No. 2, Vol. 1 for physical data on tributaries and more fish data (1973).

Vol. 2 appendices:

Ross Lake limnological data; fishery data; Skagit River system trout data; etc.

Smith, V.E., and M.C. Anderson. 1921. A preliminary biological survey of the Skagit and Stillaguamish Rivers. University of Washington School of Fisheries, for Washington Department of Fisheries and Game. 76 pp. NPS, Sedro Woolley, Robert Wasem/John Douglass files.

This report was the first biological survey of the Skagit River system and was performed by University of Washington fishery biologists in 1920 (just as Gorge Dam was being completed). For readability, excerpts from this report are presented in "outline" form rather than as a pure narrative.

General:

The authors stressed that salmon runs were significantly depleted and heading towards elimination due to exploitative fishing practices and environmental degradation. They describe how the lower river commercial fishermen's net size "selected" for returning females (larger fish) and how the spawning grounds were accessible to locals who killed the spawners. Also mentioned were poor management watershed practices (logging, shingle bolt camps, etc.).

Summary, Main River, 3 sections (of relevance here):

- 1 Canada to Ruby Creek: Dolly Varden, resident trout.

- 2 Ruby Creek to Gorge Creek: falls and rapids block salmon; rainbow, Dolly Varden; pre-1920, salmon 1 mile above Gorge.

- 3 Gorge Creek to Rockport: chinook, coho, pink, chum, steelhead, Dolly Varden, rainbow; spawning areas.

Summary, Tributaries:

- Ruby Creek: Dolly Varden, trout.
- Thunder Creek: no fish, blocked by falls.
- Stetattle Creek: rainbow, too small for game fish; obstructing falls at 1.5 miles.
- Goodell Creek: rainbow, spring chinook, a few pink and chum; farthest upstream utilization for salmon.
- Thornton Creek: a few chinook, coho, pink.
- Bacon Creek: good for game fish.
- Diobsud Creek: steelhead, chinook, pink, chum.
- Cascade River: steelhead, all salmon except sockeye.

  Detail, Main Stem:

Page 2,
1st. section of main river:

"Extensive log jams are reported as obstructing the river a short distance south of the International Boundary. The river bottom is practically free from vegetation, owing to the gravely nature of the bed, the swiftness and coldness of the water." river, but it is well stocked with rainbow trout and Dolly Vardens. Game fishing is unusually good in this part of the river."

Page 3,
2nd. section of main river:

Referring to the proposed Ross Dam site, "...to construct a dam at a narrow gorge 1700 feet down the Skagit river from the mouth of Ruby

Creek." Referring to the future Ross reservoir, "...many game fishermen who should find excellent fishing if proper measures of conservation are taken by the state."

Page 4, .

Referring to the 14 river miles between Ruby Creek and Gorge Creek, the Skagit, "...runs through the most rugged country drained by the river. The banks in many places are abrupt precipices. Through this region the Skagit boils and foams for the greater part of the distance. Several pictures will indicate the character of the country and the condition of the waters [no pictures were found]. While no single fall or rapid observed would form an unsurmountable barrier to the upward migration of salmon, yet the continued series of low falls and rapids seem to have proved effective in stopping the run of salmon through this part of the river. Those living in this region who have given close attention to the movement of fish have never seen salmon more than one mile above the City of Seattle Camp [refers to the Falls Creek area about one mile above Newhalem]."

"The bottom and shores are rocky and covered in many places with immense boulders. The water is clear, cold and almost devoid of plankton life and the bottom has no vegetable growth worth mentioning."

"Salmon have been seen about one mile above the City of Seattle Camp. Rainbow trout and Dolly Vardens are very abundant in this part of the river and afford excellent fishing."

Page 5,
3rd. section of main river (Gorge Creek to Rockport):

"The bottom consists for the most part of coarse gravel, which makes an excellent spawning bed for salmon. In some parts the water is very rapid."

..."There are no obstruction[s] in this part of the river that would impede the upward progress of migrating salmon." "This stretch is reached by chinook, silver, hump and dog salmon migrating from Puget Sound. In the spring a considerable number steelhead trout reach this part of the river and ascend the tributaries to spawn. It is also well stocked with trout, the most important of which is the rainbow. Dolly Vardens are also very abundant. The river here or anywhere else where salmon run cannot be used for artificial propagation as the stream is far too large and swift to be racked."

Page 6,
4th. section of main river (not listed above):

"...Rockport to Lyman, a distance of about 25 miles." Not relevant to Upper Skagit fish and wildlife study.

5th. section of main river (not listed above):

About 25 miles, "...through a flat, well settled country." Not relevant to Upper Skagit fish and wildlife study.

Detail, Tributaries:
Page 7,
Big Beaver Creek:

"Within one mile and one quarter of its mouth it falls 300 feet. In this stretch there is a series of falls and rapids which completely obstruct the passage of fish (see pictures) [no pictures located]."

"Several years ago some cutthroat trout were planted in the smooth water one mile and one-half above the mouth [Ranger Thompson's work]. ...They were unusually beautiful fish and in perfect condition."

"...The stream, owing to the precipitous nature of its banks, is subject to sudden freshets."

..."A short distance above the mouth a dam has been recently constructed for irrigation purposes [at Davis' place at Cedar Bar], but provision has been made for fish to ascend the dam. About 1.5 miles above the mouth is a falls said to be 60 feet high, which completely obstructs the passage of fish."

"The stream is fairly well stocked with rainbow trout below the falls. A few trout were planted above the falls last year The stream is too small to be worthy of much consideration from the standpoint of game fish."

Page 11,
Goodell Creek:

"There were no obstructions worthy of consideration in the lower four or five miles of the stream. ...The stream should be fairly good for game fish. ...rainbow trout..."

"During the September visit we observed a few spring salmon spawning. There were probably less than one hundred in the lower two miles of the stream and the character of the stream was such that the fish would not seed the upper reaches as spawning grounds. A few humpback, silver and dog salmon visit the stream, but the numbers are insignificant compared with the numbers reported to visit this stream in earlier years. This is the farthest branch of the Skagit from its mouth in which salmon run, and as the depth of the stream, the character of its water and the bottom are very favorable to spawning one would expect to find a considerable number of salmon in this stream. The condition at present shows almost utter depletion so far as spring, silver, and humpback salmon are concerned."

On the tone of salmon run degradation, Smith and Anderson now discuss this topic more fully.

"Another unfortunate feature of the spring run was that the large majority of the fish were two and three year old males. In nearly every instance where it was possible to observe the spring salmon in groups of one dozen or more it was found that an occasional female of large size arrived on the spawning beds for every six or eight small males. This condition appears to be largely due to fishing with nets in the lower Skagit. The mesh of the fish nets were of such a size as to catch and hold the large fish while the smaller ones escaped. Unfortunately there are extreamely [extremely] few females small enough to escape through the nets, while a considerable per cent of the males are small enough to pass through. Another reprehensible feature is that people living in the vicinity of this stream destroy many of the fish [mostly Tarheal emigrants and their descendants]. They are particularly anxious to catch the females in order to get their eggs for trout bait. They even kill the fish for the pure fun of killing. Few of the males at this time are fit for food, never the less [nevertheless] the spearman landed every one he could get. Often leaving their dead bodies on the banks. This stream was surveyed but recently by the State Fish Commission with a view to building a hatchery there. It seems to us that the utter [d]epletion of the fish makes such an enterprise not worth undertaking. It might pay to rack the stream a short distance above the mouth and take the eggs to a central hatchery to which the eggs from a number of streams might be taken."

Page 13,
Thornton Creek:

"Less than one-half mile above the mouth is a falls of about 75 feet in height, which, of course, prevents the upward migration of fish. Spring, silver and humpback salmon run in this stream in small numbers."

Smith and Anderson's report continues with information on the middle and lower Skagit River and its tributaries. No more material is copied here.

Stanley, George F. 1970. Mapping the frontier. Charles Wilson's diary of the survey of the 49th parallel, 1858-1862, while secretary of the British Boundary Commission. Toronto, Canada. 182 pp. UW PNWC, F854 W5 1970.

This book is a good record of the tasks of the commission and difficulties encountered during travel and working on projects. There are especially good accounts of Northwest Indians, their habits, nature, etc.

There are a few comments of flora, wildlife, and fish, not applicable to this study. Some notes on resident trout fishing and the killing of grouse for food.

Thompson, Erwin N. 1970. North Cascades National Park and Lake Chelan National Recreation Area, history basic data. Office of History and Historic Architecture, Eastern Service Center. 301 pp. UW PNWC, F897 C3 T35.

This National Park Service history of the North Cascades contains a reference to the character of the Upper Skagit River on page 164, "Above the portage, [lower Skagit area] miners found travel extremely difficult, even dangerous. Between Ruby Creek and Newhalem, the Skagit flowed through narrow, steep canyons. High mountains on either side..."

The only reference to fish was for the Stehekin River from Alexander Ross's journal of his expedition (about 1882), "...lusty trout in the river."

- Ross Lake (18 sq. mi.) is underutilized (by sport fishermen) due to inaccessibility .

Commercial fish information:

- By 1903, mass production (of fish processing) allowed exploitation of the commercial fishery; causing a large impact on Puget Sound and Columbia River fisheries [supports Smith and Anderson (1921) observations of declining runs]; also environmental damage impacts to the fishery (see below). Hydroelectric development: rivers and side streams lost; forage areas (especially winter range) loss to wildlife.
- Reservoirs enhance the sport fishery.
- Numbers given are for all of the Washington Cascades. Environmental degradation: (potential impacts to fisheries).
- Mineral development impacts.
- Azurite mine at headwater of Skagit [Ruby?], since early 1900s.
- Fires: erosion, siltation, log jams, temperature increase, high runoff, etc.
- r.e. relevance to early big burns in Upper Skagit area.
- Logging: cedar bolt camps, roads - erosion, etc.

Washington Hatchet. No date (pre-1918). Section title: Encyclopedia Washingtonia III. FARC, Seattle, WA, RG-95 Acc. No. 76-A-2058, Box 8 of 8 No. 68116.

An early publication in the Whatcom County area covering timely issues. Page 4-5 "Future Use" has possible indication (indirect) of time(s) when spring/summer Chinook could ascend the Skagit River's Diablo Canyon:

"There will be a market in future for all water power the Forest can develop, since its volume has been over-estimated. The extremely low minimum flow is responsible for this. Upon his recent trip to the

found in a literature search covering succeeding years under Crawford, Lucas, Kincaid or Smith at University of Washington or State libraries.

Page 13 briefly discusses Phinney Creek (opposite Birdsview), the Baker River, and mentions the need to examine the Sauk and Cascade rivers. No reference was found for any Upper Skagit areas.

Washington State Department of Fisheries and Game. 1929-1931. Division of Fisheries, 40th and 41st Annual Reports, April 1, 1929 - March 31, 1931. UW Fish. Oce., 639.2 W27a.

Page 137-138 in this report contains some stream survey data for the Skagit River and its tributaries. The only data were all lower river information. Species and relative abundance data were included. No other report was found on this survey in later publications in UW or State libraries.

Washington State Department of Fisheries and Game. 1919-1921. Division of Game, Game Warden, 7th & 8th Reports, 1919-1921. UW Fish. Oce., 639.2 W271.

On page 5 of this biannual report is a reference to a planned biological state survey (potentially including the Skagit) of lakes and streams to be done by the University of Washington's Trevor Kincaid, E. Victor Smith, and others. The proposed survey would take several years.

No reports were found under WDFG or Kincaid or Smith in later years...unless the 1921 Smith and Anderson report was a result of the survey(s).

Wiseman, A.B. (Brown). No date. Notes on fish planting activities, including:

other citations. No stream survey reports are given for the Skagit River for late 1920s to 1930s.

Majors, Harry M. 1974. North Cascades archival resources in Washington State repositories. A preliminary bibliography of unpublished sources documenting the history of the North Cascades. U.W. Libraries, Manuscripts Section. 17 pp. UW, Manuscripts.

Some examples of relevant material:

Bureau of Land Management, Portland

- 1880-1940 Land Office surveyors' field notes. USFS Mt. Baker National Forest, Seattle.
- Early settler interviews, reports, photos. North Cascades National Park, Sedro Woolley.
- Interviews, papers, photos.

University of Washington Libraries. 1980. Comprehensive guide to the manuscripts collection and to the personal papers in the University of Washington archives. University of Washington Libraries, University of Washington Archives and Manuscripts Div. UW, Manuscripts.

Selfexplanatory title.

Wasem, C.R. 1974. A partial listing of history and natural science related papers and publications of concern to the North Cascades National Park, Ross Lake and Lake Chelan National Recreation Areas. A progress report. NPS, USDA, Sedro Woolley, WA. NPS, Sedro Woolley; and Envirosphere Co. files, Seattle.

The annotated bibliography of this report (the Upper Skagit anadromous fish analysis) includes much of the material in Wasem's bibliography. Wasem's citations are organized into topic sections.

A complete copy is in the Envirosphere Co. reference file. There are 33 vegetation references. The mammal section is not as current as Taber's report (1984). Taber (1984) is reviewed in the Upper Skagit Wildlife Annotated Bibliography. The aquatic section has 44 references but no additional update material. An example of a reference not in the Upper Skagit annotated bibliography is No. 4, Eggers, et al.: Ross Lake tributary, fish report FRI, UW; and is summarized in City of Seattle 1974.

State of Washington. 1981. Historical records of Washington State. Guide to records in State Archives and its regional depositories. Dept. of Gen. Admin. 386 pp. UW, Manuscripts.

Good volume for determining existing personal records, interviews, etc. and their locations.

State of Washington. 1981. Historical records of Washington State: records and papers held at repositories. Washington State Historical Records and Archives Project. 766 pp. UW, Manuscripts.

Good volume for determining existing personal records, interviews, etc. and their locations. This document contains more listings versus the previously cited guide to State Archive material.

7.4 SYNOPSIS OF ACCESSIONS/TOPICS REVIEWED AT LIBRARIES AND ARCHIVES.

(To be utilized for future research at archives.)

Federal Archives and Records Center (FARC), Seattle, Washington Record Group 95 (RG-95), USFS files.

USFS records: Portland accessions (regional headquarters).

Mt.Baker-Snoqualmie (inclusive of Washington Nat. Forest) - 1909-1960s

- historical documents
- FPC license material
- maps of forest type/use
- maps of range areas
- game studies
- Portland accessions(s), Box number(s): 73A416: 5608, 5609 66A595: 42903
- No information for Upper Skagit fish and wildlife study.
- Portland accession 54EP045 E-39: 354971
- Diablo and Ruby file: general information, technical articles on Diablo and Ross, no fish or wildlife data.
- Portland accession 54AP045: 53667, 53668, 53670, 53674 (old numbers on shelf list)
- Power, Seattle, Skagit;
- Boxes not on shelf (`gone').
- Portland accessions for wildlife:

54C0111:	59857	Tmbr. Stat. Repts.	1909-40
54E0111:	59859	Forest Survs.	1927-35
54A0117:	21127	Hist. Recds.	1935-37
55AP012:	55384-92	Range Surv. Maps	1936-38
55AP032:	55318-29	Tmbr. Survs.	1909-49
56AP027:	51741	Tmbr. Survs.	1938
57AP061:	54134	Range Mgmt. Repts.	1908-53
57A0113:	9702-11	Frst. Surv. Res. Recds.	1956
59B0083:	30243-44	WL Mgmt. Recds.	1942-56
59D0491:	28466	Tmbr. Stat. Repts.	1953-56

- Mt.Baker-Snoqualmie accession 58-A279 (the following Box numbers from the current shelf list are not used on the current computer record).

56102 (71-D49)	1909-1936	56107 with maps	1911-1940
56103 with maps	1920-1942	56108 with maps	1911-1940
56104	1944-1945	56131-33 correspondence, etc.	

- Accession destroyed.

- Mt.Baker-Snoqualmie accession 54-A126 (1912-1942)

29682 water power 29690-1 historical data 29688 surveys

- Accession destroyed/gone' (misplaced on another shelf?).
- Mt.Baker-Snoqualmie accession 59-A540 28217 & 28219 consolidated into first Box, rest destroyed 28217:
- Reference to Ruby - Harts Pass road construction possibilities 1930's-1940's...will be under water when Ruby Lake develops.
- USFS material: procedure and logistics to float goods down the new reservoir and to haul material over Ruby Dam on SCL hoist.
- Power, withdrawals; Seattle, City of; reservoir and transmission line, 8/17/17.
- Final Power Permit copy and correspondance for Gorge Dam.
- Final Power Permit, amendment: to build 2 dams Diablo/Ruby instead of 1 (Ruby) to control flow for the later Gorge Dam rebuild (too narrow and too high a flow at Gorge to allow an economical rebuild to the desired scale without total flow control). Also, by the mid 1940's, it was evident that Ruby Dam would also aid in Lower Skagit River flood control when completed to Step 3.
- Granger, C. (Dist. Forester) letter to Exect. Sec. (FPC). 1/20/26. r.e. FPC license change (10/1/24), with photos and topographic blue prints, etc. of Diablo site.
- No author (USFS, Portland) memorandum for engineering to Park (USFS, Superint., Bellingham). 3/8/20.
- r.e. Refers to obtaining a Special Use Permit for a $10,000 fish hatchery on a side stream, as mitigation for Gorge Dam.
- "Mr. Cecil (Dist. Forester) states after conference with City officials, that the City of Seattle does not desire to install a fish ladder under the Snoqualmie permit but will accept the alternative provided by State law,

namesly [namely], to build a fish hatchery for the State Fish Warden."

- Later the City and the USFS agreed that the loss of the salmon run would be inconsequential, and the hatchery plans were canceled.
- Other letters mention: site suitability at Newhalem near the proposed Gorge Powerhouse, side stream size, hydropower characteristics, etc.

Washington State Archives, Olympia, Washington.

WDF & WDG - Skagit River files.

Important accessions, WDF:

76-11-854 Dams

73-07-675 Surface waters, the most informative accession. Box No. 1010-40, has most all of the important correspondance.

745 Stream improvement

72-06-566 Stream improvement and hydraulics Box No. 0061-14

University of Washington Libraries, Manuscripts Division, Seattle, Washington.

Batcheller, Willis T., papers. Accession No. 195, 2497, 2497-2; Box 1 Diary, Box 12 Skagit files, Box 13 Skagit files.

Batcheller was the primary civil/hydropower engineer for Seattle Lighting Department projects Box 1 Diary

- 1925 to 1951 on professional and some personal history; no relevant information to Upper Skagit fish and wildlife study. Box 12 Skagit Files
- Data on all aspects of Skagit development: charts, graphs, maps, pictures, design drawings; data on flow,

storage, releases, power, etc.; cost comparisons and analyses with other potential projects. 1917/18-1950's.
- Good (detailed) hydrologic data for various locations on the Skagit; some predevelopment data available.
- 3/29/18 letter to Mayor Ole Hanson (from W. Batcheller?, not signed:
- letter of important facts on the Skagit site
- also: minimum stream flow normally >900 cfs
- pre 1918 recorded lowest flow of 738 cfs.
- Pictures in Skagit River project areas.

Box 13 Skagit Files

- Files on Skagit River project designs.
- Proposal
- Report on the Skagit projects, preliminary report, 1918.
- Pictures, same as in Box 12. Report on hydroelectric development, 1919.
- Most of the information and reports are bound and well organized.

Seattle Lighting Department files, Container Listing (accession) 33-2.

Box 6 Newspaper Clippings

- Miscellaneous clipping relevant to Northwest and West Coast power issues; most of the information is about Bonneville Power Administration projects.

Box 20 Clearing - Timber Sales (for Ross Reservoir area)

1st. file, clearing - Walton Brothers.

- City Light map, "Key Map of Ruby Reservoir", 3/21/33:
- 1"=2000'
- Has lower Big Beaver Creek, Ruby Creek.

- Notes on pictures (now in Ross Reservoir).
- Aerial photo of future Ross Reservoir, 9/11/47.
- Clearing specifications, e.g.'s:
- Clear everything 1550-1605 feet elevation.
- Top trees projecting above 1550 feet.
- Timber sales, special conditions:
- Page 8 Purchaser's Operations on Ruby and Big Beaver Creeks:
- "The purchaser shall not fall timber into or across the Skagit River, Ruby Creek or Big Beaver Creek and shall remove at once any trees or debris that fall into or are placed in any of said streams due to his operations."

  2nd. file, timber sales: Whitworth Ranch - 1940's & '50's.
- Administrative material on sales in lot 221 and 222, Canadian tax records.
- Information on flood level elevations, e.g.'s:
- Ross spillway gates installed early 1953.
- Flood elevation at spring runoff 1953 to 1600 feet, possible to 1608 feet.

3rd. file, USFS, USDA information, 1937-1952.

- In file jacket pocket:
- Hoffman, E.R. (Superint. Lighting) letter to J. Frankland (USFS, Portland). 1/5/51:
- Ross built to roadway elevation 1615 feet; water level to 1600 feet.
- After 1953, necessary to log/clear some areas above 1605 feet to 1700 feet.
- Maps
- 1933 for timber sale amendment to 1936 agreement with USFS.
- Standing timber (with water level up) under lake at north end 1950.

- 1950 photos/maps of available timber in Big Beaver area; under 5/51 amendment.
- Melrose, G.P. (Off. of the Deputy Minister of Lands, B.C.) letter to Farris & Co. 8/9/48. Concerning Canadian compensation (an "invoice") for proposed Step 3 of Ross Dam construction:
- Part 4. of letter, Wildlife: "At present the Skagit River in British Columbia is one of the best fishing streams in the Province and it is quite possible that the flooding of it and the raising and lowering of the level of the lake may have a very detrimental effect on the fishing."
- The B.C. officials found it difficult to assess a compensation amount, set at $150,000.
- Pencil note in margin by SCL reviewer: "Will make fishing better. El 3484 Lloyd Royal."

4th. file, USFS, USDA, 1953 and 1954

- More on fire plans, etc.
- Road construction/improvement for Diablo to Ross, map (1949). 5th. file, USFS, USDA, B-From 1954
- Multi-use information, Forest Service plans, Glacier Peak wilderness.
- Trail building, etc. (mitigation for flooded areas, and general improvement) - potential impact to wildlife.
- Extension of timber sales agreement, debris clearing.

Box 33 Transmission Lines

- Skagit Transmission Line:
- Information not relevant to Upper Skagit study.
- Ruby Creek transmission line fire 1938, Illabot Creek. Box 41 Hydrography
- Data on general hydrology, dam discharges/releases for low flows, etc.

- Precipitation data, snow pack surveys and more hydrology data. Box 84 Railroad, Trails, Bridges, Landscaping SLD homes
- Technical, as well as, general material.

Seattle Public Library files

- No correspondance material, no "new" reports of relevance to Upper Skagit fish and wildlife study.
- Press material: this serves as a summary of the press material on high Ross that has the most information for the Upper Skagit historical fish and wildlife study, older material is also noted.

T = fish (trout) information.
F = flora information.
WL = wildlife information.

File headings:

Seattle Presses - Seattle Public Utilities

- No relevant material.

Seattle Lighting

- Seattle Lighting Dept. Annual Rpt. 1922 (same abridged in Amer. City 29:569-574, 12/23)
- Seattle Lighting pay Canada for flooding large area
- Municipal News, 4/24/67, p. 34
- City Light's part in the North Cascades
- Seattle Times, 12/17/68, p. 10

Skagit

- The Skagit venture (material against)
- Washington State Monthly, 2/25, p. 10-11
- City Light, British Columbia agree on Skagit project
- Seattle Times, 3/19/53, L4
- At stake in the Ross Dam controversy: Big Beaver Valley
- Seattle Times, 10/1/72, Pict. Sec. p. 26
- Big Beaver will be flooded 5.5 mi., r.e. Miller's material (see * below).

Washington, Dams

- Gorge, Diablo, no relevant material.
- Ross (environmental consequences of high Ross flooding)
- Air survey of Ross area is sought (not found)
- Seattle Times, 6/13/49, L4
- Where flooding would occur (high Ross), map only
- PI, 10/29/69, p. D08
- Game Department opposes raising of Ross Dam
- Seattle Times, 3/1/70, p. H6

T - Flooding would decrease spawning habitat (on Ruby, Lighting, Big Beaver, Devil's Creeks) for "unique" (native, robust, chunky, deep red meat) rainbow and fish may not survive; and the lake is too large to stock.

T - Dolly's to 12 lb, a few brook trout, rainbow present.

T - Canada

- would wipe out finest fly fishing in lower B.C.

- Skagit (above Ross Lake), one of top 5 rainbow streams in Ross Lake watershed.

F - One of the last large, old Red Cedar groves.

W - Flooding of beaver ponds would occur on Big Beaver Creek.

W - Loss of deltas and low elevation valleys and streams;

implies loss of winter range habitat for black tailed deer.

- Existing lake already wiped out former deer winter range.
- Theorize deer populations could not survive (die out within 3 winters).
- B.C. deer herd population 400-500.
- Raise Ross? (pro and con)
- Seattle Times, 3/13/70, p. A5

W - Wildlife called losers if dam is raised (not found)
- Seattle Times, 4/19/70, p. E10

++ - Ecology official adamant against raising Ross Dam
- Seattle Times, 12/7/72, p. H16

W - John Biggs (Director) "...energy gain only short term vs permanent, major environmental damage..."

* - Two become one against Ross Dam project (Miller's, Bellevue)
- Seattle Times, 5/2/74, p. B6

F, W - Plant and animal life studies since 1969 (Big Beaver)
- Big Beaver Valley assets: large cedars, unusual mix of eastern and western plant species.
- People vs fish protection: state agencies at odds over Ross Dam
- Seattle Times, 10/27/78, p. C10

++ - DOE pro high Ross.
- WDF, WDG concern about temperature and flow fluctuation effects on Skagit salmon and steelhead.

++ Note change in DOE's attitude.