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Forested Wetland Regeneration Pilot Study Summary Report

JULY 2004

SUBMITTED BY

Washington Department of Ecology
and the Wetlands Scientific Advisory Group

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Forested Wetland Regeneration Pilot: Final Report
Disclaimer

The Forested Wetland Regeneration Pilot: Final Report is classified as a
"Project Development Report"

This project development report was prepared for the Cooperative Monitoring, Evaluation and Research Committee (CMER), and is intended to support design and implementation of Forest and Fish Adaptive Management research and monitoring studies. The project is part of the Forested Wetland Regeneration Program, and was conducted under the oversight of the Wetland Scientific Advisory Group (Wet SAG).

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November 21, 2005

Forested Wetland Regeneration Pilot Study

Summary Report

A Report for the Wetlands Working Group (WETSAG)
July 31, 2004

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Introduction

Background

The Washington State Forests and Fish Report (FFR) called for the establishment of a group comprised of members with the scientific expertise to determine current knowledge of wetlands (FFR Appendix F) (USFWS *et al* 1999). The Wetlands Scientific Advisory Group (WETSAG) was established in 2001. Based on identified gaps in the current wetland knowledge, WETSAG members are charged with conducting research and making scientific recommendations to address issues related to the protection of wetland functions.

In addition to several research issues WETSAG identified related to forested wetland functions and the adequacy of existing wetland rules that need further study, WETSAG was charged with specific research priorities including "evaluate the regeneration and recovery capacity of forested wetlands." (F.3 (b) in FFR).

Current Forest Practices rules (WAC 222) are based on the premise that harvesting trees in forested wetlands will result in relatively short-term impacts to wetland functions. The assumption is that by the mid-point of the harvest rotation the wetland will have recovered sufficiently to provide wetland functions similar to pre-harvest conditions. Anecdotal observations underlie the assumption that wetlands will regenerate trees of similar size and species which will provide a similar type and degree of hydrologic and biological functions. However, other anecdotal observations suggest that some forested wetlands convert to emergent or shrub wetlands after being harvested. Thus far there has been no quantitative investigation of either theory. Therefore, a scientific study is needed to objectively evaluate the regeneration and recovery capacity of forested wetlands.

No published scientific research on establishment and growth of tree or understory species in forested wetlands following timber harvest has been conducted in the Pacific Northwest. As a result, WETSAG initiated a pilot study to characterize regeneration in forested wetlands. This pilot study was intended to develop research methodologies. It was also intended to examine current methods of forested wetland regeneration and to determine the success of their implementation. In addition, the pilot study began gathering information that will contribute to guidance for landowners on how best to ensure the regeneration of forested wetlands.

Pilot Study Goals and Objectives

To address the research task from the FFR to "evaluate the regeneration and recovery capacity of forested wetlands", WETSAG intended to conduct a pilot study followed by a larger, more comprehensive study. The two studies have different goals and objectives.

The goal and objectives of this pilot study are limited in scope, and are intended to provide a basis for the larger, full-scale study. The primary goal of this pilot study was to develop and test methods for collecting, summarizing, and analyzing data on the effectiveness of forested wetland regeneration. Finally, the pilot study was to begin accumulating information on the factors contributing to regeneration success or failure (e.g., harvest methods, regeneration methods, species selection, etc.).

This pilot study was <u>not</u> designed to provide statistically significant results that prove or disprove a hypothesis. Rather, it was intended to provide a basis for WETSAG members to establish sound scientific methodology for future evaluations of forested wetland.

The principal objectives of the pilot study were:

1. To develop a process for identifying suitable sites to sample. This included working with landowners who manage forested wetlands to identify forested wetlands that have been harvested.

2. To develop and test methods for site selection, develop and test sampling protocol, develop measures of regeneration success, develop methods for data analysis, and collect some preliminary information about regeneration in forested wetlands to guide study design for the full scale study.

The objectives of the larger study are:

- Establish if forested wetlands are re-establishing tree cover after they have been harvested.
- Identify methods used to regenerate forested wetlands
- Investigate factors that influence regeneration.
- Develop a definition of successful regeneration that can be measured.
- Evaluate success in regenerating forested wetlands that achieve biotic and structural complexity similar to original conditions by mid-harvest rotation.
- Address the effect of harvest operations and reforestation roles on ecological function.

Methods

The purpose of this section is to describe the initial methodology developed for data sampling. It also explains the problems that emerged in the field and describes how the methods were revised to address those problems. Possible alternatives are recommended for conducting a future study.

Site selection

Members of WETSAG helped identify landowners willing to participate in this study and provide information about wetlands that appeared to meet study criteria. The Cooperative Monitoring, Evaluation, and Research Committee (CMER) Study Implementation Coordinator then contacted all the landowners to formally request their cooperation and permission to access their land. Six landowners participated in this study, including Boise Cascade, Crown Pacific, Rayonier, Simpson, and the Washington State Department of Natural Resources and the Washington State Parks and Recreation Commission.

The investigator/author worked with representatives from each landowner to select forested wetland sites. The criteria for site selection included:

- Landowner perception that the site met the legal definition of a forested wetland. Investigators tried to confirm or verify wetland conditions before the site visit using aerial photos, topographic maps, soil surveys, and National Wetlands Inventory (NWI) GIS data.
- Trees were harvested from the wetland site at least 5 years ago, but no more than 15 years ago. Sites harvested between 1987 and 1998 were chosen, focusing the study on sites harvested since the current wetland rules were adopted. These selection criteria were subsequently expanded due to difficulties finding enough suitable wetland sites.
- Area of forested wetland should be at least one acre.

The correct identification of harvested forested wetlands was significantly more difficult than expected. The DNR site selection process clearly illustrates the difficulty of identifying sites. The DNR provided a list of sites that were generated from GIS data layers. Harvest units that met the criteria for date of harvest were overlaid with NWI and stream/hydro layer maps. Potential sites were identified where harvest units intersected or overlapped with mapped wet areas. The majority of these sites either did not contain forested wetland meeting federal definition criteria (US ACOE EL 1987), or the wetland portion of the site had not been not harvested, significantly reducing the population from which to randomly select study sites.

Because the pool of acceptable sites proved so difficult to identify, the goal of random site selection was abandoned. Instead, investigators relied on landowners to volunteer sites for this pilot study. In order to study suitable wetland sites, the investigators expanded the selection criteria to include one site harvested less than five years ago and four sites harvested more than 15 years ago.[1]

Wetland Determination

Without a preliminary field visit to determine wetland boundaries within a harvest unit, it was often difficult to ascertain the wetland area(s) location. Locating wetland area in the field often required multiple days to complete sampling and data collection. Likewise, preliminary estimations of wetland acreage were often inaccurate. Therefore, sample plots often landed on uplands even when wetland area existed within the harvest unit. In addition, aerial photos were often of pre-harvest conditions making it difficult to navigate to a particular position with any certainty, particularly in large harvest units.

Prior to collecting data, a quick reconnaissance was conducted to determine if any part of the harvest unit qualified as forested wetland. When no forested wetland was found on a site, or if the wetland area was not harvested, the site was dropped from the study.

The process of identifying wetlands within a site was relatively rapid. However, determining the boundary of wetland area(s) and estimating approximate wetland acreage took a substantial amount of time, depending on the size of the harvest unit and the degree of visibility within the site. The difficulty in finding wetland areas and determining wetland boundaries ultimately influenced how a site was sampled and where sample plots were located.

Locating Sample Plots

Initially transects and sampling plots were systematically placed without bias onto an aerial photo of the entire harvest unit, NWI identified wetland area, or area suggested by a forester. Plot size was 1/70th of

[1] Two sites lacked background information, including date of harvest.

an acre. This equated to a radius of 14.1 feet. The investigators estimated the size of the wetland in order to calculate the required number of sample plots. The suggested sampling density was originally three plots per acre, with a minimum of 10 plots per site. These plots were then evenly distributed along parallel transects (at least 60-100 feet apart) until the desired number was achieved.

The investigators navigated along transects from one sampling plot to the next noting when a plot was on an upland hummock or near the edge of the wetland. When a proposed sample plot was located on an upland, the plot was not sampled and the investigators moved on to the next plot. To ensure that the required number of wetland plots was sampled (based on the estimated wetland acreage), the investigators often placed twice the number of plots necessary on the aerial photo to account for any upland plots encountered.

When no contiguous area of at least one acre of wetland was found, the investigators traversed the site sampling wetland areas as they were found. This affected sampling density. For example, a few sites had a specific area that was already identified as wetland (e.g., NWI). After confirming that the area was in fact wetland, the investigators focused sampling in that area (Refer to Figure 1). However, when no specific wetland area meeting the one acre threshold was identified on the map but the harvest unit was identified as containing a wetland, the investigators placed plots throughout the site (refer to Figure 2). Regardless, all plots were established in areas that met the definition for wetlands or jurisdictional criteria (Washington State Department of Ecology 1997).

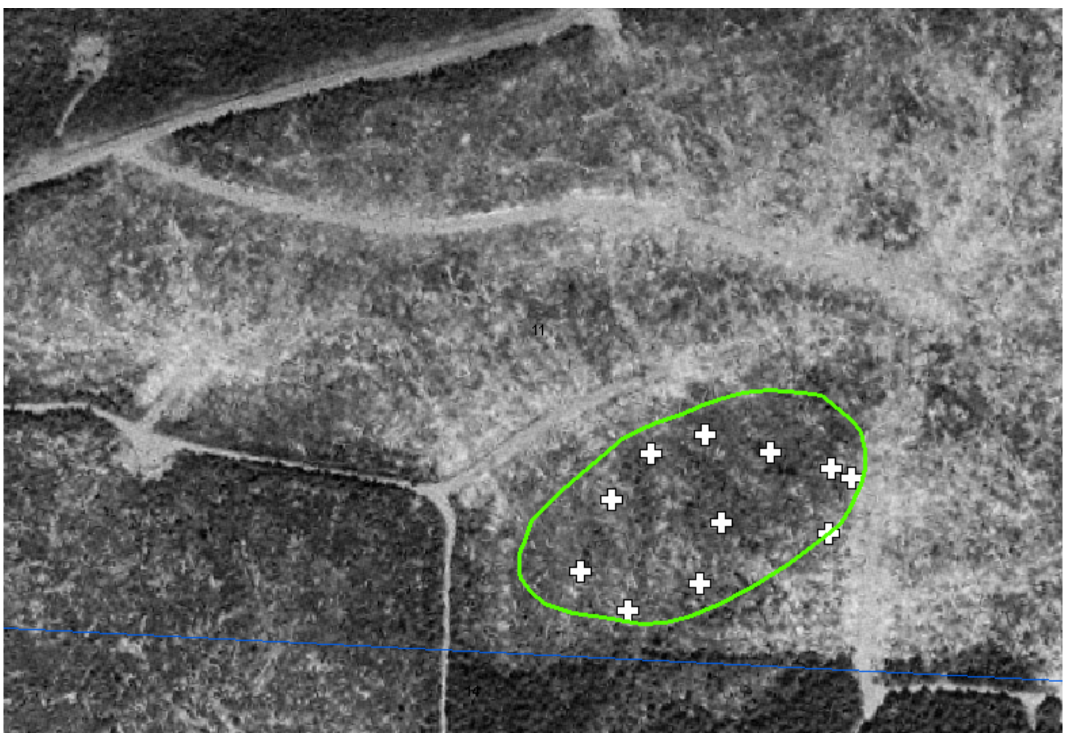


Figure 1. Dense sampling. Circled area was NWI identified wetland, about 4.7 acres, within a larger harvest unit. Eleven plots were concentrated in this area, resulting in a sampling density of 2.34 plots/acre (scale=1:3000).

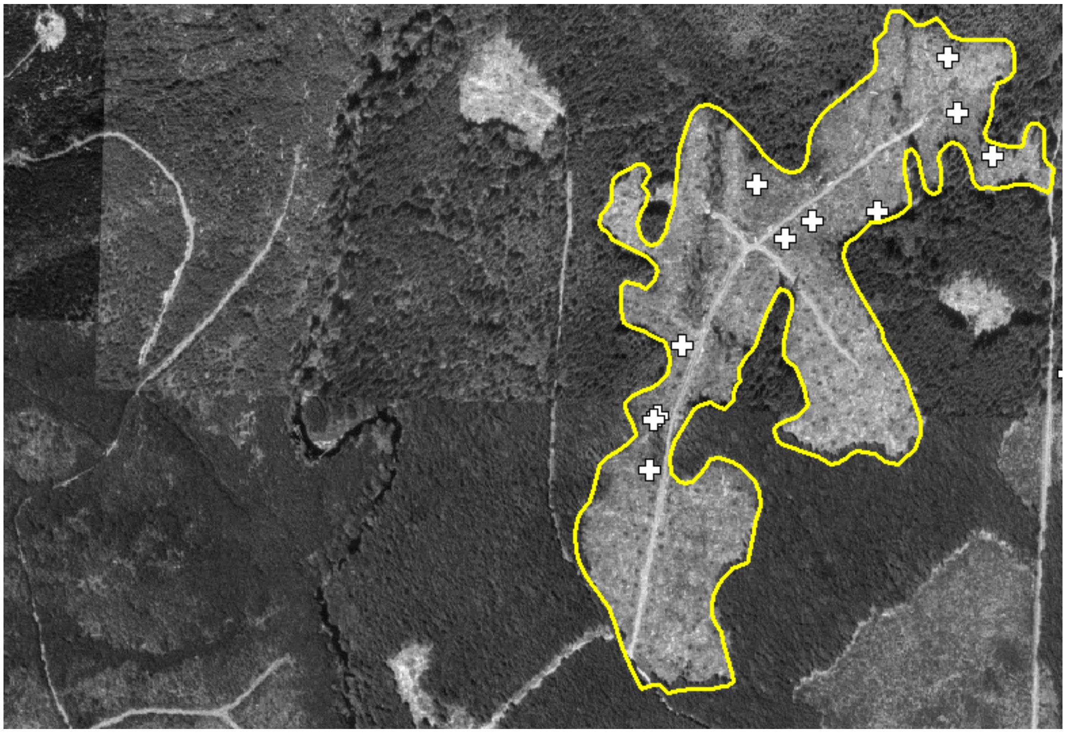


Figure 2. Sparse sampling. Outlined area was the harvest unit, about 56 acres. Eleven plots were scattered across this area, wherever the investigators found wetland conditions. This resulted in a sampling density of 0.2 plots/acre (scale=1:7000).

The methods used may have introduced statistical bias. The mosaic nature of the ecosystems on the landscape made systematic sampling (i.e. plots in a grid) unrealistic. Varying sampling intensity per wetland may also have introduced bias. In order to meet the objectives of the study while addressing the difficulty of locating plots, the following adjustments were made to plot location procedure. Investigators addressed the difficulties of having pre-identified plots fall on uplands and trying to assess wetland acreage in the field by:

1. Placing sample plots only in wetland areas. Plants known to occur in wetlands were used as a guide.
2. Reducing the sampling density, particularly for larger sites. The larger the site, the lower the sampling density. Plot density became:
   - 1 plot/acre of wetland with a minimum of 10 plots per site (sites up to 15 acres)
   - 1 plot/2 acres of wetland with a minimum of 10 plots per site (sites 16 to 30 acres)
   - 1 plot/3 acres of wetland with a minimum of 15 plots per site (sites 31 to 50 acres)
   - 1 plot/5 acres of wetland with a minimum of 15 plots per site (sites >50 acres).

3. Using a GPS device to navigate through a site. Transects were used as a guide to keep plots a minimum distance apart. However, locations of sample plots were assigned one at a time as a navigation target. For example, the investigators set a navigation target for a chosen sampling plot. Upon arriving at the navigation target they determined that the plot was upland. Since the investigators skipped upland plots, they assessed where the next sample plot should be located based on visible landscape features and the area that had already been traversed. They then set a new navigation target to the next sample plot based on this assessment.

Depending on the objectives of a future study, some possible alternatives for locating sample plots include:

1. Determine approximate wetland boundaries before conducting any sampling. This would take extra time.
2. Determine whether sampling should be restricted to sites that have at least one acre of contiguous wetland area.
3. Determine whether it would be acceptable to sample several wetland areas within a harvest unit when no single wetland area amounts to one acre but the combined area exceeds one acre.
4. Systematically sample the entire harvest unit at the prescribed density. Note plots that occur in upland and move on. (Recording sample data on uplands could provide a valuable comparison to sample data collected from wetland areas.)

Locating Plot Centers

The center of each sample plot was located where a soil pit could be dug to verify wetland soils and hydrologic criteria. Plot centers were generally placed in a relatively open area free of tree roots and slash. This practice may have biased the results by favoring areas that were more open, with fewer trees, and less slash and downed woody debris.

To address this potential bias, the methodology of a future study could direct investigators to navigate/pace to the sample plot. The resulting end point would automatically become the plot center. The soil pit could then be moved to the nearest open space if the plot center (end point of navigation/pacing) did not easily allow for a soil pit.

Data Collection

Background Information

The following data were collected for each site, to the extent possible:

- **Pre-harvest site conditions.** Data were collected from landowner records and aerial photographs including tree species (where possible) and stocking density (basal area, stems per acre, % cover). Attempts were made to identify remaining stumps on the site and use them to estimate pre-harvest species composition and conduct a relative assessment of pre-harvest stocking levels. Stump data were collected from all plots but not along transects. These stump estimates were compared to pre-harvest inventory information where it existed. Tree density was calculated using methods for determining stocking levels from the Forest Practices Board Manual (WDNR, Section 6).

- **Harvesting data**. Investigators sought information on the type of harvest methods (shovel, skidder, high-line, etc.), whether it was a salvage operation, and the time of year of the harvest.

- **Reforestation data**. Landowners were requested to provide information on reforestation methods (natural, seed-tree, planting), site preparation (piling, vegetation control, burning, etc) planting stock (species and stock type, nursery, seed source, planting tool, planting quality audit, re-planting efforts, planting date), and any other management measures.

- **Current site conditions**. Tree species were recorded and stocking density (stems per acre) was calculated using the plot sampling methods from the Board Manual for determining acceptable stocking levels. Data were also collected on herbaceous vegetation (species and percent cover), wetland hydrogeomorphic classification (Brinson 1993 and 1995), wetland soil type, elevation, aspect, depth to soil saturation, slope, and substrate (i.e. soil or downed wood).

- **Other**. Additional data were collected on possible factors influencing regeneration, such as road construction, beaver activity, and surrounding stand condition.[2]

Sampling procedures.

The sampling design is based on the Forest Practices Board Manual Section 6 – Adequate Stocking. Initially sample plots were divided into quadrants starting with north and working clockwise (e.g., NE, SE, SW, and NW), to facilitate sampling and help investigators visualize the plot area. With some practice it became unnecessary to divide plots into quadrants, and data were then collected for the entire plot.

Within each plot the following data were collected:

- Seedlings, saplings, and trees were recorded by species and counted.[3] Trees were assigned to one of the following size categories:
  - < 6 inches height. Initially, the number of seedlings was to be lumped into categories (<5; ≥5 but <30; ≥30), but most plots had so few seedlings that it was easier to count them.
  - 6 inches to 4.5 feet in height.
  - >4.5 feet in height with a DBH < 5 inches.
  - >4.5 feet in height with a DBH > 5 inches.

  Trees were also assigned to one of the following categories of condition or vigor:
  - Good[4] = healthy.
  - Dead or dying.
  - Browsed.

  A tree characterized as "good" was anything that was not dead or browsed. Trees that were definitely dead (no needles or brown needles) were recorded as "dead or dying". Trees that were obviously browsed by an herbivore were recorded as "browsed". All other trees, including those with yellowish needles, were recorded as "good."

- Dominant vegetation, including herbs, shrubs, and trees that directly provided cover over the plot. Cover was cumulative (i.e., the percent cover of a plot generally totaled greater than 100%). Investigators assigned a cover class to the dominant species that were observed in each plot. Cover classes included:

1 = >0<10%	3 = ≥20<30%
2 = ≥10<20%	4 = ≥30<40%

[2] Information on adjacent seed sources was not specifically collected.
[3] Advanced regeneration trees were not specifically identified. Investigators counted the trees of each species that were present in a plot and assigned them into a size category.
[4] "Good" was data category used in the field and was not intended as a statement of value.

$5 = \geq 40 < 50\%$ $8 = \geq 70 < 80\%$
$6 = \geq 50 < 60\%$ $9 = \geq 80 < 90\%$
$7 = \geq 60 < 70\%$ $10 = \geq 90\text{-}100\%$.

- Ground condition for the following categories was also assigned a cover class:
  - Standing water (i.e. areas of inundation or evidence of inundation during the growing season).
  - Bare soil
  - Downed wood. The investigators distinguished between wood that appeared to be from natural causes (downed wood) and wood that resulted from logging activities (slash, which was assigned a cover class as a separate ground condition category). The decay class of the downed wood was noted, using Maser and Trappe (1984). However, decay classes were lumped for ease of identification, thereby providing three categories
    - Sound wood (decay classes I and II)
    - Decayed wood (decay classes III and IV)
    - Hardly recognizable as a log (decay class V)

  - Disturbance. The investigators recorded an observation of cover class for each of the following disturbance categories, when present:
    - Slash
    - Scraped
    - Compacted
    - Rutted
    - Other

  - Forest floor/duff/humus was recorded as everything else (i.e., 100 minus the total for the other four categories). It was assumed that forest floor underlies vegetation.

  Rutting or compaction often coincided with standing water. A cover class was assigned to both the standing water category and the rutting/compaction category, but it was not double counted, meaning that it did not subtract from the forest floor cover class.

- Previous stand structure was estimated by counting and categorizing stumps. Stumps were recorded by number present in each plot, size class (<15 inches; 15-30 inches; or >30 inches), and by species, if possible. When the species of a stump could not be identified, the investigators recorded it as either 'unknown conifer' or 'unknown deciduous'. In rare cases stumps were simply recorded as 'unknown'. It was also noted whether stumps were from the most recent harvest or from previous harvests.

  Initially stumps were also recorded when they occurred within 10 feet of the transect, or on the way from one plot to the next plot. However, this was time-consuming and problematic. First, thoroughness (i.e., being able to record every stump within 10 feet of the transect) depended upon visibility within the site. For example, an older site with taller trees or a site with dense trees offered limited visibility of stumps. Second, transects often crossed through upland areas or the transect line was in wetland, but 10 feet off the line it was upland. Ultimately WETSAG members determined that sampling stumps along the transect was of limited utility, and for the majority of sites, stumps were instead sampled in the plot area. Data used in analyses came from the plots only; not the transects.

- The investigators noted whether the plot appeared to represent the area. When it did not, the investigators described why. This information was not utilized in the analysis of the pilot, but is available for future analysis.

- If there were few or no established trees in the plot, or if the trees appeared to not be thriving, the investigators also made the following observations about each plot:
  - Wet
  - Dry
  - Soil compacted
  - Browse
  - Disease
  - Disturbance (explain)
  - Other (explain)

Data Analysis

As mentioned in the introduction, this pilot study was not designed to test a specific hypothesis or yield statistically significant results. The data collected is considered preliminary test data, and was generally collected opportunistically rather than by experimental design. The data have been summarized in tables and descriptive graphs.

Results

The investigators for this study visited a total of 25 forested sites that had been harvested and were believed to contain forested wetlands. Of these, only 15 sites contained forested wetland that had been harvested and, therefore met the study's site selection parameters. Four sites of the 15 sites were older than 15 years, while one site was younger than five years post harvest. Refer to Figure 3 for the locations of sites visited.

Ultimately, three sites resulted from the DNR's GIS generated list of sites that met the initial site selection criteria. Four sites were suggested by state agency or tribal representatives to WETSAG. Private landowners volunteered the remaining eight sites. The majority of the sites that were determined to be wetlands in the office but were found not to be wetland by the investigators in the field came from the NWI information.

Harvest Information

The information on harvest and regeneration methods was available only for13 of the 15 sites. Complete background information was available for only three sites. For the few sites that did have information describing species or volumes/quantities of wood removed during harvest, this information applied to an entire harvest unit, while the wetland area generally occupied a small portion of the harvest unit. The data did not distinguish between what was harvested upland and what was harvested in the wetland. Only one of these sites had any post-harvest site preparation or post-planting maintenance (Table A6). Six of the 15 sites had replanting density information. Older data from harvest records were not in a database and were not accessible.

Current Site Conditions

The investigators reviewed USGS 7.5 minute quadrangle maps and soil surveys to determine hydrogeomorphic (HGM) class (Brinson 1993 and 1995), soil types, elevation, and aspect of the sites. However, observations made in the field contributed to the categorization of a site's HGM class. Nine sites (60%) were predominantly slope wetlands; of these, two also had depressional features. Four sites (27%) were predominantly depressional wetlands, and two sites (13%) were predominantly riverine wetlands. Despite the fact that the majority of sites were categorized as slope wetlands, all the wetland areas were located in relatively flat terrain with slopes of less than five percent.

Investigators identified the mapped soil types for each site. All but one site was mapped as a silt loam, silty clay loam or part of a complex or association containing silt loam. The site near Ellensburg in eastern Washington was mapped as a stony loam which surrounded an open water area. The forested wetland existed in the transition zone between a seasonal pond and the central Washington foothill forests.

Elevation varied from very near sea level to nearly 5,000 feet. All sites but one were located below 1,000 feet. The site near Ellensburg was located on the top of a ridge, about 4,960 feet elevation.

Table A5 in the appendix contains site specific information.

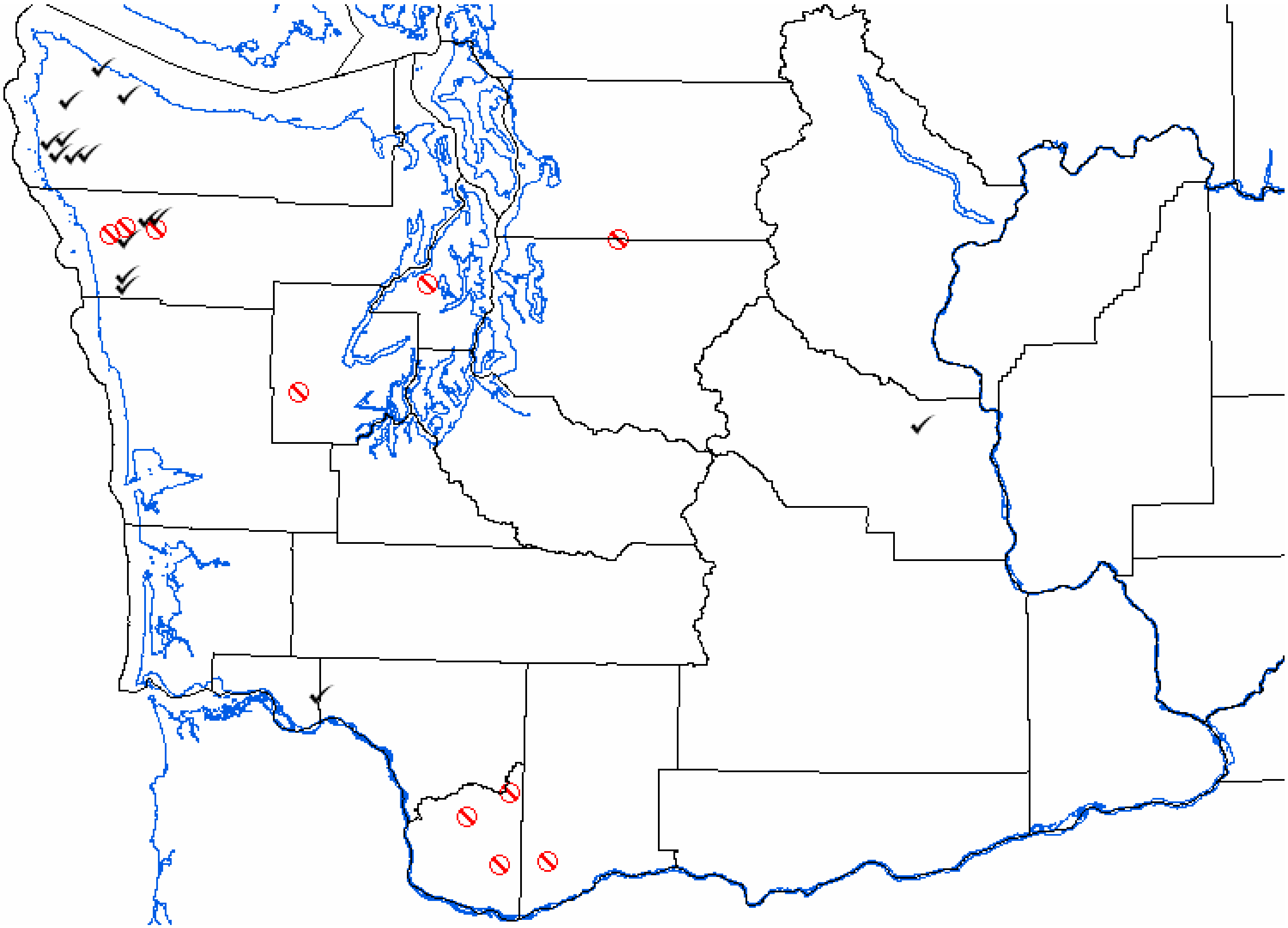


Figure 3. General locations of the sites visited.
✓= Sites that were sampled, because they contained sufficient area of forested wetland.
⦸ = Sites that were visited but not sampled, because they did not contain forested wetland.

Seedling/Sapling Counts

The data in Table 1 represents the average number of conifers and alders per acre for each site. All but one site had at least one conifer or alder, on average, in each plot, and all but three sites had more than 10 seedlings/saplings/trees in the average plot (i.e. more than 714 seedlings/saplings/trees per acre).

The only eastern Washington site, Ellensburg, was not clearcut as the other sites appeared to have been. The site was selectively logged. Mature trees and advanced regeneration saplings were left uncut.

Table 1. Basic Sapling Statistics.

Site	Mean number of conifers & alders per acre	Standard Deviation	Coefficient of variation
Clallam 1	1042.9	771.4	0.7
Clallam 2	821.4	385.7	0.5
Clallam 3	864.3	857.1	1.0
Nolan Normal	1092.9	878.6	0.8
Red Creek 1	1578.6	614.3	0.4
Red Creek 2	1778.6	1314.3	0.7
Ridge Runner	1307.1	842.9	0.6
Springfield	1414.3	892.9	0.6
Dickie West	4821.4	2035.7	0.4
Wentworth Lake	585.7	492.9	0.8
Dickie West 2	1914.3	1392.9	0.7
Gunderson	521.4	321.4	0.6
Colby Creek	1900.0	1335.7	0.7
Cowlitz	42.9	64.3	1.5
Ellensburg	1442.9	1364.3	0.9

Figures 4 depicts the number of conifers per acre (not including alders), divided into two height categories, for each site. This graph illustrates that the majority of sites had more than two conifers greater than 4.5 feet per acre. The presence of larger trees in a plot provides some indication of the existence of older, well established regeneration at a site or remnant trees that were not harvested.

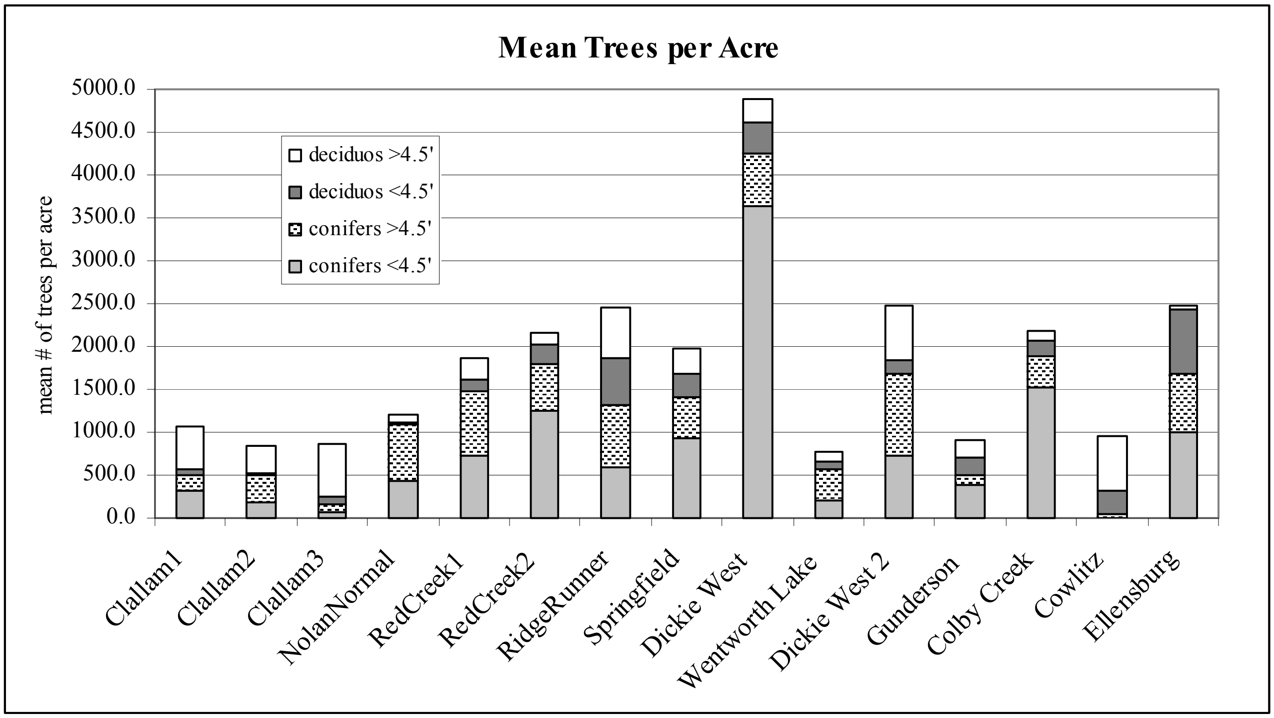
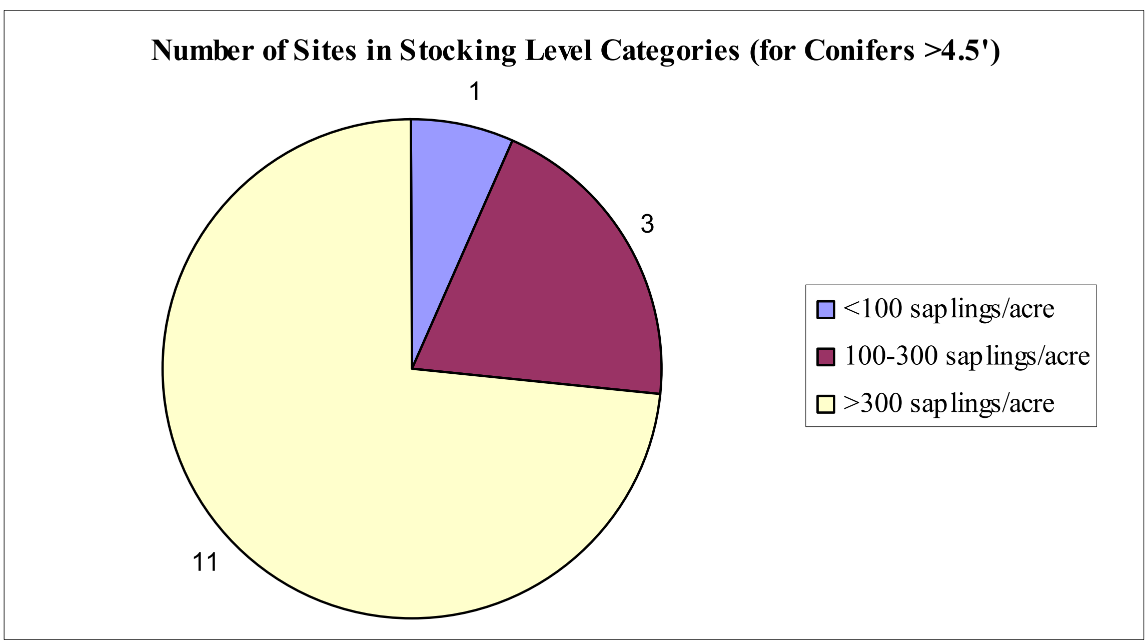


Figure 4. Mean Trees per Acre. Tree species are shown by type (coniferous vs. deciduous) and divided into 2 height categories.

All but one site would meet the acceptable stocking level of 100 trees per acre (1.4 saplings/plot) recommended in the State Board Manual. In fact, most sites had at least 300 saplings per acre that were greater than 4.5 feet (4.3 saplings/plot) (Figure 5).

Figure 5. Number of sites in each of the three stocking level categories. Number of saplings per acre was calculated from the average number of saplings per plot.



One site, in Cowlitz County, did not meet the state's acceptable stocking level of 100 stems per acre. The wetland area for this site was about one acre in size, and occurred at the lowest elevation of the harvest unit. Douglas-fir (*Pseudotsuga menziesii*) were planted throughout the harvest unit, including the small wetland area. Douglas-fir did persist in the wetland area; however, they were sparsely distributed and appeared stunted compared to neighboring firs in upland areas. Cascara (*Rhamnus purshiana)* was abundant but was not counted in the sapling/tree analysis since it is generally not considered a canopy co-dominant species.

An outlier at the opposite extreme was a site in Clallam County. The site exhibited an excessive number of saplings (mean of 3570 saplings/acre) less than 4.5 feet tall. The site was harvested five years ago, but had recently been planted. The wetland area was bordered on one side by an older regenerating stand, and an uncut riparian buffer was within about 500 feet. The vast majority of saplings were hemlock (*Tsuga heterophylla*), which could have regenerated from the neighboring seed source.

Though all but one site would meet acceptable state stocking levels for conifers, Table 1 also indicates that every site exhibited considerable variability between plots. In some cases the standard deviation was equal to or greater than the mean. The variation between plots for every site was at least 40 percent. For example, Clallam 3 had a mean of 12.1 trees per plot (864.3 trees/acre) but a standard deviation of 12.0 (857.1). This means that one plot could have as many as 24 trees while another plot could have none.

The high degree of variation could be due, in part, to the low sampling density. Increasing the number of sample plots per acre could help reduce this variability. However, the Cowlitz site had one of the highest sampling densities (approximately 9% of the wetland area was sampled) and the highest coefficient of variation (Table 1).

The large variability can also be attributed to the highly variable conditions of the sites sampled. During field reconnaissance, it was evident that some areas had few trees, while other areas had high stem counts (Figures 6 and 7). Microtopography (slight changes in elevation and aspect) is known to produce different ecological conditions within a single wetland. Microtopographic variations within sites may have produced variable growing conditions, and thus, resulted in highly variable stem counts from plot to plot.

Figure 6. Clallam 1 - Area with few saplings in the plot.

Figure 7. Clallam 1 – Area with many saplings in the plot.

For example, the investigators observed that trees generally did not grow in standing water or in the wettest parts of a site. Instead, trees tended to grow in dense clumps on slight hummocks.

Vegetative Cover

The herbaceous layer provided the greatest amount of vegetative cover for nearly all the sites sampled, accounting for more than 75% of the cover on a plot at the majority of sites (Figure 8). The exceptions were the eastern Washington site, Ellensburg, sampled in late summer and the southwestern Washington site, Cowlitz, sampled in late fall. Neither of these sites was sampled during its prime growing season. In addition, Ellensburg appeared to have been heavily used by elk, which may also have contributed to the lack of herbaceous and shrub cover.

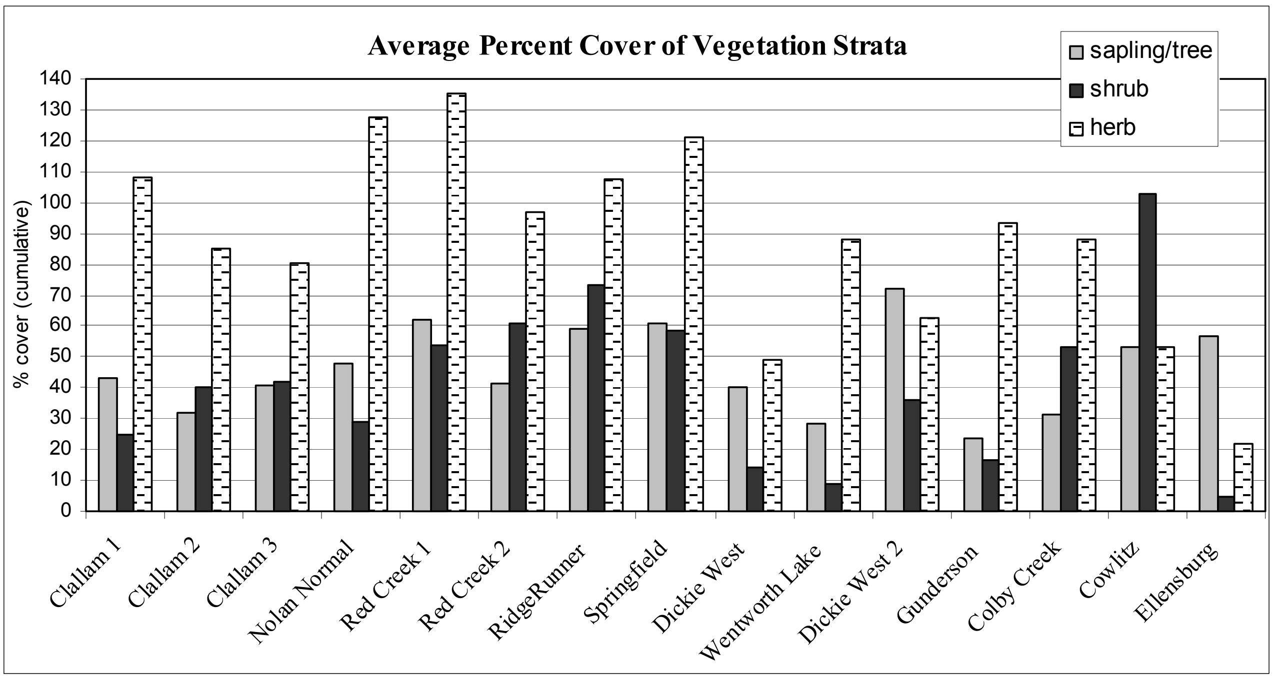


Figure 8. Percent cover provided by each vegetation strata in the average plot. Percent cover was cumulative and therefore added up to greater than 100% in most cases.

Aside from the eastern Washington site (Ellensburg), Dickie West had the least amount of cumulative vegetative cover. This could be due to the fact that it was a relatively young site (5 years post harvest). Though this site had the highest stem count (Figure 4), most of the seedlings were below 4.5 feet in height, and therefore, did not provide substantial vegetative cover. The youngest site, Gunderson (<5 years post harvest), had high herbaceous cover but the lowest average tree cover (<25%).

Ground Cover

The trends from the ground cover summary do not indicate that any ground cover category influences the average number of trees per plot. For example, Dickie West and Red Creek 2 both had a high percent (nearly 40%) of slash found on the average plot (Figure 9). Yet these two sites also had high numbers of conifer stems per plot. However, the high percentage of slash present at Dickie West could have influenced the low percentage of vegetative cover observed at the site (Figure 8). Since the site is relatively young, herbs and shrubs may not have had a chance to become established upon or within the slash. Gunderson, the youngest site, had the lowest percentage of cover in the forest floor category.

The investigators had some difficulty distinguishing between early decay classes of downed wood and slash. In general, early decay classes of wood were considered slash unless it appeared obvious that he wood resulted from natural blow down. Therefore, the downed wood category (Figure 9) generally applied to later decay classes.

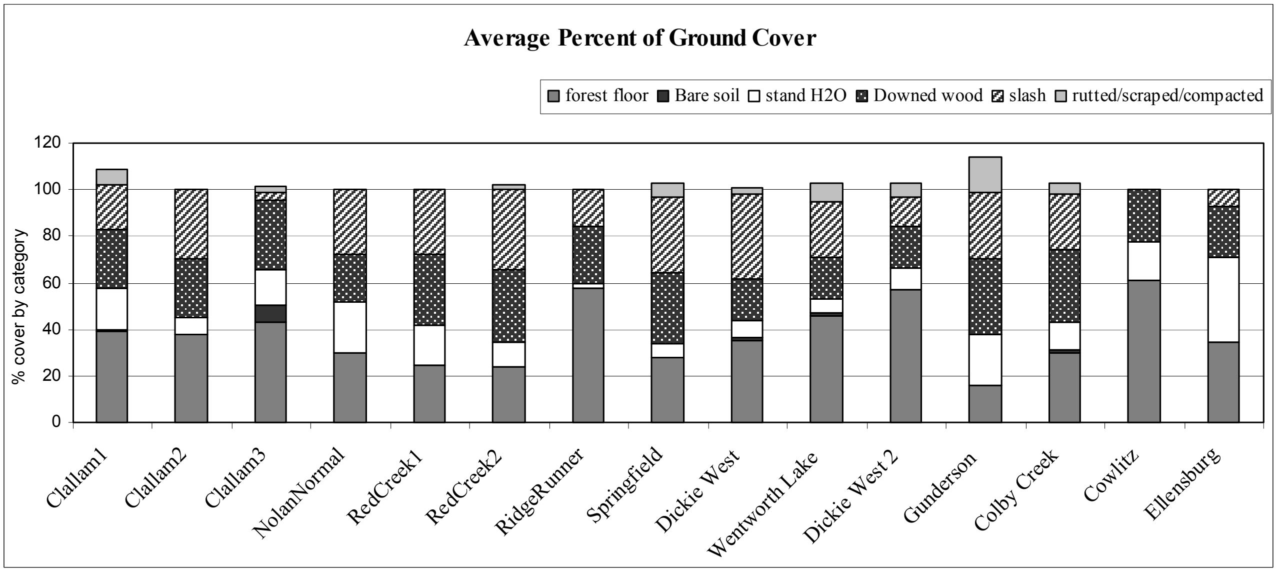


Figure 9. Percent cover provided by each ground cover category in the average plot. Standing water often occurred in a rutted/compacted area. Though occupying the same space on the ground, both were counted. Percentage totals greater than 100 were converted into relative cover.

Standing water included both actual inundation and evidence of inundation (e.g., watermarks, drift lines, sediment deposits, water stained leaves, etc.). In the case of Ellensburg, evidence of inundation was observed throughout the site, resulting in the high percentage of standing water recorded on the average plot. It is possible that what investigators attributed to standing water may have been related to snow pack. In the process of melting, the snow produced saturated soil that was then extensively trampled by elk. Without returning to the site in late spring/early summer, it is impossible to be certain.

The sites with the lowest percentage of slash (Clallam 3 and Cowlitz – Figure 9) also had the least number of stumps recorded per acre (Table A3). The author hypothesizes that few conifers were harvested from the wetland portion of these sites; therefore, few stumps and little slash were generated. Slash and stumps of deciduous species decompose relatively quickly, and were not in evidence.

Stumps

Figure 10 indicates that the majority of stumps were from the most recent harvest. The majority of recorded stumps had a diameter at breast height (DBH) between 15 and 30 inches (Figure 11). This was a visual extrapolation since most of the recently harvested stumps were cut below breast height.

As mentioned, Clallam 3 and Cowlitz had the lowest number of stumps per acre (Figure 10 & Table A3). In the case of Clallam 3, the investigators observed that alder (*Alnus rubra*) and hemlock (*Tsuga heterophylla*) were most recently harvested (Figure 13).

In the case of Cowlitz, the only stump recorded in a plot was greater than 30 inches DBH, from a previous harvest (Figure 16). Though the investigators recorded this stump as an unknown species, the diameter and height of this and other stumps observed outside of sample plots suggests that they are western redcedar (*Thuja plicata*). The entire harvest unit was then planted with Douglas-fir (*Pseudotsuga menziesii*), which are not thriving in the wet conditions.

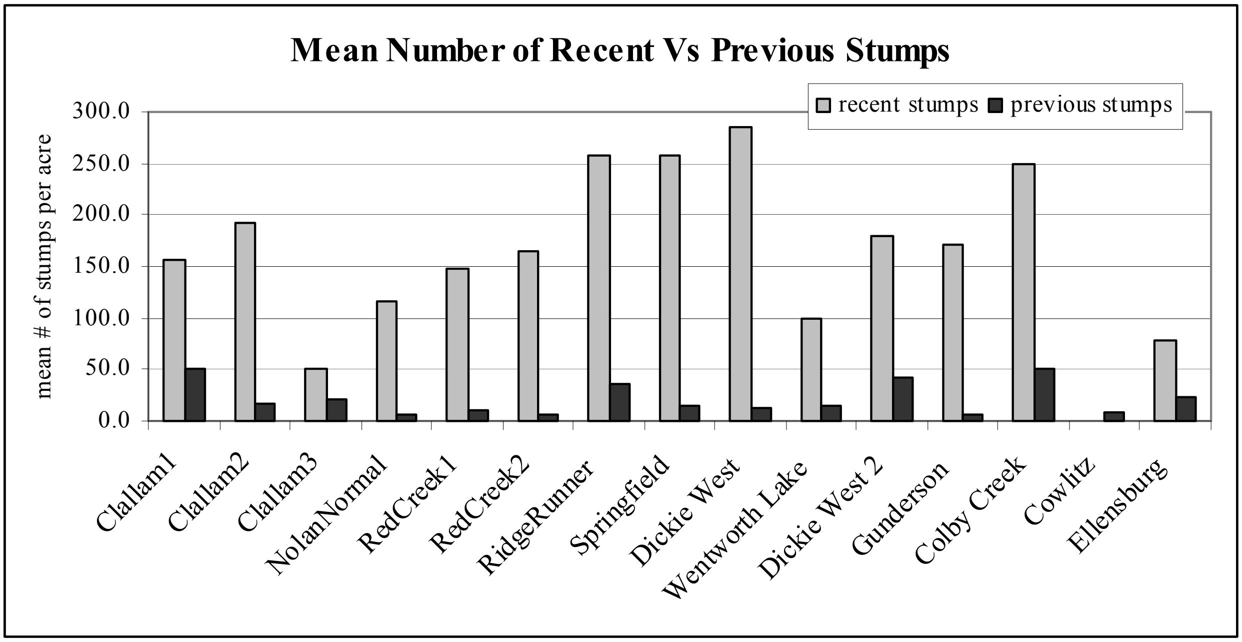


Figure 10. Mean number of stumps per acre for each age category. "Recent" refers to the harvest that occurred most recently, and "previous" refers to the harvests that occurred prior to the most recent one.

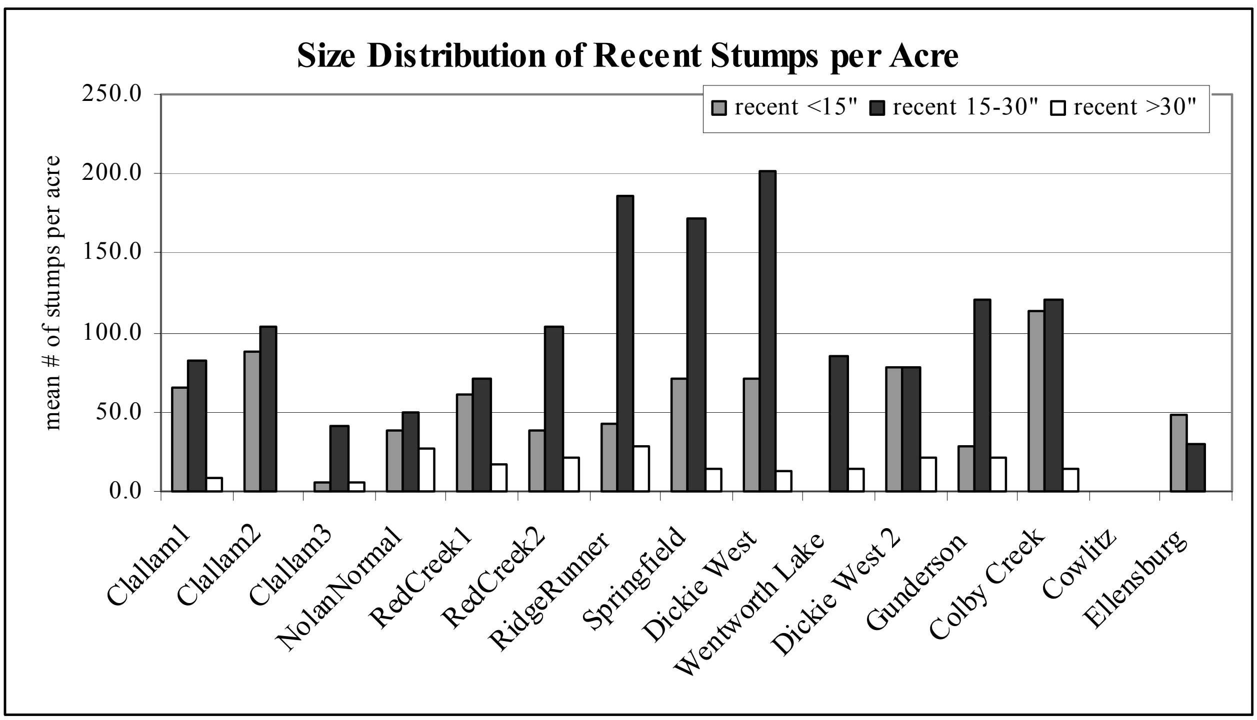


Figure 11. Mean number of recent stumps per acre for each size category. Sizes refer to diameter at breast height (DBH).

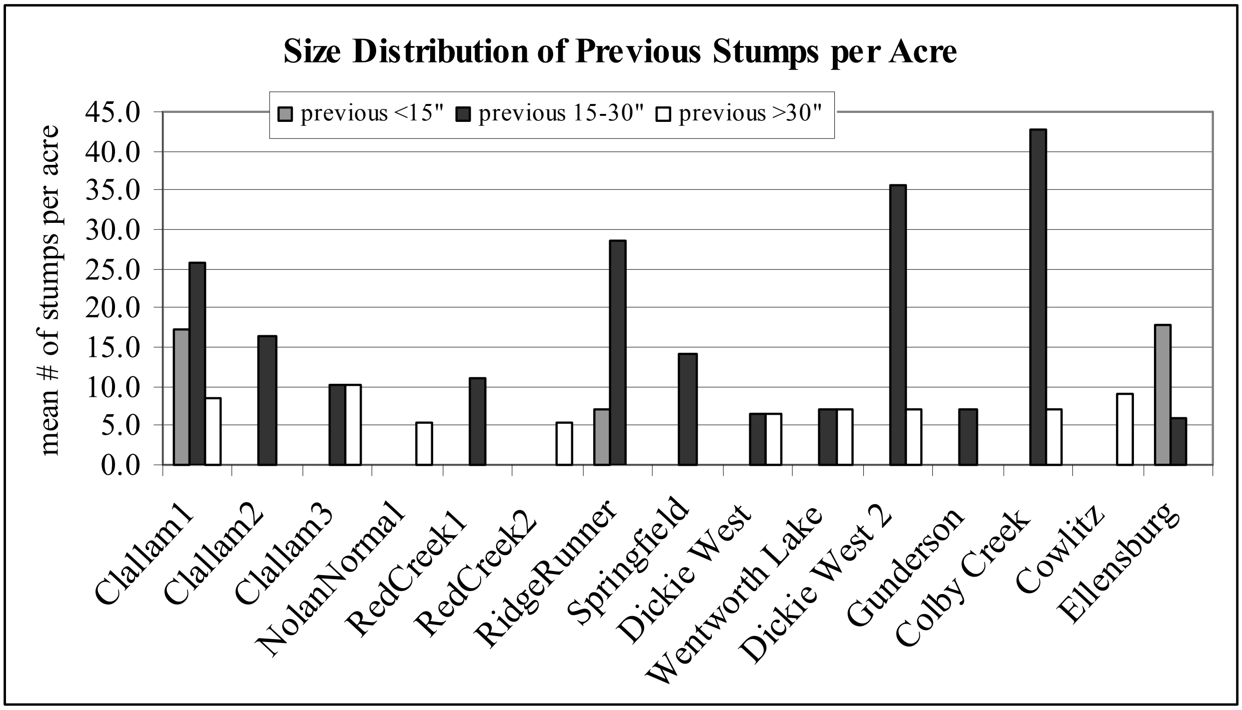


Figure 12. Mean number of previous stumps per acre for each size category. Sizes refer to diameter at breast height (DBH).

Sapling and Stump Species Composition

Comparing the species of stumps with the species of saplings recorded in the plots suggests that, for the most part, the same species are regenerating. However, the proportion of cedar stumps for most sites was greater than the proportion of cedar seedling/saplings. This may be due to the presence of cedar stumps from previous harvests that tend to persist longer than other species. In addition, cedar is not generally re-planted after harvest. Conversely, the lack of cedar seedlings might be due to ungulate browse, which can easily eliminate cedar seedlings from a stand. Again, this study does not address future survival of seedlings to a standing forest as the mid-point of a harvest rotation.

In addition, there were a large number of cascara (*Rhamnus purshiana*) seedlings/saplings and a general lack of cascara stumps. Cascara is a deciduous tree that often grows multiple stems rather than one main stem. It is likely that the majority of cascara stumps decomposed rapidly, and were not observed or recognized. A similar explanation may apply to the low proportion of alder (*Alnus rubra*) stumps compared to alder saplings observed.

Spruce (*Picea sitchensis*) is another species that was not represented in the regeneration at the same levels as it was represented by stumps. Some sites had many spruce saplings but few to no spruce stumps (e.g., Clallam 3, Red Creek 2, Dickie West 2, Colby Creek). All of these sites had stumps of an unidentified species that could have been spruce.

The Clallam 3 site had a larger proportion (and number) of hemlock stumps than hemlock saplings (Figure 13). While this site had very little slash (<5%/plot), the average plot had about 30 percent downed wood (Figure 9), which should have provided ample locations for hemlock seedlings to establish themselves. It is not clear why more hemlock saplings were not present in the sample plots since mature, uncut hemlocks existed immediately adjacent to the site.

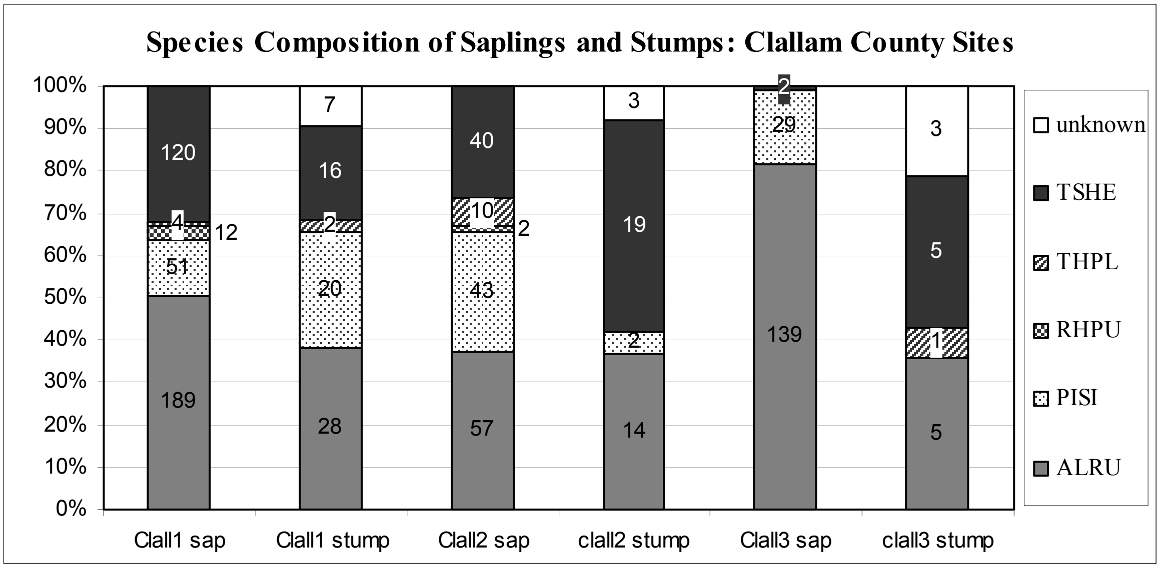


Figure 13. Species composition of saplings and stumps for Clallam sites. Species of saplings and stumps are displayed by the proportions observed at each site. The numbers within the bars represent the total number of that species recorded for that site.

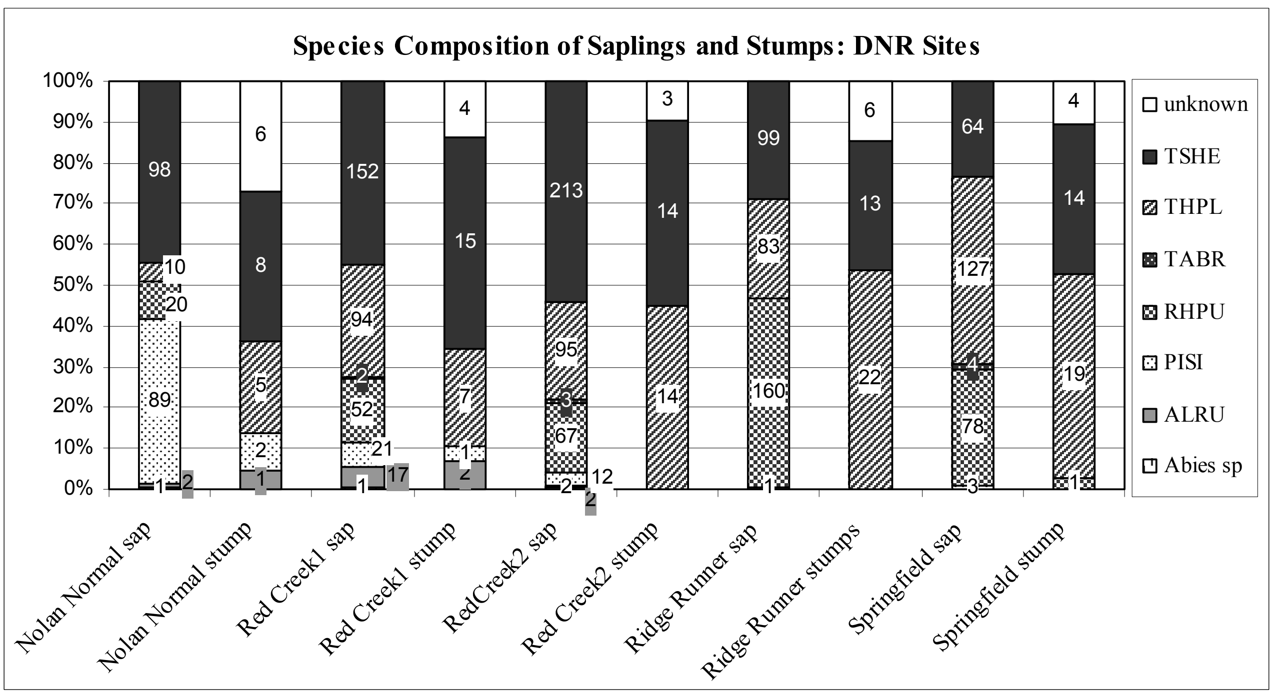


Figure 14. Species composition of saplings and stumps for DNR sites. Species of saplings and stumps are displayed by the proportions observed at each site. The numbers within the bars represent the total number of that species recorded for that site.

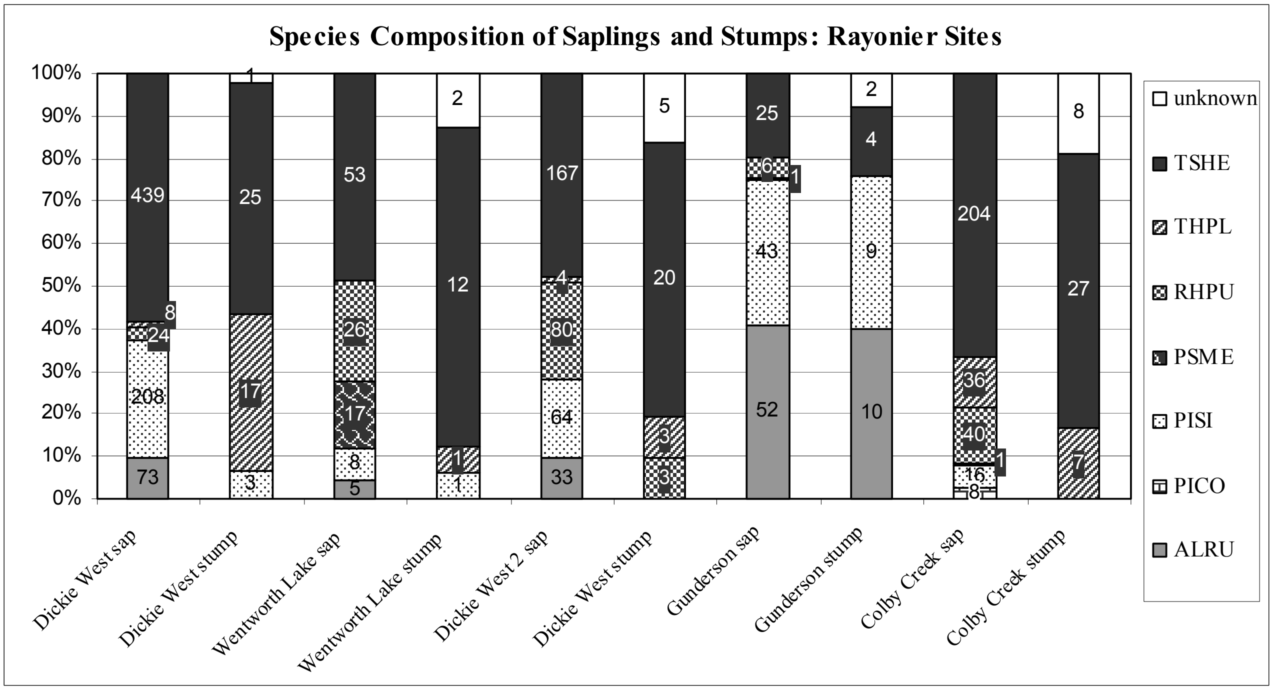


Figure 15. Species composition of saplings and stumps for Rayonier sites. Species of saplings and stumps are displayed by the proportions observed at each site. The numbers within the bars represent the total number of that species recorded for that site.

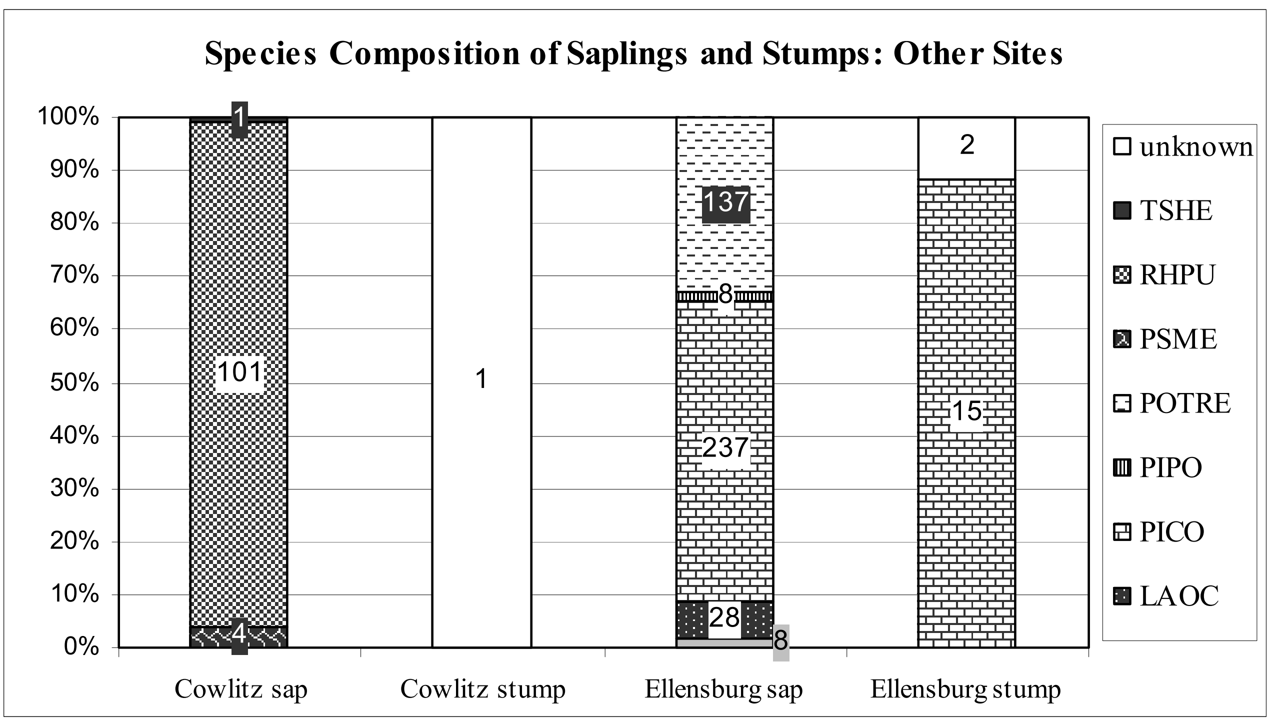


Figure 16. Species composition of saplings and stumps for Cowlitz and Ellensburg. Species of saplings and stumps are displayed by the proportions observed at each site. The numbers within the bars represent the total number of that species recorded for that site.

Ground Water Levels

Figure 17 displays the ground water levels as observed in and at soil pits. All but two sites had ground water at 16 inches or above in the majority of soil pits. Two sites, Cowlitz and Ellensburg, were not included in this summary because they were sampled at a different time of year than the other 13 sites. Cowlitz was sampled in the winter during a heavy rain, while Ellensburg was sampled in late summer. The ground water levels observed at both sites were probably not representative of ground water levels during the prime growing season.

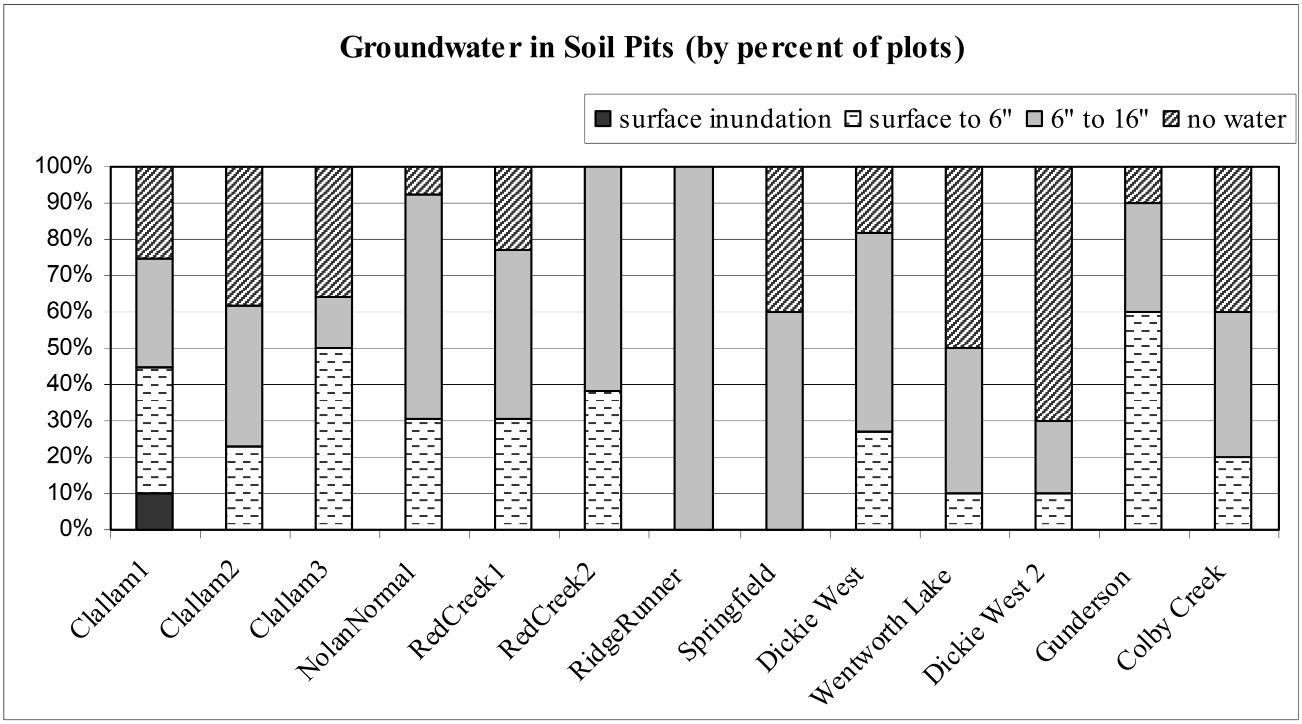


Figure 17. Ground water levels as observed in sample plots and soil pits. Soil pits were approximately 16 inches deep. Pits with "no water" therefore had groundwater levels below 16 inches. Cowlitz and Ellensburg were not included in this analysis because they were each sampled at a different time of the year than the other 13 sites.

"Surface inundation" meant that water was present above the surface of the soil where the investigators dug the soil pit. This differs from the "standing water" category in the ground cover analysis (Figure 9), which referred to water (or evidence of inundation) that was primarily observed in ruts and compacted/scraped areas.

Extracting a representative soil sample from which soil type and color could be characterized was generally difficult. Areas with surface inundation usually produced slurry conditions in the soil pit. Only Clallam 1 exhibited surface inundation.

Clallam 1 had a large area of surface inundation. The investigators attributed the standing water to a small beaver dam that appeared to have been recently installed in the middle of the harvest unit (Figure 18). This area was not extensively sampled since the ponding did not appear to be the result of harvest operations.

Figure 18. Photo of beaver pond from Clallam 1.

Soil Type

The investigators observed that 47 percent of sites contained both mineral and organic soils (Figure 19). The majority of sites appeared to have a higher proportion of mineral soil, while no site had entirely organic soil. Soil type varied from plot to plot. For example, within the same site, one plot had organic soil while another plot 100 feet away had mineral soil. Mineral soils were silty loams, silty clay loams, and silty clays. A surface layer of ash of varying thickness was observed throughout the majority of the Ellensburg site.

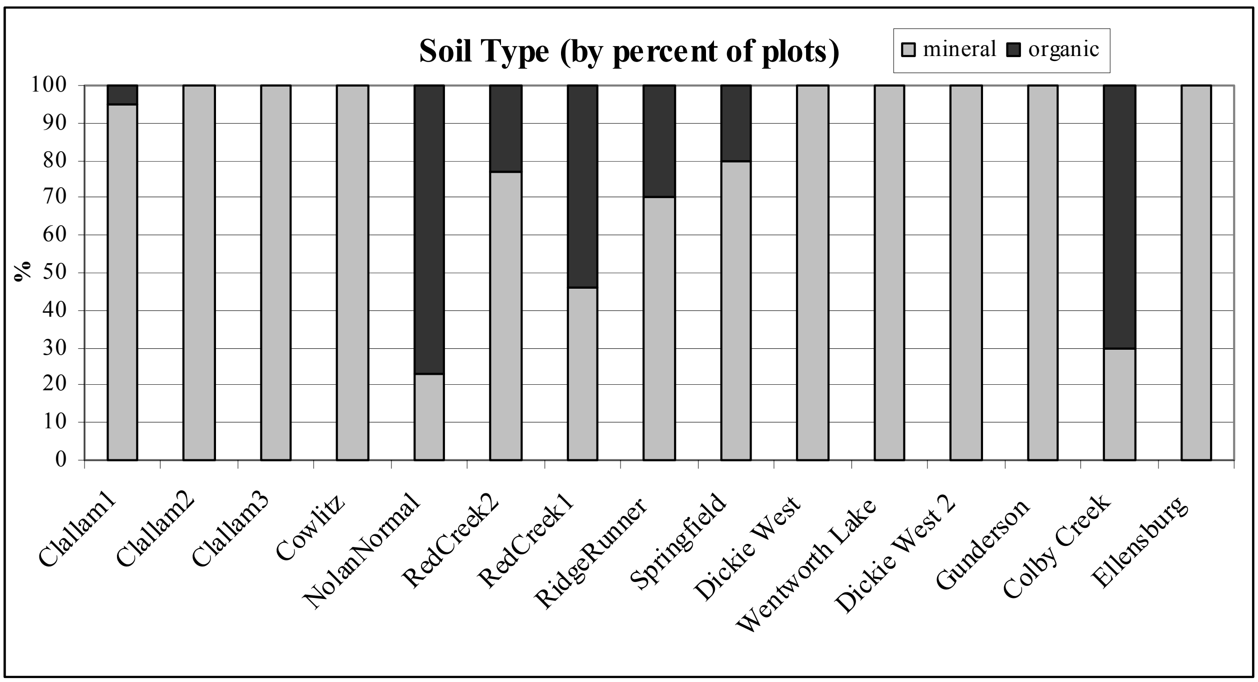


Figure 19. Soil types for each site. Soil type is displayed by the percentage of plots within each site that had either mineral or organic soil.

Discussion

The forested wetland regeneration pilot study provides a general indication of how well forested wetlands re-establish tree cover after they have been harvested. Data from 15 sites indicate that all but one site is meeting the State Board Manual acceptable stocking level for conifers greater than 4.5 feet in height.

The trends seen in the pilot study indicate that regeneration of seedlings and saplings is occurring on forested wetlands that have been harvested. However, the data also demonstrate considerable variability between plots, suggesting that microtopography within a site may affect regeneration.

Additional trends indicate that the herbaceous layer provided the greatest amount of vegetative cover on all but three sites. The data collected on ground cover at each site indicate that all the sites exhibited some standing water, slash, downed wood, and forest floor. However, the trends seen do not suggest that any ground cover category influenced the average number of seedling/saplings per plot.

Trends from the stump summary illustrate that the majority of stumps were from the most recent harvest with a DBH between 15 and 30 inches. Comparing the species of stumps with the species of trees recorded for each plot suggests that the same species are regenerating,.

Trends from the ground water and soil summaries indicate that most sites had ground water present at 16 inches or above in the majority of soil pits. The majority of sites had entirely mineral soil, but many sites contained both mineral and organic soils. None of the sampled sites had entirely organic soil.

No comparisons were made based on upland versus wetland site locations. Wetlands exist along a continuum of moisture gradient from very wet to very dry. We did not have a large enough sample size to separate out plots on the dry end of the spectrum. The high variability of wetlands within the mosaic of ecological landscapes makes it difficult to establish an unbiased sampling scheme.

In general, the data illustrate no definitive relationships between the amounts of slash, surface inundation, downed wood and amount of regeneration (stem counts). This could be due to the small sample size and the high degree of variability within sites.

All but three sites were volunteered by private landowners or suggested by state agency, tribal, or non-profit representatives. Though the process of site selection used in this pilot study was not random, the trends for all sites were fairly consistent. However, due to small sample size and plot distribution, the data does not represent regeneration success across the state.

The pilot study also set out to develop methods for identifying forested wetlands that have been harvested. The investigators found this to be the most difficult aspect of the study. National wetland inventory (NWI) coverage for forested wetlands was both inaccurate (i.e., designating areas as forested wetlands when they were not wetland) and incomplete (i.e. most of the forested wetland sampled in this study were not designated by NWI as wetland). However, this study was not designed to verify the accuracy of the NWI. Relying on landowner recollections of wetland areas was also relatively unreliable because most foresters use a working definition of a forested wetland inconsistent with the legal definition. In addition, memories were often deceiving in terms of how wet and how large an area really was. The investigators found no solution to the problem of finding suitable forested wetlands for the study.

A second difficulty was finding complete background information. The investigators could not quantify what was harvested from forested wetlands nor identify the methods used to regenerate forested wetlands. The background information provided by landowners applied to the entire harvest unit, while the majority of forested wetland sites occupied a small portion of their harvest units.

Finally, this pilot study was also intended to develop methods to synthesize the collected information and to develop a process for evaluating forested wetland regeneration. Through an iterative process, methods were developed to sample forested wetlands that have been harvested. Examples for data analysis have been provided that can be used to evaluate regeneration. However, questions still exist regarding how sites should be sampled in order to maximize data collection and the time and energy expended, particularly regarding sampling density and achieve statistical integrity.

Recommendations

After conducting this pilot study, the author does not recommend replicating the approach used in this study on a larger scale. Several challenges were encountered and questions were raised that need to be addressed before proceeding in a larger study:

Site location

The investigators found no solution to the problem of finding forested wetlands suitable for the study. In addition, the lack of background information on tree species, relative densities, and sizes prior to harvest makes it impossible to know if the site is regenerating in a similar fashion, and therefore providing the same functions. Without a database of forested wetland sites to select from and a guarantee of more complete background information, there is little value in repeating this study.

A statewide database that includes information on forested wetlands is needed to accurately map the locations of forested wetlands as they are identified. This database could also serve as a repository of background information containing at minimum the date of harvest, harvest method, and identifying the species and density of replanting in wetland areas.

Sampling methods

If a database were developed that would allow for a random selection of forested wetland sites and provide complete background information, then a larger study of forested wetland regeneration would be worthwhile. Such a study should include greater representation from eastern Washington forested wetlands. In addition, a study with a statistically valid sample size could perform any of the following analyses to look for correlations:

- Compare the percent of slash with the number of saplings
- Compare the percent of standing water with the number of saplings
- Compare the number of saplings present in marginal wetland plots with “wetter” sample plots
- Compare the percent of downed wood with the number of saplings
- Investigate biodiversity compared with moisture gradient

For future studies, different methods for stump data collection will need to be developed. Low level photography could be investigated to determine its usefulness and accuracy in developing stem, downed wood, and stump maps in forested wetlands. Using different disturbance categories and categorization schemes for tree classes could also be investigated to correlate more closely with established silvicultural measures.

Recovery of function and baseline conditions

The pilot study indicates that seedlings and saplings are able to establish in forested wetlands that have been harvested. All but one site met the State Board Manual for acceptable stocking level. However, the data do not answer the long term question whether a functional forest is recovered at the mid-point of a timber rotation cycle as stated in WAC 222 timber harvest policy. The question remains whether established trees persist throughout a harvest rotation, and whether growth rates are sufficient to restore the function provided by mature forested wetland in the time-frame assumed by the WAC 222 policy. If not, how long does it take for regenerating trees in a forested wetland to provide the functions of a mature forested wetland? To answer these questions would most likely require a long-term study.

The pilot study generally characterized ground cover within sample plots, but it did not specifically identify the substrate upon which saplings and seedlings were growing. Therefore, a future study could specifically identify the substrate trees are growing upon to determine if different tree species favor different substrates and if substrate affects long-term survival.

The pilot study did not address the role of hydrology in forested wetlands or what potentially affects the hydrology. Future studies may include investigations as to how the moisture gradient correlates with or affects the biodiversity of a site and how timber harvesting within a forested wetland affects the hydrologic functions of the wetland. A study that attempts to examine the harvesting question should perform sufficient pre-harvest (and pre-road building/maintenance) hydrologic monitoring to understand and characterize water movement and level of function. Similar monitoring should then be performed at pre-determined points of time after the harvest has occurred. The study should be stratified by HGM class, since wetlands of different HGM classes perform hydrologic functions differently. The study should also include adequate representation of eastern Washington wetlands. A hydrologic study might attempt to determine whether water levels/flows change in forested wetlands after the trees have been removed, or whether roads and skid trails impact the direction of water flow.

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Appendix

Table A1. Mean Number of Saplings per acre (Categorized by Size and tree type)

	Number Conifers <4.5' per acre	Number Conifers >4.5' per acre	Number Deciduous <4.5' per acre	Number Deciduous >4.5' per acre
Clallam 1	311.4	188.6	62.9	511.4
Clallam 2	186.8	324.2	16.5	307.7
Clallam 3	61.2	96.9	86.7	622.4
Nolan Normal	428.6	659.3	27.5	93.4
Red Creek 1	725.3	758.2	126.4	252.7
Red Creek 2	1252.7	533.0	236.3	142.9
Ridge Runner	600.0	707.1	550.0	592.9
Springfield	942.9	471.4	257.1	300.0
Dickie West	3642.9	610.4	370.1	259.7
Wentworth Lake	207.1	350.0	92.9	128.6
Dickie West 2	728.6	950.0	164.3	642.9
Gunderson	378.6	114.3	207.1	207.1
Colby Creek	1528.6	364.3	171.4	114.3
Cowlitz	0.0	44.6	267.9	633.9
Ellensburg	1000.0	672.6	767.9	47.6

Table A2. Species Composition of Saplings (Total Numbers per Site)

	Abies sp	ALRU	LAOC	PICO	PIPO	PISI	POTRE	PSME	RHPU	TABR	THPL	TSHE
Clallam 1	0	189	0	0	0	51	0	0	12	0	4	120
Clallam 2	0	57	0	0	0	43	0	0	2	0	10	40
Clallam 3	0	139	0	0	0	29	0	0	0	0	0	2
Nolan Normal	1	2	0	0	0	89	0	0	20	0	10	98
Red Creek 1	1	17	0	0	0	21	0	0	52	2	94	152
Red Creek 2	2	2	0	0	0	12	0	0	67	3	95	213
Ridge Runner	1	0	0	0	0	0	0	0	160	0	83	99
Springfield	0	0	0	0	0	3	0	0	78	4	127	64
Dickie West	0	73	0	0	0	208	0	0	24	0	8	439
Wentworth Lake	0	5	0	0	0	8	0	17	26	0	0	53
Dickie West 2	0	33	0	0	0	64	0	0	80	0	4	167
Gunderson	0	52	0	0	0	43	0	1	6	0	0	25
Colby Creek	0	0	0	8	0	16	0	1	40	0	36	204
Cowlitz	0	0	0	0	0	0	0	4	101	0	0	1
Ellensburg	8	0	28	237	8	0	137	0	0	0	0	0

Abies=true firs, grand or silver fir (not specifically identified
ALRU=Alnus rubra - red alder
LAOC=Larix occidentalis - larch
PICO=Pinus contorta - lodgepole pine
PIPO=Pinus ponderosa - ponderosa pine
PISI=Picea sitchensis - Sitka spruce
POTRE=Populus tremeloides - quaking aspen
PSME=Pseudotsuga menziesii – Douglas-fir
RHPU=Rhamnus purshiana - cascara
TABR=Taxus brevifolia - Pacific yew
THPL=Thuja plicata - western red cedar
TSHE=Tsuga heterophylla - western hemlock

Table A3. Mean Number of Stumps per Acre (Categorized by Size and Age)

	recent <15"	recent 15-30"	recent >30"	previous <15"	previous 15-30"	previous >30"
Clallam 1	65.7	82.9	8.6	17.1	25.7	8.6
Clallam 2	87.9	104.4	0.0	0.0	16.5	0.0
Clallam 3	5.1	40.8	5.1	0.0	10.2	10.2
Nolan Normal	38.5	49.5	27.5	0.0	0.0	5.5
Red Creek 1	60.4	71.4	16.5	0.0	11.0	0.0
Red Creek 2	38.5	104.4	22.0	0.0	0.0	5.5
Ridge Runner	42.9	185.7	28.6	7.1	28.6	0.0
Springfield	71.4	171.4	14.3	0.0	14.3	0.0
Dickie West	71.4	201.3	13.0	0.0	6.5	6.5
Wentworth Lake	0.0	85.7	14.3	0.0	7.1	7.1
Dickie West 2	78.6	78.6	21.4	0.0	35.7	7.1
Gunderson	28.6	121.4	21.4	0.0	7.1	0.0
Colby Creek	114.3	121.4	14.3	0.0	42.9	7.1
Cowlitz	0.0	0.0	0.0	0.0	0.0	8.9
Ellensburg	47.6	29.8	0.0	17.9	6.0	0.0

Table A4. Species Composition of Stumps (Site Totals)

	ALRU	PICO	PISI	RHPU	THPL	TSHE	unknown
Clallam 1	28	0	20	0	2	16	7
Clallam 2	14	0	2	0	0	19	3
Clallam 3	5	0	0	0	1	5	3
Nolan Normal	1	0	2	0	5	8	6
Red Creek 1	2	0	1	0	7	15	4
Red Creek 2	0	0	0	0	14	14	3
Ridge Runner	0	0	0	0	22	13	6
Springfield	0	0	0	1	19	14	4
Dickie West	0	0	3	0	17	25	1
Wentworth Lake	0	0	1	0	1	12	2
Dickie West 2	0	0	0	3	3	20	5
Gunderson	10	0	9	0	0	4	2
Colby Creek	0	0	0	0	7	27	8
Cowlitz	0	0	0	0	0	0	1
Ellensburg	0	15	0	0	0	0	2

ALRU=Alnus rubra - red alder
PICO=Pinus contorta - lodgepole pine
PISI=Picea sitchensis - Sitka spruce
RHPU=Rhamnus purshiana - cascara
THPL=Thuja plicata - western red cedar
TSHE=Tsuga heterophylla - western hemlock

Table A5. Site Conditions

	HGM class	Mapped soil type(s)	Elevation	Slope	Aspect
Clallam 1	Riverine/ slope?	Tealwhit silt loam	240 ft.	0-5%	East facing (ENE)
Clallam 2	Slope	Queets/Tealwhit silt loams	140-160 ft.	0-5%	North facing (NNW)
Clallam 3	Riverine	Queets/Tealwhit silt loams	0-40 ft.	0-5%	North facing
Nolan Normal	Slope (?)	Tealwhit silt loam	520 ft.	0-5%	North facing
Red Creek 1	Depressional	Hoko gravelly silt loam/Tealwhit silty clay loam	520-560 ft.	0-15%	South facing
Red Creek 2	Slope (?)	Hoko gravelly silt loam/ Tealwhit silty clay loam	560-600 ft.	0-15%	North facing (NNW)
Ridge Runner	Slope	Tealwhit silty clay loam	840-860 ft.	0-8%	South facing (SSW)
Springfield	Slope	Tealwhit silty clay loam	640 ft.	0-5%	South facing (SSE)
Dickie West	Slope/ depressional?	Tealwhit silt loam	100-120 ft.	0-5%	East facing (ESE)
Wentworth Lake	Slope (?)	Tealwhit silt loam	100-120 ft.	0-5%	NW facing
Dickie West 2	Slope/ depressional?	Tealwhit silt loam/ Klone very gravelly loam	100-120 ft.	<5%	West facing (WNW)
Gunderson	Slope	Klone-Ozette-Tealwhit complex	320-340 ft.	0-5%	East facing (ESE)
Colby Creek	Depressional	Kydaka silty clay loam/ Zeeka silt loam	240 ft.	<5%	North facing (NNE)
Cowlitz	Depressional	Edgewick silt loam	700 ft.	0-3%	South facing
Ellensburg	Depressional	Jumpe stony loam	4960 ft.	<5%	Top of watershed

Table A6. Background information – pre and post harvest

Owner	Site Name	County	T/R/S	Date of harvest	Harvest methods	Species harvested	Post-harvest site prep	Date replanted	Replant - species	Replant - density	Comments
Crown Pacific	Clallam 1	Clallam	31/12W/10	1995 (FPA date is 5/5/95)	Shovel	? (Estimated harvest of 2095 MBF)	Natural regen	If not fully stocked then site will be planted (FPA).	Hemlock, Douglas-fir, cedar, silver fir or spruce (FPA). [5]		Forester mentioned that it would not be clear cut again.
DNR	Springfield	Jefferson	24/12/11 (N central)	1991-92	shovel	Cedar, hemlock and white fir, also spruce, white pine, and Douglas-fir.	none	1995	THPL	135 stems per acre	
DNR	Ridge Runner	Jefferson	24/12/11 (SE of NW 1/4)	1986 *still harvesting in 1998.[6]	highlead - cable	cedar*, hemlock and white fir, Douglas-fir, white pine	none	1986(?)	TSHE	174 stems per acre to reach target of 300 stems per acre	natural regen for a year then planted to bolster stems/acre in southern 17 acres of unit
DNR	Nolan Normal	Jefferson	26/12/13	1984	cable	?	Natural regen 1985-86	Reprod survey 1988	Hemlock =400 spruce=200 stems/acre		Not to be clear-cut again, thinned perhaps
DNR	16 Springboard #2 (Cowlitz)	Cowlitz	9/4W/17 (SE ¼)	1983	highlead - cable	Mostly Douglas-fir, small amount of hemlock and red alder	Broadcast burned, spring 1984	Spring 1985	Douglas-fir	most likely 450 trees/acre	Sprayed 2,4-D for alder control. Thinned 1999 to 300 trees per acre
DNR	Red Creek Cedar (1&2)	Jefferson	26/11W/3	1982	?	?	?	?	?	?	
Rayonier	Dickie West	Clallam	29/14W/18 &19	1998	?	Hemlock =76% cedar=12% spruce=11% hardwoods =1% (by volume). 98 stems/acre (estimate)	?	2001	Spruce	343 stems per acre	

[5] Forester said planted with hemlock and spruce.
[6] Not mentioned by the regional forester.

Table A6. Background information – pre and post harvest

Owner	Site Name	County	T/R/S	Date of harvest	Harvest methods	Species harvested	Post-harvest site prep	Date replanted	Replant - species	Replant - density	Comments
Rayonier	Wentworth Lake	Clallam	29/14W/17	1998	?	Hemlock =82% cedar=6% spruce=10% hardwoods =2% (by volume). 131 stems/acre (estimate)	?	1998	Hemlock =45 spruce=23 D.fir=327 stems per acre	394 stems per acre	
Rayonier	Dickie West 2	Clallam	29/14W/19 &30	1993	?	?	?	1993	?	?	
Rayonier	Gunderson	Clallam	29/13W/29	2000	?	Hemlock =60% spruce=35% D.fir=2% hardwoods =3% (by volume). 91 stems/acre (estimate)	?	2000	Hemlock =15 spruce=24 D.fir=325 stems per acre	364 stems per acre	
Rayonier	Colby Creek	Clallam	29/14W/26 &27	1996	?	Hemlock =71% cedar=4% spruce=23% D.fir=1% hardwoods =1% (by volume). 204 stems/acre (estimate)	?	1996	?	?	
Boise Cascade	Ellensburg 1	Kittitas	19/20E/5	1988	tractor/ skidder	Lodgepole pine, grand Fir, ponderosa Pine, D.fir, western larch (forester just guessing)	none		none		Not much information in the file, but post harvest information is accurate