The Story in 2016:
45 Road Forest Restoration Project Monitoring

Cedar River Municipal Watershed

Bill Richards,
Andy Chittick, Melissa Borsting, Rolf Gersonde, Amy LaBarge

Watershed Management Division,
Seattle Public Utilities

July 2016

Introduction
The 321-acre 45 Road Forest Restoration Unit is located along the western boundary of the Cedar River Municipal Watershed (CRMW). The Unit includes 157 acres that were thinned in 2003, 72 acres (within the thinned area) that were planted with tree seedlings in 2004, 2005, 2014, and 2016, and 164 acres that were maintained as "leave" or unthinned areas. The leave areas were not intended to be control areas in a strict monitoring sense because they continue, like the rest of the project area, to be subject to various disturbance factors like disease and windthrow.

Prior to thinning, the Unit was dominated by 70-year-old Douglas-fir (*Pseudotsuga menziesii*) trees, with a dense salal (*Gaultheria shallon*) understory. Species and structural diversity was relatively low. Laminated root rot (*Phellinus weirii*) was present throughout the Unit, with the northern section more heavily affected than the remainder. Canopy gaps created by the root rot, which kills some conifers (with preferred hosts being Douglas-fir and western hemlock (*Tsuga heterophylla*)), provided some horizontal structural diversity.

This restoration project was implemented under the Cedar River Watershed Habitat Conservation Plan (CRW-HCP) with the goal of accelerating the development of late-successional forest characteristics, providing wildlife habitat for targeted species, and enhancing natural biological diversity. Specific management objectives were to: 1) maintain or increase the growth rate of trees, 2) increase structural diversity, 3) increase species diversity, 4) facilitate maintenance and recruitment of large-diameter snags and coarse woody debris, 5) protect special habitats, and 6) protect water quality. Prescribed silvicultural treatments designed to achieve these objectives included ecological thinning and restoration planting.

Because of the experimental nature of the restoration program, and the fact that the Unit is representative of over 3,000 acres of similar forest in the CRMW, monitoring of this project is essential for evaluating restoration techniques and informing future efforts. A system of 17 permanent plots was established within the Unit prior to thinning, with 10 plots in the treatment area and seven plots in the leave area (Figure 1). Treatment area plots were resampled in 2004, 2006, 2009, and 2015, while portions of the leave area plots were resampled in 2006 and 2009, and completely resampled in 2015 (Table 1).

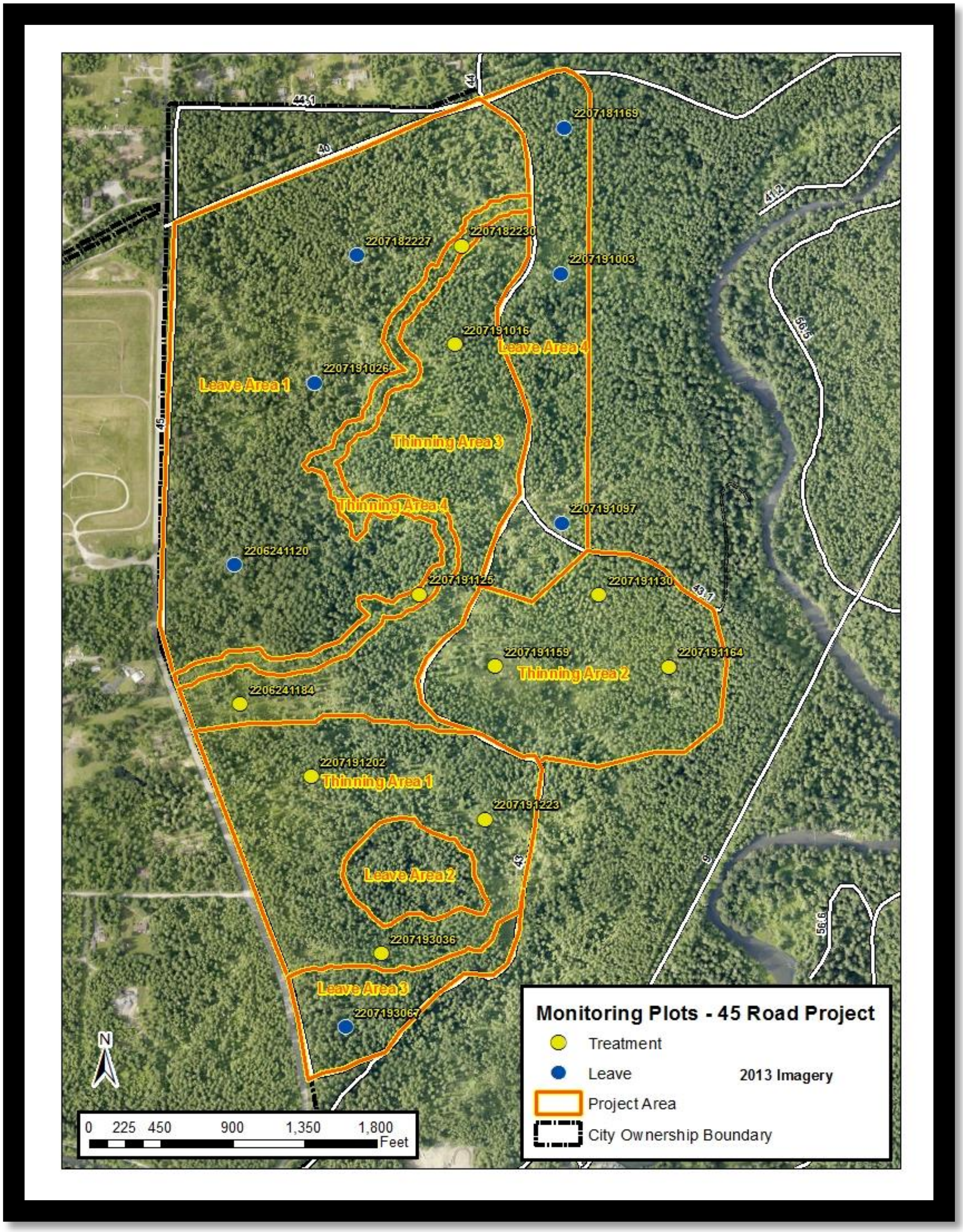
Methodology
Plots were randomly located in 2003 following the delineation of treatment and leave areas based on stand condition. Generally, relatively dense forest patches were delineated as treatment areas while pockets extensively infected with root rot were grouped as leave areas. Confounding issues inherent and typical in this and other forest sampling includes varied pre-treatment stand conditions across the Unit, varied implementation of treatments based on those pre-treatment stand conditions, and varied on-going disturbance processes since treatment. Trees, shrubs, herbs, downed wood were sampled according to a protocol established in 2003 and 2004, and refined for successive sampling.

Table 1. Sampling schedule for the monitoring plots in the 45 Road Forest Restoration Project.

	Unit Number	Plot Number	Sampling Year				
			2003	2004	2006	2009	2015
Treatment Area Plots	1	2207191202	X	X	U	X	X
	1	2207191223	X	X	U	X	X
	1	2207193036	X	X	U	X	X
	2	2207191159	X	X	U	X	X
	2	2207191130	X	X	U	X	X
	2	2207191164	X	X	U	X	X
	3	2207191016	X	X	U	X	X
	3	2206241184	X	X	U	X	X
	4	2207191125	X	X	U	X	X
	4	2207182230	X	X	U	X	X
Leave Area Plots	L1	2207182227	X		U	X	X
	L1	2207191026	X		U		X
	L1	2206241120	X		U		X
	L3	2207193067	X		U	X	X
	L4	2207181169	X		U	X	X
	L4	2207191003	X			X	X
	L4	2207191097	X		U		X

X = all variables sampled, U = only understory shrubs and herbs sampled

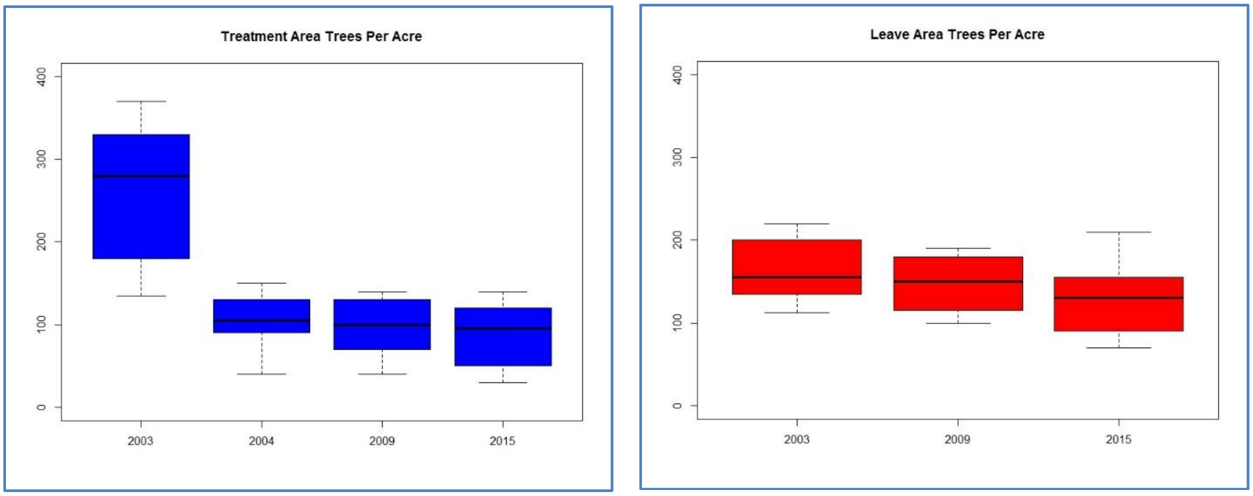
Figure 1. Monitoring plots locations in the 45 Road Forest Restoration Project.



The Over Story

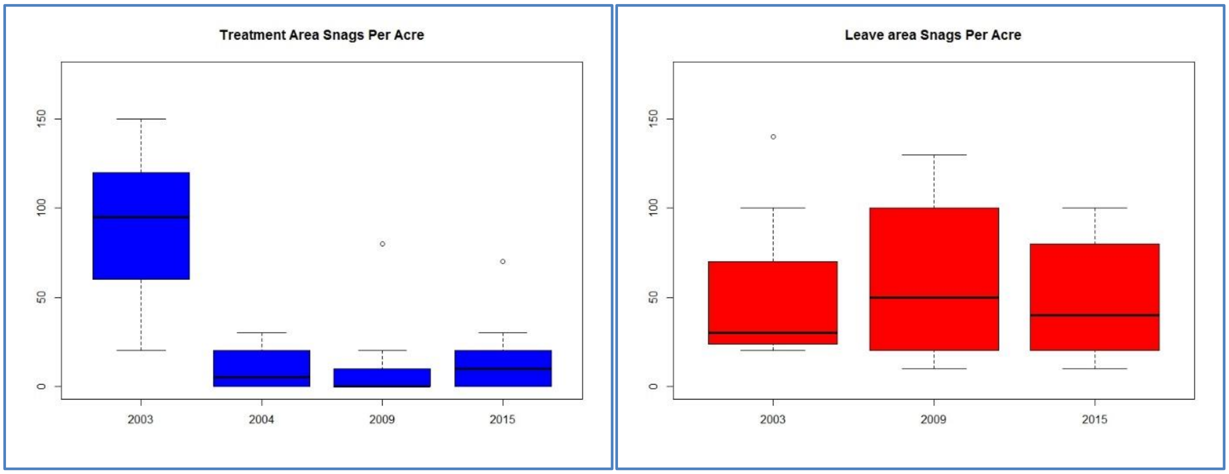
Prior to thinning in 2003, the density of trees greater than five inches diameter at breast height (DBH) in the plots varied from 370 to 113 trees per acre (TPA) and was significantly different in the leave and treatment areas (p = 0.005) (Figures 2 and 3). The average density was 263 TPA in the treatment areas and 165 TPA in the leave areas. After thinning, the tree density in the treatment areas was more similar to the leave areas, with treatment area density ranging from 150 to 40 TPA and leave area density from 220 to 113 TPA. Tree density in both treatment and leave areas showed a modest decline over time as natural disturbances continued to cause mortality. Two of the leave plots indicated modest ingrowth by 2015. Twelve years after thinning, tree density is not significantly different (p = 0.089) between treatment and leave areas, with the average overstory tree density of 129 TPA in the leave areas and 87 TPA in the treatment areas.

Figures 2 and 3. Live tree density in treatment and leave areas of the 45 Road Forest Restoration Project. There was no sampling in leave areas in 2004.



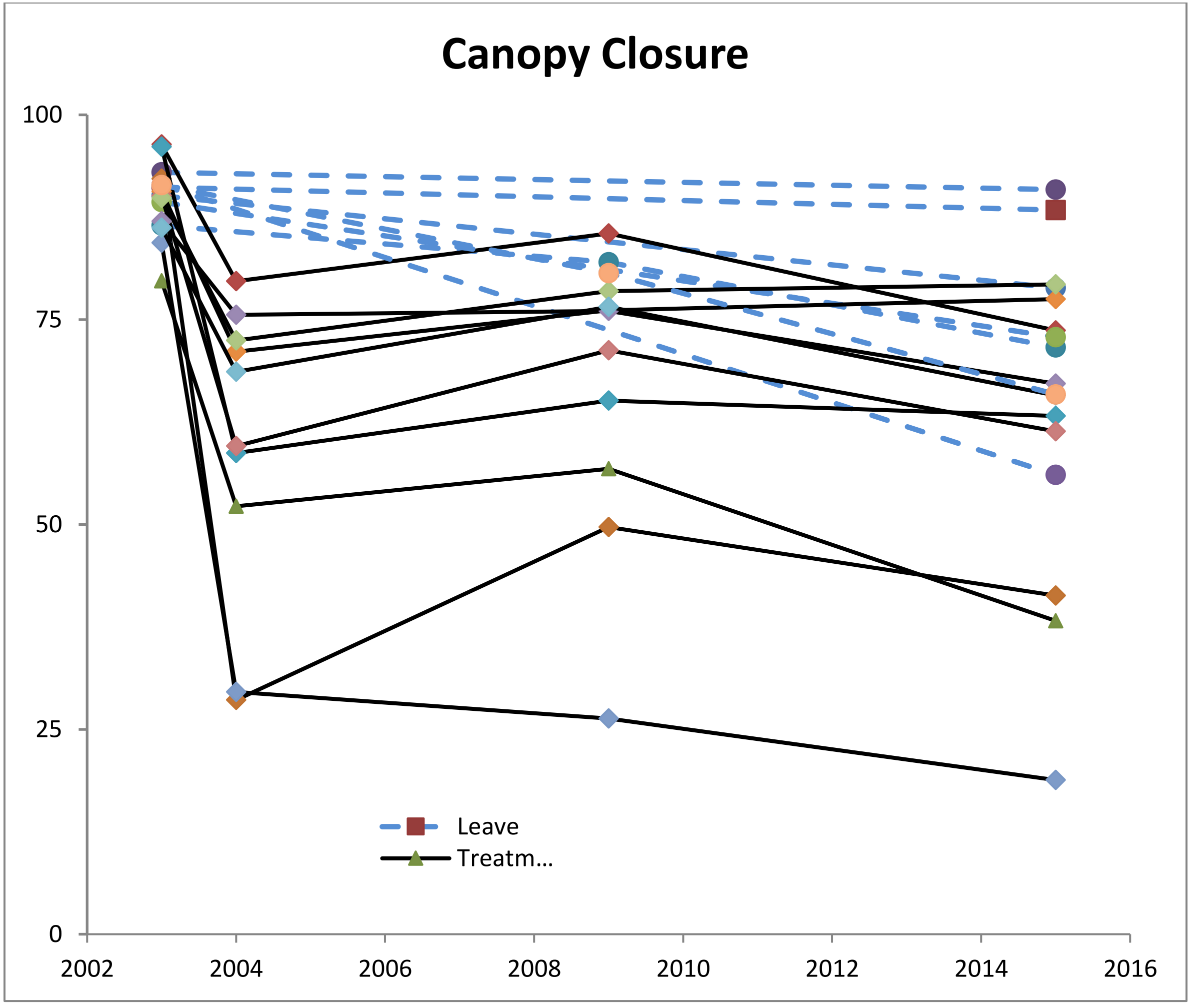
Prior to thinning, the density of snags in the treatment areas was not significantly different than those in the leave areas (P=0.118) (Figures 4 and 5). After thinning, snag density decreased greatly in the treatment area probably because many were knocked over or removed during the thinning. The average snag density in 2015 was 50 per acre in the leave areas, compared to 16 in the treatment areas (p= 0.054), and were significantly smaller (p = 0.001), averaging 8.5 inches DBH compared to 12.8 inches DBH in the treatment areas. Snag height was not significantly different (p = 0.15) between the leave and treatment areas. All of the snags were Douglas fir.

Figures 4 and 5. Snag density in treatment and leave areas of the 45 Road Forest Restoration Project. There was no sampling in leave areas in 2004.



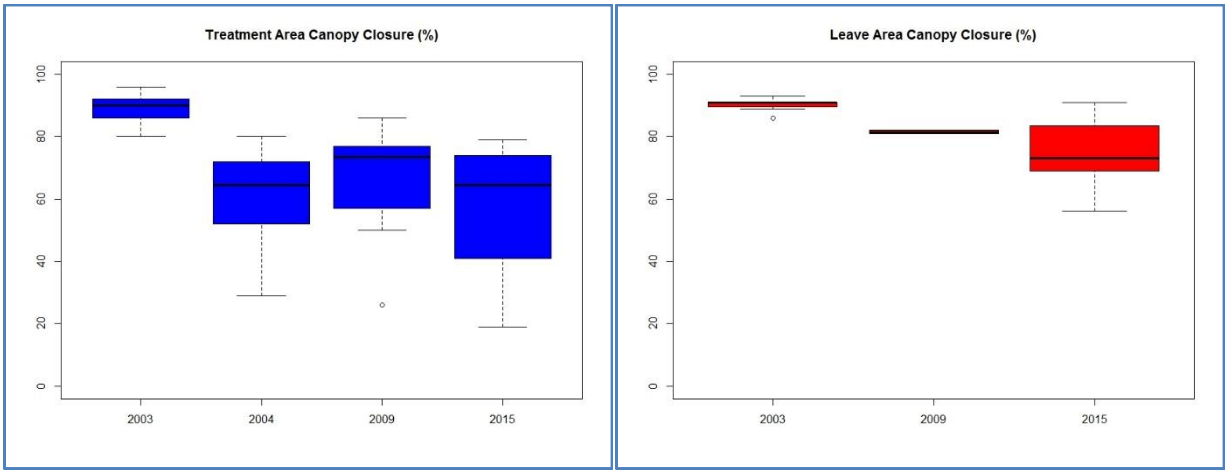
Understandably, the canopy closure of the overstory trees decreased in the treatment areas with the thinning (Figure 6), but it also declined in most of the leave areas over the intervening years, probably from tree mortality caused by root disease and windthrow.

Figure 6. Canopy closure (%) of overstory trees in the 45 Road Forest Restoration Project.



There is no significant difference in canopy closure between the treatment and leave areas in 2003 (p = 0.610), but there nearly is in 2015 (p = 0.052) (Figures 7 and 8). There is increased horizontal heterogeneity (more variability) in canopy closure in the treatment areas than the leave areas.

Figure 7 and 8. Canopy closure in treatment and leave areas of the 45 Road Forest Restoration Project. There was no sampling in leave areas in 2004. Only one plot in the leave areas was sampled in 2009, but 2003 did indicate little variance.

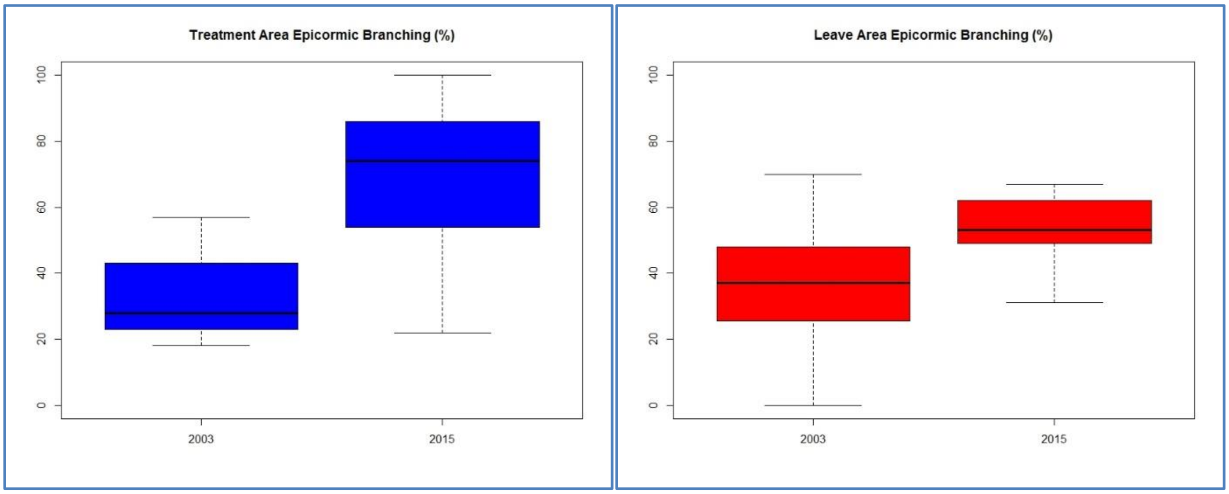


Treatment Area Canopy Closure (%)

Leave Area Canopy Closure (%)

The percent of overstory Douglas fir trees that exhibited epicormic branching increased in both the treatments and leave areas from 2003 to 2015 (Figures 9 and 10). There was a greater difference between areas in 2015 than 2003 (p = 0.151 and p = 0.660, respectively).

Figures 9 and 10. Epicormic branching in treatment and leave areas of the 45 Road Forest Restoration Project.

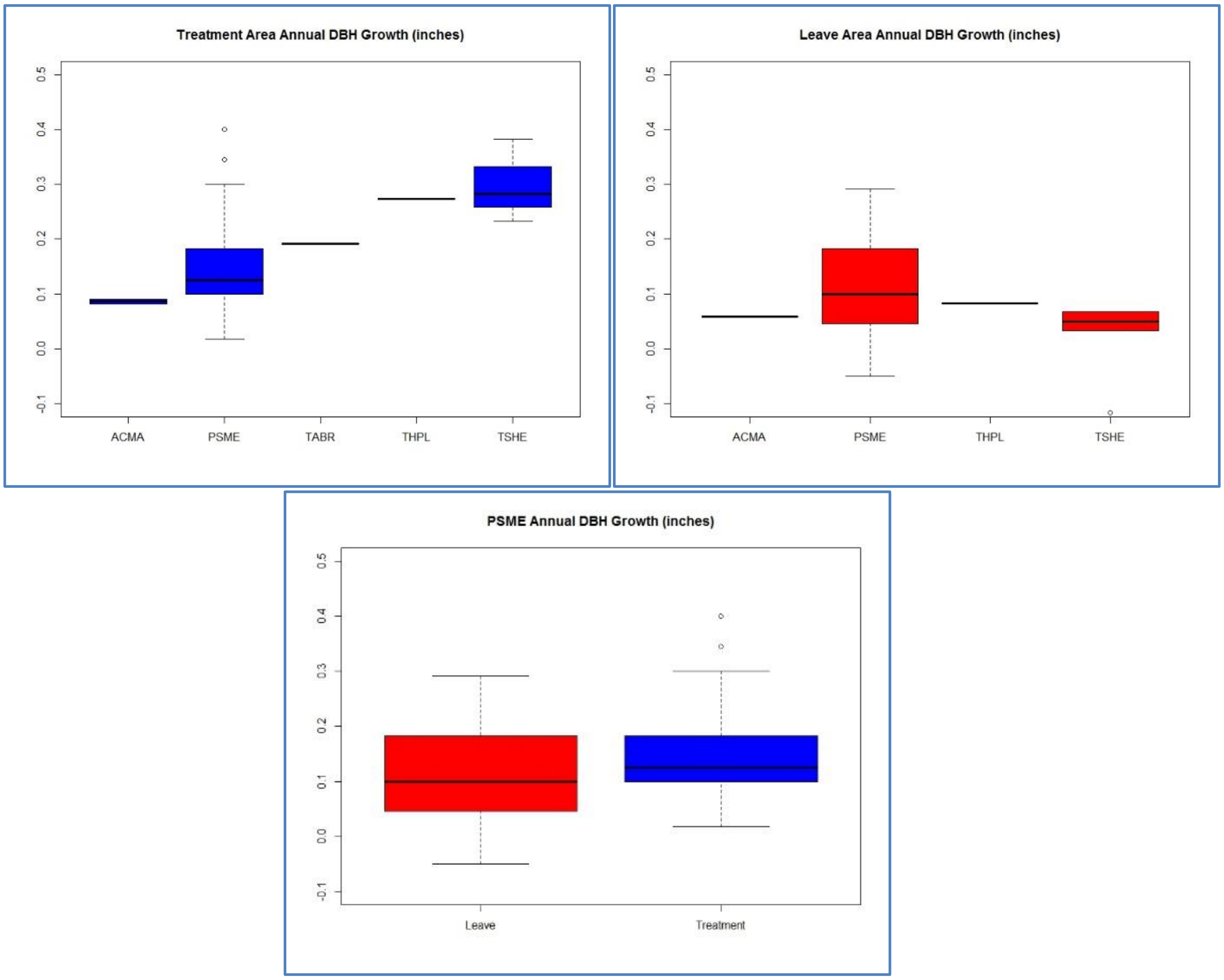


Treatment Area Epicormic Branching (%)

Leave Area Epicormic Branching (%)

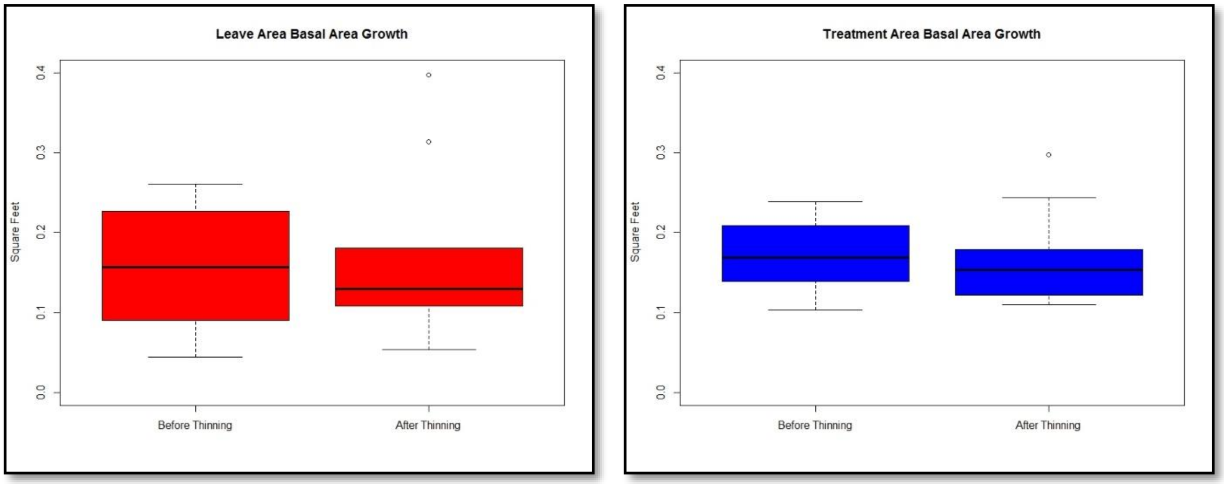
The diameter growth of overstory tree species found in the treatment and leave areas is shown in Figures 11 and 12. There is a significant difference in growth of Douglas-fir trees (p = 0.036), the only species with sufficient sample size to make this test worthwhile. The difference is primarily due to some slower growing trees in the leave areas (Figure 13). The plot with the greatest diameter growth, however, is also in a leave area (#2206241120).

Figures 11-13. Annual DBH growth of overstory trees in the 45 Road Forest Restoration Project. (ACMA = bigleaf maple, PSME = Douglas fir, TABR = Pacific yew, THPL = western redcedar, TSHE = western hemlock)



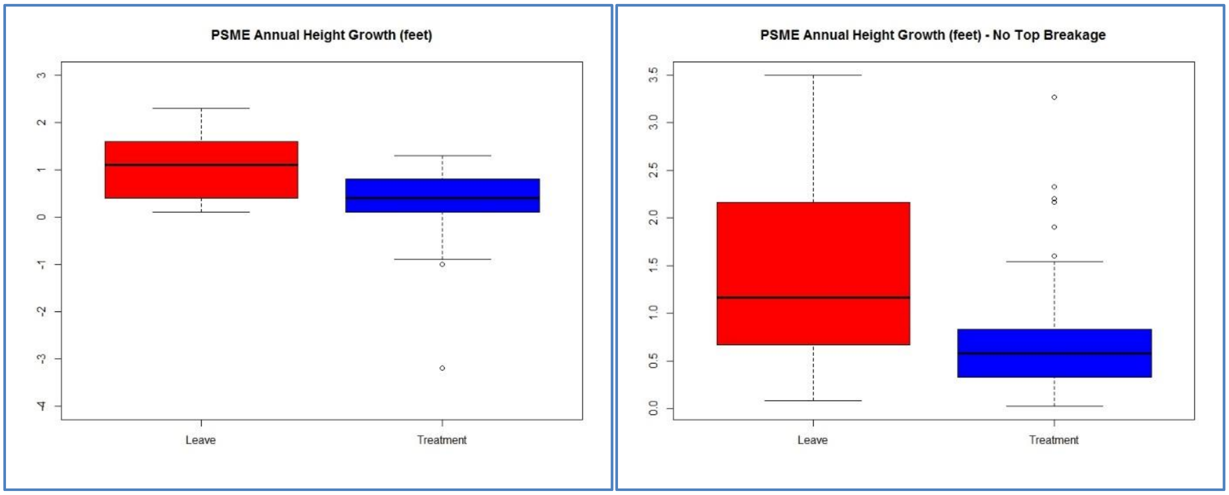
Tree cores from just co-dominant Douglas fir trees, however, indicated no difference (p>0.80) in diameter growth either before and after thinning or between the treatment and leave areas (Figure 14 and 15).

Figure 14 and 15. Basal area growth as determined from cores of Douglas fir trees in the 45 Road Forest Restoration Project.



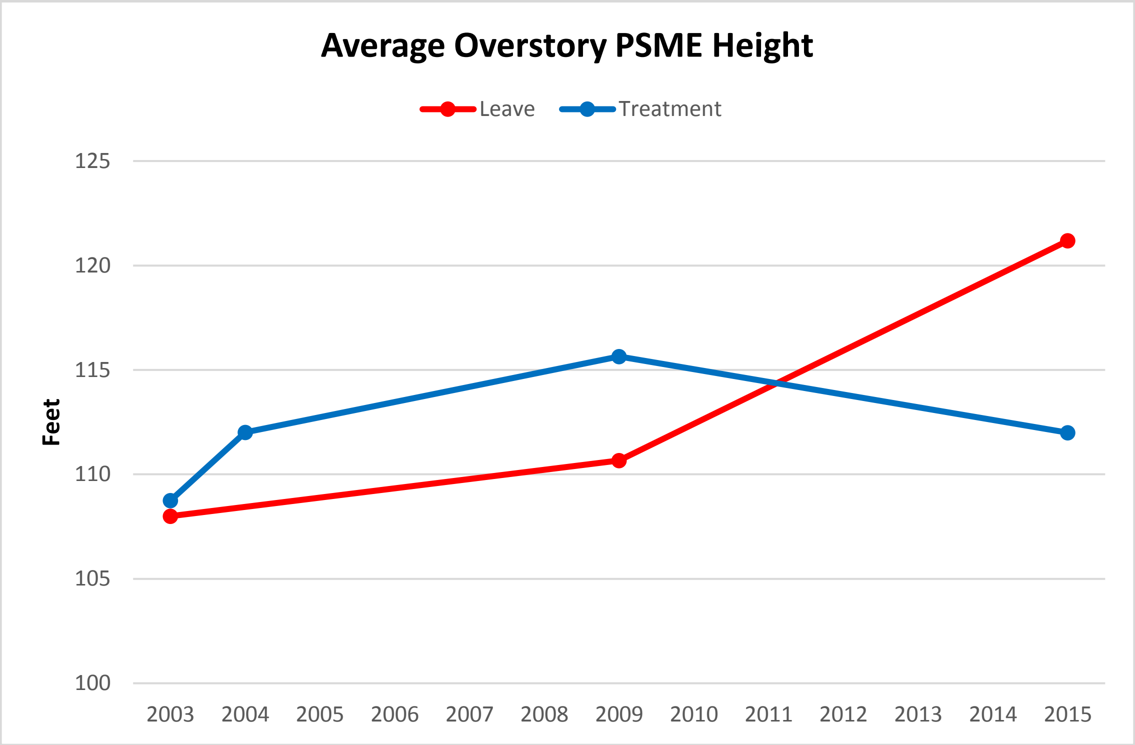
Height growth for Douglas fir trees average 1.10 feet/year in the leave areas and 0.27 feet/year in the treatment areas, but that is not a significant difference (p=0.425) (Figure 16). The distribution of the growth of individual trees indicates more top breakage (e.g., negative growth) in the treatment areas. Indeed, removing all trees showing negative growth indicates that Douglas fir trees in the leave areas are growing taller faster than the treatment areas (p = 0.002) (Figure 17). Samples for other species in the plots (western hemlock, bigleaf maple [*Acer macrophyllum*], western redcedar [*Thuja plicata*], and Pacific yew [*Taxus brevifolia*]) were insufficient to determine differences in growth.

Figure 16 and 17. Annual height growth (feet) of Douglas fir trees in the 45 Road Forest Restoration Project, with and without top breakage.



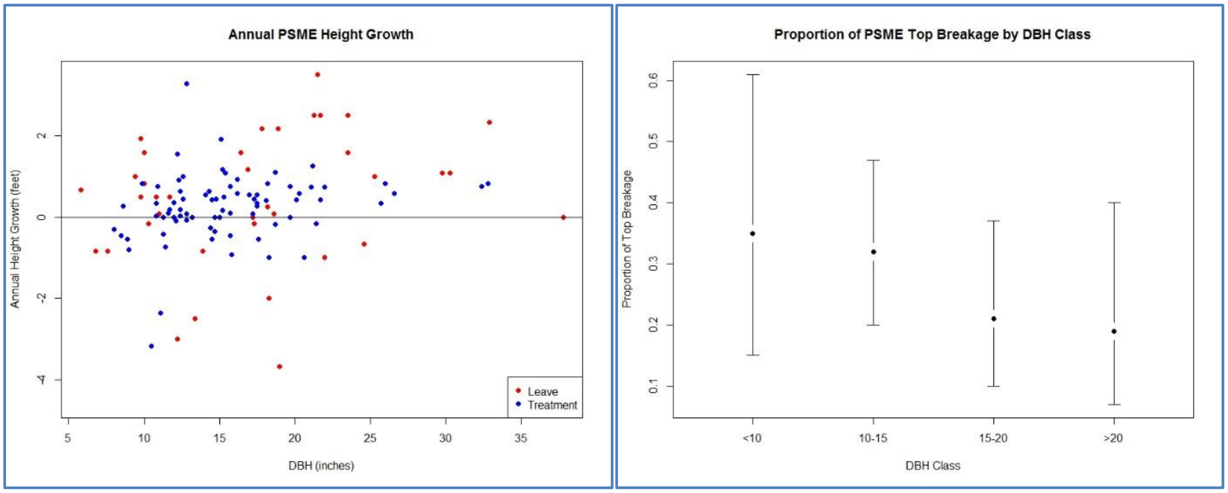
The evidence for top breakage in the treatment areas is also shown in the average height of the overstory Douglas-fir trees (Figure 18), where initially the height in both the leave and treatment areas was the same. Breakage occurred in roughly 60 percent (n = 28) of the Douglas fir trees sampled at four time intervals (2003, 2004, 2009, 2015) in the treatment area, and only 20 percent of the leave area trees (n = 11). Immediately following the thinning, which removed the smaller trees, the average height in the treatment areas increased relative to the leave areas. This continued until sometime between 2009 and 2015 (there was an ice storm in 2011), when top breakage occurred resulting in a higher average tree height in the leave areas. “Self-thinning” in the leave areas, or mortality caused by light competition in the smaller trees, could have also contributed to the increased relative height in the leave areas.

Figure 18. Average overstory Douglas-fir (PSME) height in the 45 Road Forest Restoration Project.



Top breakage (e.g., negative annual height growth) impacts the smaller trees in both areas more than bigger trees (Figures 19 and 20).

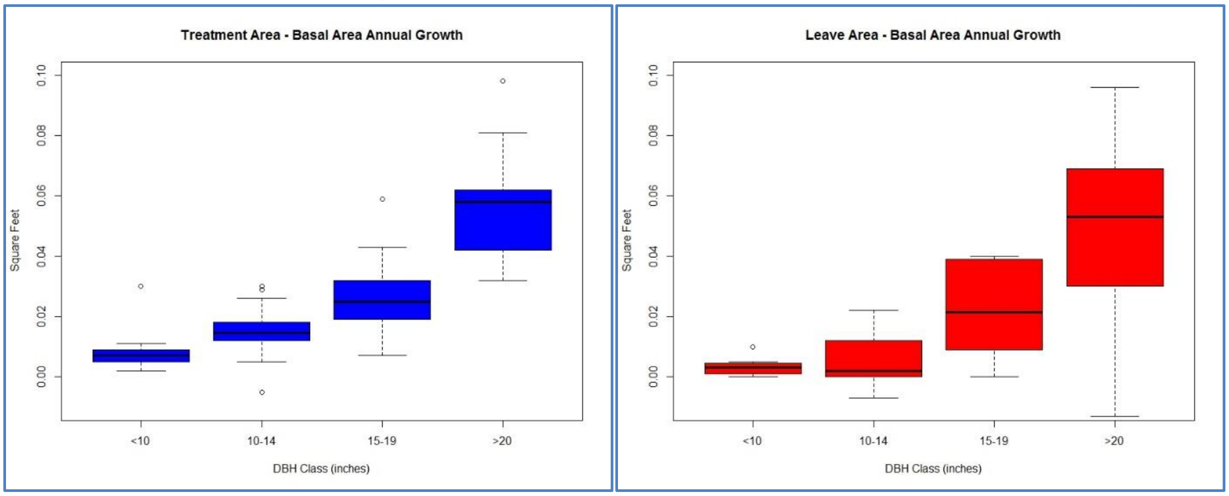
Figures 19 and 20. Annual Douglas fir growth by diameter and the proportion of Douglas fir top breakage by diameter class in the 45 Road Forest Restoration Project.



The basal area (Figures 21 and 22) and volume growth (Figures 23 and 24) of Douglas fir is very similar in the treatment and leave areas, with both metrics indicating increased growth as the trees get bigger.

Only the 10-14 inch diameter class showed a significant difference between the treatment and leave areas for both basal area (p=0.026) and volume (p=0.023).

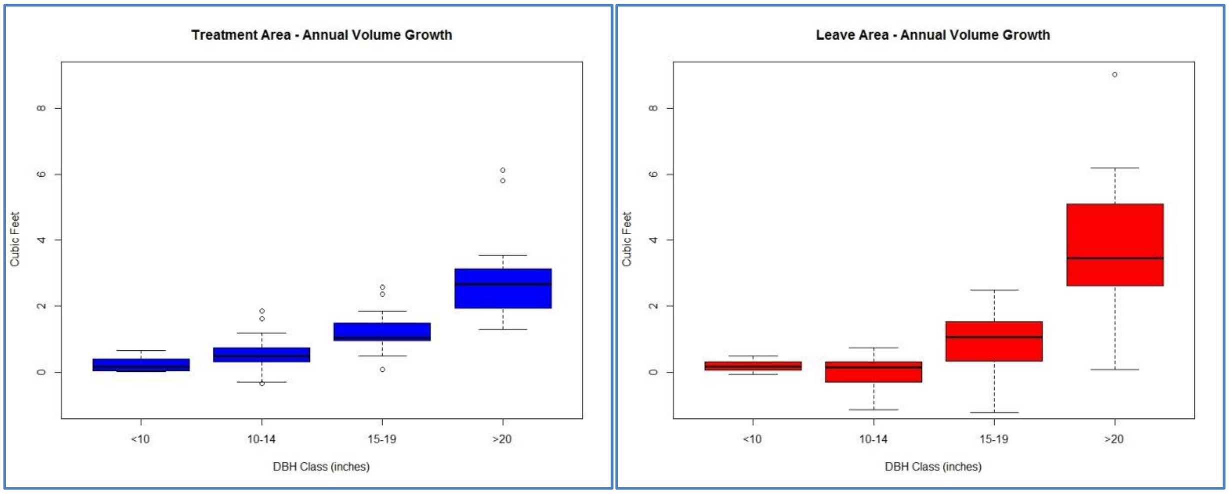
Figures 21 and 22. Annual Douglas fir basal area growth in the 45 Road Forest Restoration Project.



Treatment Area - Basal Area Annual Growth

Leave Area - Basal Area Annual Growth

Figures 23 and 24. Annual Douglas fir volume growth in the 45 Road Forest Restoration Project.

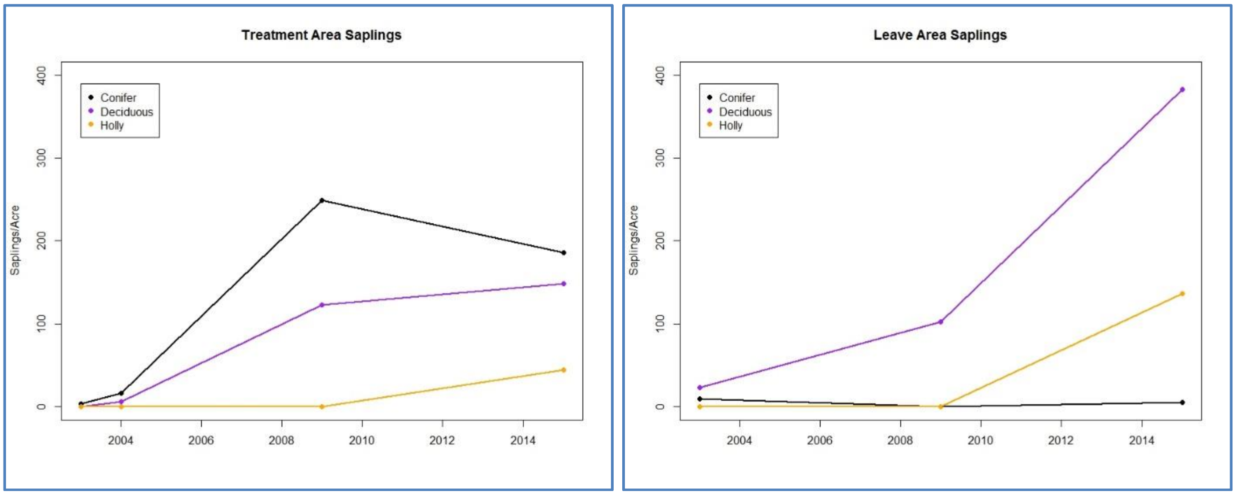


Treatment Area - Annual Volume Growth

Leave Area - Annual Volume Growth

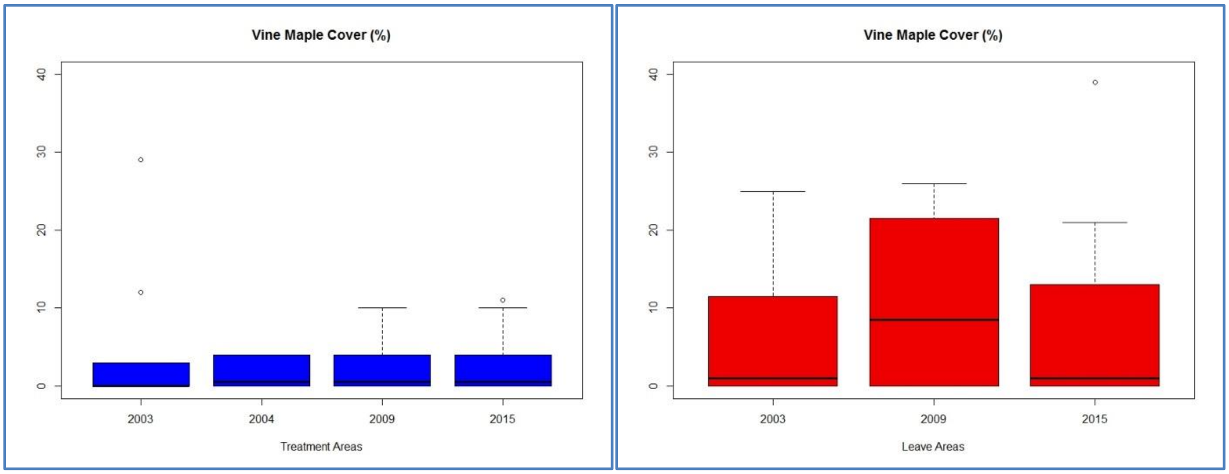
Conifer tree saplings, or trees under 5.0 inches DBH, are found almost entirely in the treatment areas, while the density of deciduous saplings increased in both treatment and leave areas over time (Figures 25 and 26). Holly (*Ilex aquifolium*), an invasive small tree species, has appeared in both treatment and leave areas, though they were found in relatively high numbers (44) in only three plots which skewed the average results. The sapling sample was unreliable (used a different protocol) for 2003 and the data was not collected again in the leave areas until 2009. Conifer trees species found in all of the 2015 samples include Douglas-fir (n=44), western hemlock* (13), western white pine (*Pinus monticola*)* (2), and western redcedar* (1) (*species planted after thinning – see Appendix A). Deciduous tree species found include cascara (*Rhamnus purshiana*) (80), bitter cherry (*Prunus emarginata*) (17), hazelnut (*Corylus cornuta*) (16), Indian plum (*Oemleria cerasiformis*) (15), mountain ash (*Sorbus aucuparia*) (2), bigleaf maple* (1), and red elderberry (*Sambucus racemosa*) (1). In 2015, Cascara, hazelnut, and Indian plum were found either more predominantly or exclusively (hazelnut and Indian plum) in the leave areas, while cascara and bitter cherry made up most of the deciduous species in the treatment areas, where they could have been planted in 2004. Bitter cherry also tends to be a pioneer species and is shade intolerant.

Figures 25 and 26. Saplings per acre in the 45 Road Forest Restoration Project.



The occurrence of vine maple (*Acer circinatum*), another understory tree species that was sampled separately, showed no significant differences (p>0.285) either between treatment and leave areas either before or after thinning (Figures 27 and 28). This could be due to the relatively small sample size, where only four of seven leave area plots and five of 10 treatment area plots contained any vine maple.

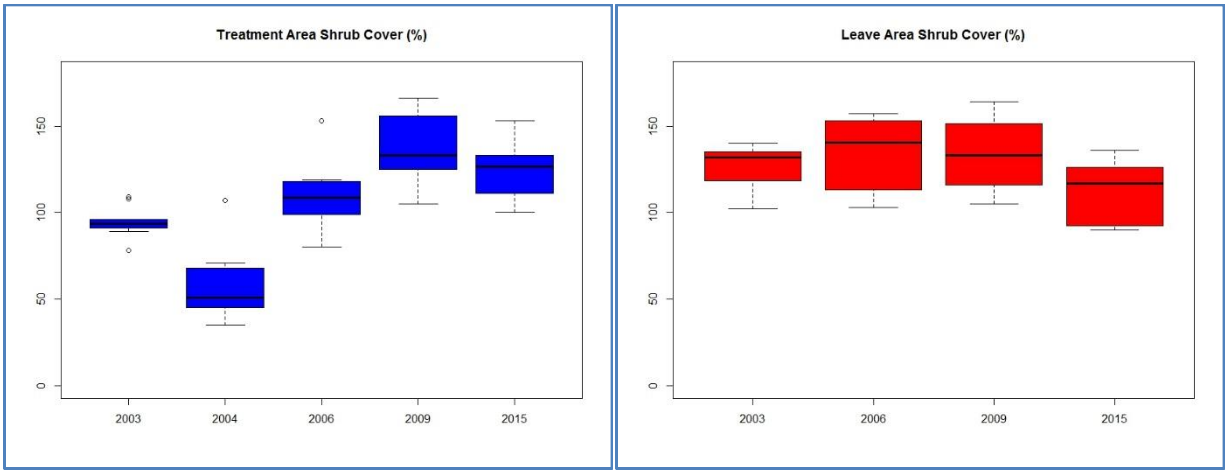
Figures 27 and 28. The percent of vine maple cover in treatment and leave areas in the 45 Road Forest Restoration Project.



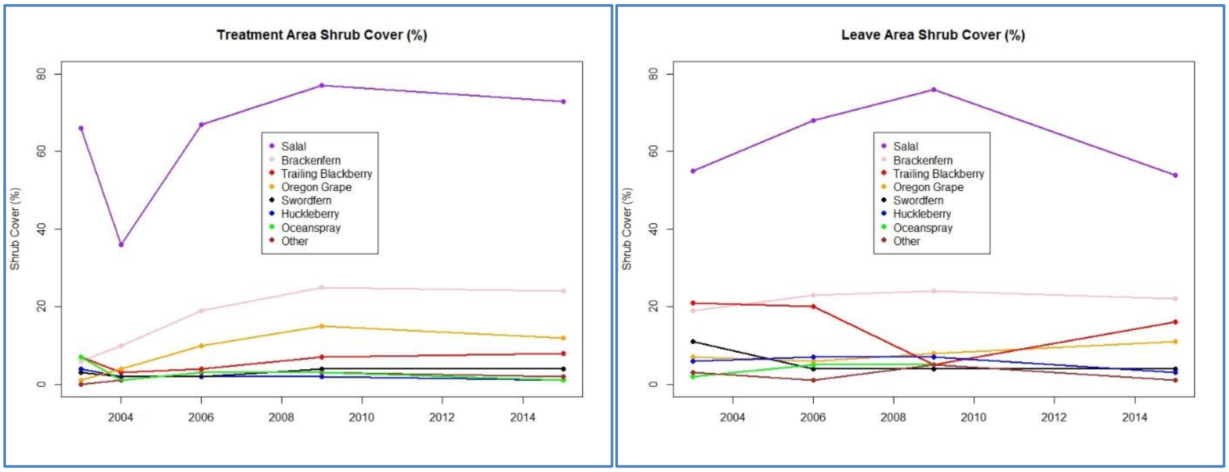
The Under Story

The shrub understory in the treatment area of the Unit was understandably impacted by the ground-based tree harvesting operations between 2003 and 2004 (Figure 29). It has uniformly recovered in the intervening years, but has declined more recently, as has the shrub cover in the leave areas (Figure 30). All of the plots were generally dominated by salal, with various amounts of brackenfern (*Pteridium aquilinum*), swordfern (*Polystichum munitum*), trailing blackberry (*Rubus ursinus*), Oregon grape (*Mahonia nervosa*), huckleberry (*Vaccinium* spp.), and oceanspray (*Holodiscus discolor*) (Figures 31 and 32). The one exception to this was a leave plot (#2206241120) dominated by six foot tall brackenfern and very little salal. There were 13 other shrub species detected over the Unit, but at densities too low to infer any patterns. Holly and English ivy (*Hedera helix*) were the only invasive species found in the shrub layer, but at very low abundance in only four of the plots.

Figures 29 and 30. Total cover of shrubs (%) in the understory of the 45 Road Forest Restoration Project.



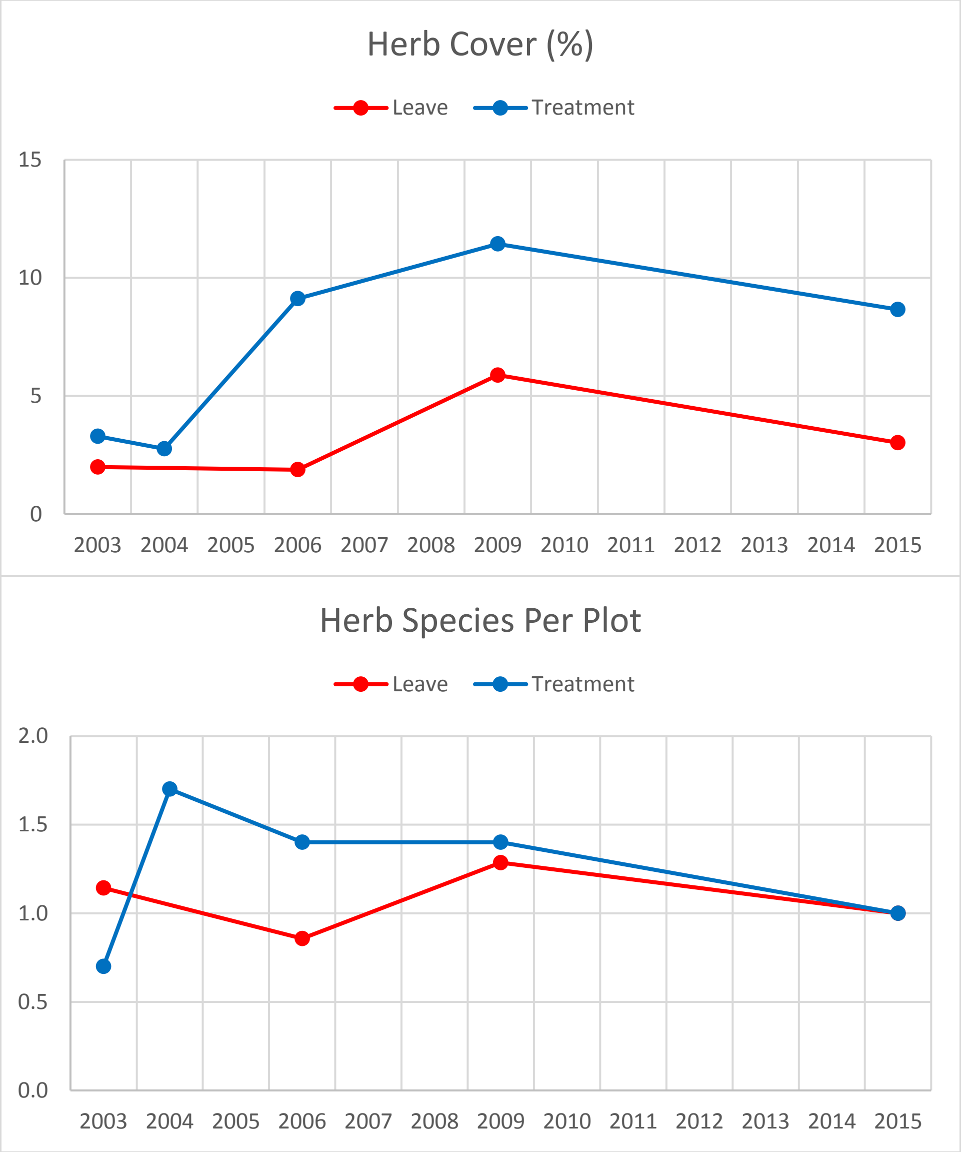
Figures 31 and 32. Cover of shrub species in the 45 Road Forest Restoration Project.



The diversity and percent cover of the herbaceous/small shrub understory increased in the treatment areas following the thinning of the overstory canopy (Figures 33 and 34). Though there were at least 39 herb species detected in the plots (Appendix B), the herb layer was dominated by twinflower (*Linnaea borealis*) (86-88% of herbal cover in both treatment and leave areas) with lesser amounts of starflower (*Trientalis latifolia*) (2-4%) and bedstraw (*Galium trifidum*) (2-3%). Pink wintergreen (*Pyrola asarifolia*)

(4% in leave areas) was the only other species to make up greater than 1% herbal cover in either the treatments or leave areas, but it was found primarily in only one leave plot (#2207181169).

Figures 33 and 34. Percent cover and number of herb species in the 45 Road Forest Restoration Project.



Invasive herb species (6) totaled less than 0.5% of all herbaceous cover. The invasive species in the leave areas (Herb Robert [*Geranium robertianum*]) were different than those found in the treatment areas (oxeye daisy [*Leucanthemum vulgare*], Canada thistle [*Cirsium arvense*], foxglove [*Digitalis purpurea*], and St. Johnswort [*Hypericum perforatum*]), which are disturbance-related species. Grass species were detected in nine of the 10 treatment plots over the course of the monitoring, but only in one of the seven leave areas.

Total vegetation cover (including herbs, shrubs, and saplings) measured at the herb plots in 2015 indicated no significant difference (p>0.133) between treatment and leave areas for any year they were both measured (Figures 35 and 36). Similarly, the amount of exposed small organic material (e.g., litter) on the ground in 2015 was not significantly different (p=0.161) between the leave and treatment areas (Figure 37).

Figures 35 and 36. 2015 total vegetation cover in the 45 Road Forest Restoration Project.

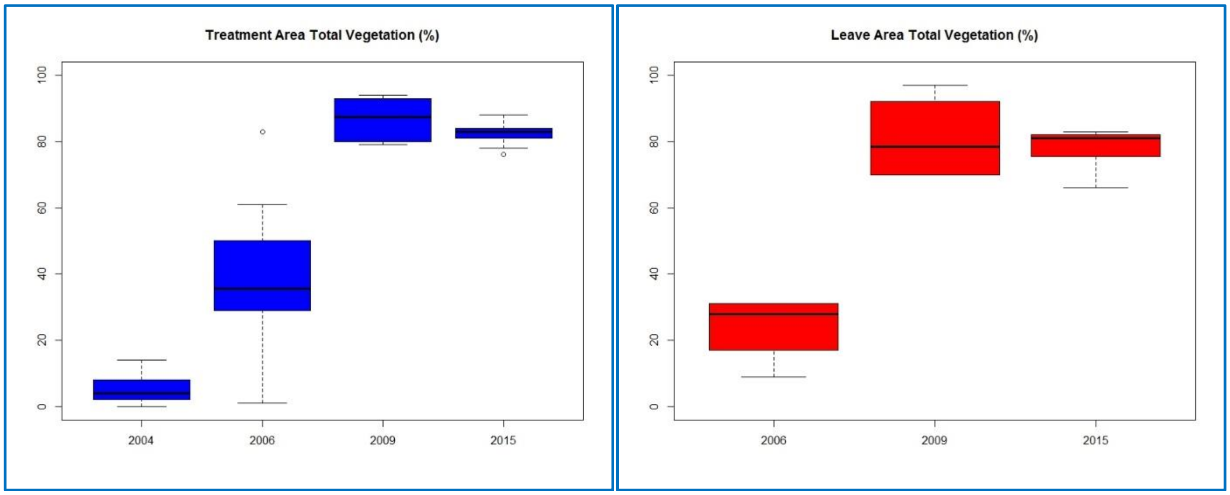
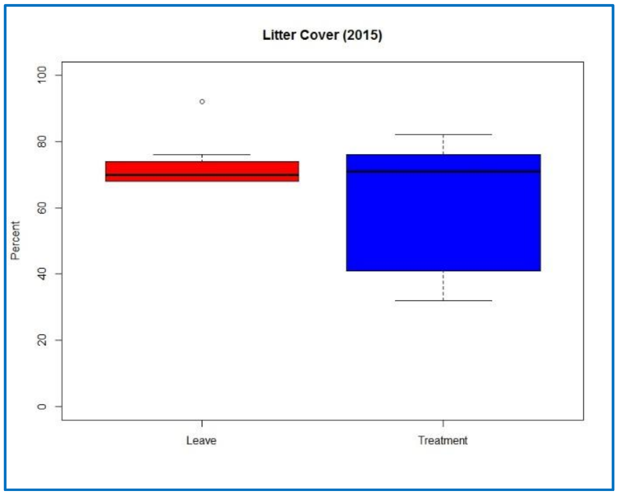


Figure 37. 2015 litter cover in the 45 Road Forest Restoration Project.



Moss cover, started out most different for the treatment and leave areas in 2003 (p=0.138), but has been more similar (p>0.720) since the implementation of the thinning (Figures 35 and 35). Bryophytes as a group were identified in only treatment areas during surveys in 2004, when they were grouped and classified by percent cover (Figure 37).

Figures 35 and 36. Moss cover in the 45 Road Forest Restoration Project.

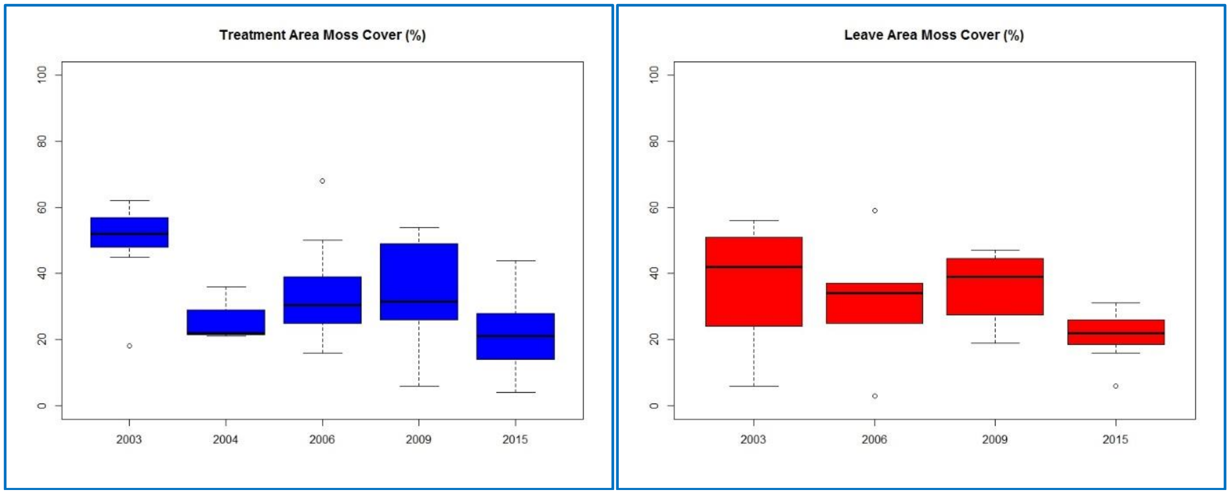
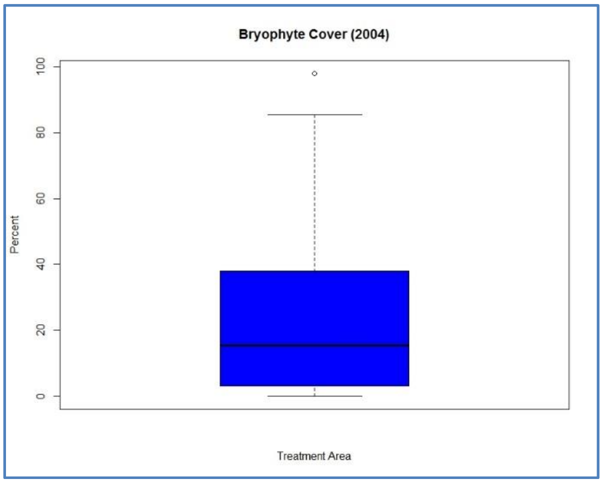
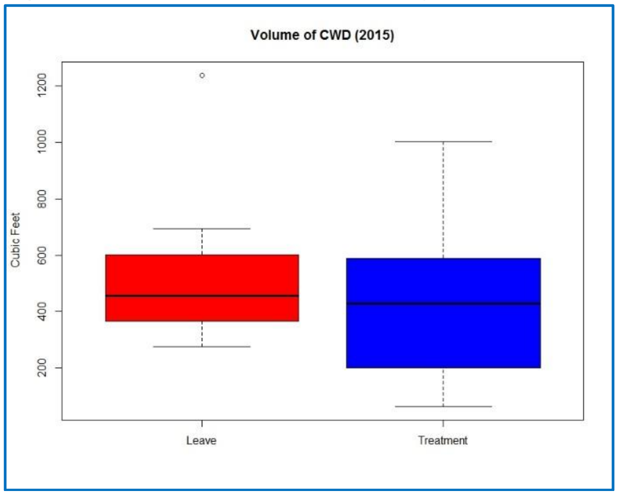


Figure 37. Bryophyte cover in treatment areas in 2004 at the 45 Road Forest Restoration Project.



Course woody debris (CWD), or fallen dead trees, is also not significantly different (p=0.397) in the treatment and leave areas in 2015 (Figure 38). Data is skewed, however, by a few large legacy logs, probably dating back to the original stand on the site. The plot with most CWD is in a leave area (#2207193067).

Figure 38. Volume of course woody debris in 2015 at the 45 Road Forest Restoration Project.



The Discussion

When this project was originally conceived it was hoped that we'd be able to demonstrate that ecological thinning could mimic natural disturbance in creating a forest with improved habitat structure while increasing tree vigor and biodiversity. Twelve years after the thinning it appears that this is indeed true, but the process that enabled us to reach these conclusions was maybe unintended. Whereas we thought we would be comparing thinning treatment areas to untreated "control" areas to quantify the difference we were making, in reality we are comparing treatment areas to untreated "leave" areas that continue to undergo significant natural disturbance mortality due to laminated root rot. So instead of quantifying a difference, we ended up quantifying the degree in which our treatments were similar to the disturbance areas.

Indeed, the density of live overstory trees became more similar to the leave areas after the thinning treatment. The closure in tree canopy in the treatment areas showed more variability over time, which was true for leave areas as well, only not as quickly. This is likely contributing to the increase in epicormic branching in both areas, which is more pronounced in the treatment areas. Diameter growth is similar in the treatment and leave areas, with some slower-growing trees smaller trees in the leave areas (as indicated by more variability at the lower end of the leave area diameter growth). Conversely, height growth is greater in the leave areas than in the treatment areas when considering of top breakage, which is extensive in the medium-sized trees. Unfortunately, tree cores did not indicate that thinning changed the diameter growth of co-dominant Douglas fir trees. This may be attributable to the ongoing disturbance in the leave areas and the co-dominant trees had already grown above their primary competition prior to thinning.

The biggest difference between the treatment and leave areas is the species composition of the tree saplings, with deciduous trees dominating the understory tree layer in the leave areas and conifers dominating in the treatment areas. A possible explanation for this trend could be that the process of thinning removed many of the small deciduous trees. Active planting in the treatment areas then replaced the deciduous trees with conifers (see Appendix A). Since the planting was not systematically even across the treatment areas, but rather patchy, it is difficult to quantify using our sampling method. At least some deciduous trees survive in the treatment areas, however, the conifer understory really does not exist in the leave areas. Vine maple appears quite resilient with no significant difference either before and after treatment or between treatment and leave areas.

The understory is really the tale of salal, which is the dominant shrub species in both treatment and leave areas. Salal showed a sharp decline following the operational impacts of thinning, but rebounded to pre-treatment levels in two years. Both treatment and leave areas had a slight decline in salal cover in 2015, possibly due to drier spring conditions. Other shrub species indicated similar trends, but at much less overall coverage levels.

Twinflower dominated the herbaceous understory, where the thinning treatment also had an impact on its cover. There was a modest increase in overall herbal cover following thinning that is still persisting 12 years after treatment. The relative number of herbal species showed a short-term benefit from thinning, but by six years out, was again similar between the leave and treatment areas. This may be a function of the salal recovery.

Not surprisingly, the treatment areas exhibit more variability in litter cover then the leave areas, perhaps another legacy of the thinning operation. Moss cover, however, after initially showing a decline after the thinning treatment, has not been different in the treatment and leave areas.

The density of snags is also a function of the impact of thinning in the treatment areas. The smaller snags were lost during thinning as reflected in the lower snag density and average diameter when compared to the leave areas. Downed wood volume is primarily a function of the few large legacy logs persisting since the original tree harvest. The volume variability may be greater in the treatment areas, but the plot with the most volume is in the leave area and is due to one very large log. There is no structural substitution for these legacy items.

The greatest concern for invasive species is holly, which was present in both the sampling for tree saplings and shrubs. It is interesting that the belt transect method of sampling tree saplings indicated a higher incidence of holly than did the line intercept method of sampling shrubs. In the few locations where it was identified, it occurs in relatively high concentrations when counting individual plants, but less so compared to the dominance of salal along a line. Invasive herbs are rare but slightly more common in treatment areas. Only thistle and English ivy (technically a shrub species) were detected in 2015. Thistle is an ephemeral early colonizer while English ivy is shade tolerant and able to persist and thrive under canopy.

Conclusions So Far: Lessons Learned

At 12 years it appears that we have been somewhat successful in utilizing overstory tree thinning to mimic the natural disturbance that continues throughout the project site, including root rot, windthrow, and top breakage. Though there continues to be a “hangover” of treatment impacts to some understory variables (snags, litter), thinning is substantially similar to the root rot mortality for overstory tree density, epicormics branching, and understory shrub cover. Though one of the project objectives at the beginning may have been to use thinning to arrest the spread of root rot, root disease continues to play a role in tree mortality in both treatment and leave areas. Tree planting has shown itself to be effective at improving tree species diversity, but more focus should be put on deciduous species. The overall differences in shrub and herb understory, as well as downed wood, appears to be nominal. Perhaps active thinning is better suited for areas not already undergoing natural disturbance processes. Forest resilience management, however, benefits greatly from the species diversification of active planting.

Circling back to the specific project objectives, did we get to where we wanted to be?

1) Maintain or increase the growth rate of trees

The data from this project indicated no difference in diameter growth in Douglas fir trees in the treatment areas when compared to the leave areas, except when including the smaller slow-growing trees in the leave areas. Since the root-rot infested leave areas were initially structurally different than the treatment areas, at least in terms of tree density, the impact of the thinning treatment might have been to make the two areas relatively more similar to each other. This is reflected in similar patterns diameter growth. Height growth initially appeared to benefit from thinning, however, storm-induced top breakage muddies the analysis. This analysis does not indicate that there is much of an increase in growth from the treatment when compared to the leave areas.

2) Increase structural diversity

Similar to tree growth, making the two areas relatively more similar to each other makes it difficult to demonstrate an increase in structural diversity from thinning. It is likely, however, that the treatment increased structural diversity on the landscape where root rot may not be as pervasive, though the data developed by this monitoring project alone cannot demonstrate that trend. The development of epicormic branching in both treatment and leave areas is helping to diversify the overstory structure, as is the emergence of a viable and diverse sapling cohort.

3) Increase species diversity

Though there was an ephemeral bump in understory diversity immediately following the thinning, perhaps the biggest benefit to the resilience of the forest at the project site is the facilitated increase in tree species diversity through active planting. With four separate planting efforts to date, the diversity can already be seen in the sampling of saplings. Tree planting will continue to be a primary method for improving diversity.

4) Facilitate maintenance and recruitment of large-diameter snags and coarse woody debris

Large-diameter snags and downed wood can only come from large trees. Therefore, the maintaining or increasing the growth rate of live trees (see objective #1) will also facilitate, maybe decades from now, the recruitment of large snags and logs.

5) Protect special habitats

The project site was chosen for many reasons including its relatively flat topography, close proximity to the hydrographic boundary of the watershed, and its relatively uniform habitat features. There are no “special” habitats (e.g., stream/wetland/riparian habitat, talus slopes, old-growth forest) present that might require protection.

6) Protect water quality

As mentioned above, one of the reasons this project site was chosen was because there are no streams linking the site directly to the City’s water supply. The long term benefits of helping to create a resilient and diverse forest cover far outweigh any short-term risks of project implementation.

Appendix A.

Summary of species planted in the 45 Road Forest Restoration Project.

2004
7,100 western redcedar, Sitka spruce, western hemlock, bigleaf maple, red alder
200 various understory plant species

2005
50 bigleaf maple
30 western redcedar
40 Pacific yew
50 Nootka rose
50 oceanspray
50 vine maple
30 Lewis mockorange

2014
800 western white pine

2016
500 western white pine

Appendix B.

Herb/Small Shrub species detected in the 45 Road Forest Restoration Project.

*Invasive species
**Non-vouchered species (e.g., not verified by a botanist)

CODE	Scientific Name	Common Name
ASTER	*Aster* species	aster
BLSP	*Blechnum spicant*	deer fern
CHLE	*Chrysanthemum leucanthemum* (now *Leucanthemum vulgare*)	oxeye daisy*
CHME	*Chimaphila menziesii*	Prince's pine
CIAR	*Cirsium arvense*	Canada thistle*
CIsp	*Thistle* species	Thistle*(likely Canada or bull)
COCA	*Cornus canadensis*	bunchberry
COHE	*Collomia heterophylla*	variableleaf collomia
DEsp	*Deschampsia* species	Hairgrass
DIFO	*Dicentra formosa*	Pacific bleeding heart
DIPU	*Digitalis purpurea*	Foxglove*
EPAN	*Epilobium angustifolium* (now *Chamerion angustifolium*)	Fireweed
EPBR	*Epilobium brachycarpum*	willowherb
EPPA	*Epilobium paniculatum* (same as *E. brachycarpum*)	Tall willowherb
GATR	*Galium triflorum*	Sweet-scented bedstraw
GERO	*Geranium robertianum*	Herb Robert*
HAsp	*Habaneria* species	Habaneria
HEHE	*Hedera helix*	English ivy*
HYPE	*Hypericum perforatum*	St. Johnswort*
HYsp	*Hypericum* species	St. Johnswort*
LIBO	*Linnaea borealis*	twinflower
LICO	*Listera cordata*	Twayblade orchid
LICO2	*Lilium columbianum*	Tiger lily
LOCI	*Lonicera ciliosa*	pink honeysuckle
LOMI	*Lotus micranthus*	Small-flowered lotus
LUsp	*Woodrush* species	Woodrush
MADI	*Maianthemum dilatatum*	false lily of the valley
PYAS	*Pyrola asarifolia*	Pink wintergreen**
PYsp	*Pyrola* species	Wintergreen
RILA	*Ribes laxiflorum*	Trailing black currant**
RULA	*Rubus lasiococcus*	Dwarf bramble
RUPH	*Rupertia physodes*	forest scurfpea
TRLA	*Trientalis latifolia* (now *T. borealis latifolia*)	Starflower
TROV	*Trillium ovatum*	Pacific trillium

VEOF	*Veronica officianalis*	speedwell
VESE	*Veronica serpyllifolia*	thymeleaf speedwell
VEsp	*Veronica* species	*Veronica* species
VIOR	*Viola orbiculata*	Round-leafed violet
VISE	*Viola sempervirens*	Trailing yellow violet