Riparian Hardwood Conversion Study Plan

Prepared by the

Riparian Scientific Advisory Group

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INTRODUCTION

Hardwoods and conifers have important roles in riparian ecosystem dynamics. Functions shared by both include their ability to stabilize stream banks, provide shade for moderating stream temperatures, and serve as sources of large woody debris (LWD).

As a legacy of historic management practices, red alder has become the dominant component of some riparian stands which previously had been dominated by conifers. In many of these stands conifers have not reestablished and are unlikely to do so within managerially relevant timeframes without substantial disturbance or human intervention (Hibbs and Giordano 1996).

This transition in tree species affects the quantity and quality of in-stream large woody debris (LWD). Conifers can attain larger size than hardwoods and as LWD decay at slower rates. As a result conifer LWD influences stream morphology for longer periods of time than hardwoods (Andrus et al. 1988). Streams that lack LWD generally have fewer in-stream pools, lower quality spawning habitat, less diverse fish communities, and a lower survival rate for juvenile salmonids (Beechie and Sibley 1997).

This study will describe hardwood conversions in riparian areas in an operational forestry context. Hardwood conversion as a management tool has been portrayed as a win – win strategy for both landowners and resource protection. Landowners are able to realize financial gain from harvesting in riparian areas while over time fish habitat is expected to improve more quickly because of a greater number of stream-adjacent conifers. Past experience has shown though that regenerating conifers in riparian areas can be difficult and expensive, and prone to failure if competing shrubs and browsing animals are not carefully monitored and controlled.

This study will provide information that supports techniques, tools, and treatments for harvesting hardwood trees in riparian areas and planting conifers that are free-to-grow and on trajectory to dominate the sites. In a case study experimental design we will collect data at 8 riparian hardwood harvests/conversions that have been added to adjoining upslope harvest units. We will work with cooperating landowners to investigate the economic and ecological outcomes of harvesting red alder trees and reestablishing conifers in their place. We will describe and quantify the silvicultural prescriptions used to establish conifers in riparian areas, and quantify the financial costs and returns to the landowner that result from the harvest and regeneration prescriptions. In addition, we will evaluate the effect of harvest treatments on shade and water temperature.

Sites selected for this project will be in riparian forests in western Washington that were once dominated by conifers and are now dominated by red alder. The minimum criteria used to select study sites included: 1) riparian forests dominated by red alder, 2) evidence of historic presence of conifers (especially presence of stumps) or indications that conifers would succeed on that site, and 3) landowner willingness to participate in the study and share data from their harvest operations.

This study plan was prepared for the Washington Department of Natural Resources (DNR) pursuant to Personal Services Contract 02-108.

Background

Washington forest practices rules (hereafter "rules") adopted in 2001 are based on pursuing three primary goals: 1) promoting a viable timber industry, 2) protecting water quality, and 3) restoring salmon habitat. The rules guiding and defining the management of riparian areas differ depending on whether the stands being harvested are dominated by conifers or by hardwoods. Where conifers are dominant, the rules allow harvest of wood from riparian management zones (RMZs) so long as the retained stream buffers remain on track to grow and develop into conditions that structurally resemble mature conifer forests, otherwise known as the 'desired future condition' in the rules. Where hardwoods are dominant, the rules allow removal of wood from the RMZ as long as the harvest and regeneration will convert the stand to conifer dominance. The aim of this rule is to promote conversion of hardwood dominated RMZs to conifer dominance to accelerate succession of these stands to mature conifer forests (i.e. DFC) as compared to stands left unmanaged, and thereby creating stand conditions that more quickly work to improve water quality and fish habitat. Landowners benefit by being able to harvest timber from these stands.

In this context hardwood conversion can be viewed as a restoration activity, especially on sites that were once dominated by large conifer trees. Stakeholders in the negotiations that developed the current forest practices rules crafted the current hardwood conversion rule with the direction that it be accompanied by a CMER-implemented study that would characterize silvicultural practices (timber harvest and reforestation), quantify economic outcomes, and measure short-term effects to stream temperature as a result of timber harvest.

RATIONALE

Riparian silviculture

Regenerating conifers in riparian areas may be the least understood part of doing riparian zone hardwood conversions. Competition from fast growing vegetation and animal damage to seedlings in RMZs can prevent successful conifer regeneration unless vigorous weed and animal control measures are taken. There are many conifer-dominated streamside forests in western Washington that were harvested before retaining riparian buffers was required. Riparian stands from which conifers were harvested sometimes had no active reforestation efforts implemented, or regeneration efforts were abandoned because of the cost and difficulty of re-establishing conifers in the highly competitive, disturbance-susceptible conditions of riparian areas. Increasing the body of knowledge about the silviculture of regenerating conifers in riparian zones will help landowners better understand and address potential problems that can be encountered when prescribing hardwood conversions in riparian zones.

Economic analysis

Hardwood conversion can be profitable for landowners because red alder prices are currently high. High prices for red alder have been relatively stable for the past several years and are predicted to remain high and possibly even increase over the next few years. In addition to harvesting red alder trees, landowners may also benefit from successful conversion by the future opportunity to harvest a portion of the conifer timber established in the inner zone if a surplus of conifer basal area is present in the core and inner zones.

The cost of ensuring successful conifer regeneration in riparian areas is thought to be greater than in upland areas but the amount of this difference has not been quantified from operational timber harvests. This study will provide forest landowners in western Washington with operational examples of the costs (and benefits) of doing hardwood conversions in riparian areas that are adjacent to upland harvest units. Landowners will be able to use the results of this study to help inform the management of riparian areas on similar sites in western Washington.

Forest practice regulations, market forces, management objectives, and individual site characteristics all influence a landowner's decision regarding hardwood conversion. The results of the economic analysis will help inform policy makers on how forest practice regulations in hardwood dominated riparian areas can work to meet the financial and management goals of landowners as well as the resource protection goals of the new (2001) FFR rules.

Stream temperature

The current rules guiding hardwood conversions permit harvest of trees from the inner zones of RMZs with the goal of creating stand openings that enable conifers to regenerate in a site. The rules though have many qualifying elements that limit the amount of wood that can be harvested from an RMZ. Only portions of the inner zone may be harvested, and many landowners believe that the current rules do not allow for large enough canopy gaps for successful, cost-effective seedling growth, especially for relatively shade-intolerant Douglas-fir trees.

Some participants involved in the negotiations of the forest practices rules suggest that scientific information currently available indicates that: 1) harvest of hardwood trees could be done closer to the stream, including removing timber volume from the core zones and more timber volume from the inner zone than in current rules, and 2) that timber could be cut along longer stream reaches than currently allowed without causing adverse impacts to water quality. Further, these participants contend that negative impacts to stream temperature, if these occur, are likely to be short-term. The long-term benefit realized by establishing conifers closer to stream edges, measured by shade and recruitable LWD produced should be balanced against short-term impacts and that, overall, there is a net gain for riparian habitat measured by both water quality and functional attributes of streams.

The results of the stream temperature analysis will help provide answers to questions about the effects of hardwood conversion on stream temperatures. Analyses will investigate whether hardwood conversions can be done without adversely affecting water temperature and identify those conditions that affect water temperature responses such that forest practices applications could be conditioned to prevent temperature changes from exceeding acceptable standards.

STUDY OBJECTIVES

1. Monitor, describe and quantify the regeneration of conifers in riparian management zones and describe the silviculture used to insure regeneration success.

2. Quantify the costs of successfully regenerating conifers in riparian zones and the net financial gain (or loss) of adding riparian hardwood conversions to adjacent upslope harvest units.
3. Describe and quantify stream temperature responses to harvesting dominant hardwood trees from the riparian management zone.

SITE SELECTION

Site selection is a key component of this project because not all sites are suitable for conifer establishment and growth and hardwood conversion treatments are intended to be limited to those sites on which it is ecologically reasonable. Site suitability for conifer dominance is dependent upon the physical and biological attributes of individual sites and the disturbance regimes on these sites. In general, study sites selected will be in riparian forests dominated by red alder that have evidence of historic presence of conifers and on which landowners are willing to share information required for the economic analyses. Evidence of the past presence of conifers (stumps, snags, large wood, historical records, landowner knowledge) will all be used as necessary though the preference is to find sites with stumps remaining from the previous stand. Sites selected will not meet DFC and hardwoods will make up >80% of the dominant/co-dominant class (by basal area for pole-sized stands and larger growing within the riparian management zone). Most sites are expected to be comprised primarily of red alder, so evidence of, rather than presence of conifer is expected. Study sites will be selected from a pool of candidate sites submitted by interested landowners. Available sites will determine the geographic and physiographic range of sites selected.

Sites without reasonable potential for supporting conifers or on which hardwood conversion would likely incur substantial financial loss will not be selected for this study. Sites on which hardwood conversion is anticipated to break-even or incur only moderate financial loss will be considered if the landowner is both aware of the possibility of financial loss and remains agreeable to the conditions of the study, in particular that regeneration failure is not an option. Negative balance hardwood conversion projects could be useful in several instances, for example, restoration projects where a funding grant for stream improvement offsets costs or in which ecological gains are judged to be worth the investment required.

Criteria that will serve as guidelines to our selection process and a relative ranking of the importance of these criteria are provided below (Table 1). A narrative will be prepared to explain why each site was selected and a summary table prepared to contrast and compare conditions amongst all of the sites.

Many of the attributes listed reflect situations that landowners will need to contend with in determining their reforestation approach, such as presence of browsing fauna, the type and potential effects of competing vegetation, etc. Narrative and quantitative summaries that describe pre-harvest site conditions will be prepared for the purpose of relating regeneration success to site conditions. The effect each of the attributes listed has on the outcome of hardwood conversion will also be evaluated and discussed in the case study narrative reports. Statistical analyses using some of these attributes or conditions will be conducted, where appropriate, to explain study outcomes.

Table 1. Environmental and Economic Criteria and Importance Ratings.

Environmental Attributes	**Ranking***
competing flora	1
browsing fauna	1
slope	2
aspect	2
soil characteristics (stability, drainage)	1
Stream characteristics (width, velocity, gradient, type)	1
Stream LWD requirements and status	3
LWD requirements of the stream	3
geomorphology	1
upslope forest conditions	2
upstream forest conditions	2
Economic Criteria	
landowner objectives	3
site access	1
Harvest cost, operability, harvest system	2
value per acre of riparian zone hardwood	2

* Importance Rating: 1 is high, 2 is medium, 3 is low

Stream Control Area

A stream control area is desired to measure and compare stream temperatures above and just below treated reaches. Where possible, sites will be selected so that they have approximately 1,000 feet of shaded stream above the treatment reach This length is desirable because distance of shade along a stream reach is correlated with a stable ambient stream temperature a desirable characteristic of water entering the treatment reach.

SILVICULTURAL PRESCRIPTIONS

Landowners will be given templates of three overstory harvest prescriptions that we propose and they will implement one of these, modifying it to fit the specific conditions of the particular site. Detailed cutting and reforestation plans will be prepared by landowners for each site and presented in the alternate plan prepared for each site. Landowners will similarly be responsible for implementing understory brush control treatments they deem necessary to ensure seedling survival, as well as protecting seedlings against browse and other potential threats to regeneration success. The type, periodicity, and intensity of treatments are left to the discretion of landowners with the understanding that regeneration failure is not an option. While landowners will implement treatments, the contractors will measure the attributes selected for analysis. Landowners will be required to report types and costs of the treatments implemented to the contractors and keep contractors informed should significant mortality occur to seedlings, substantial channel movement occur or other acute changes happen that affect the site and therefore study results.

Overstory Prescriptions

The three overstory silvicultural prescriptions we recommend are as follows:

1. Cut all hardwood trees in the existing stand to within 25 feet of the channel migration zone (CMZ) or bank full width of the stream, whichever is larger.
2. Cut all hardwood trees in the existing stand to within 50 feet of the channel migration zone (CMZ) or bank full width of the stream, whichever is larger, and implement a thinning treatment leaving trees at approximately a 30 foot spacing in the existing stand from 25 to 50 feet from the channel migration zone (CMZ) or bank full width of the stream. <u>All conifer trees must be retained</u> and red alder trees between them retained at the ~ 30 foot spacing specified. Where conifers are absent, space red alder trees to the ~ 30 foot spacing prescribed.
3. Harvest using the existing Forest Practice Rules (WAC) 222-30-021(1)(b)(i)) for Hardwood Conversion.

Prescriptions may vary from these to account for such site attributes as micro-scale topography, seeps, clumps of conifer trees within the cutting areas and others. The variation in cutting that is expected is primarily in the spacing pattern of residual trees, which may vary to account for the factors identified above. Cutting boundaries for treatment 1 might exceed 25' from the CMZ or bank full width of the stream but will not be less than this.

Understory Prescriptions

Understory treatments are left to the discretion of landowners. Specific measures they will want to consider in their treatments and for which final results will be presented include: site preparation, tree planting methodology, control of competing vegetation, animal damage control, tree species planted, stock type and other measures used to ensure successful regeneration.

Successful reforestation is required for all sites in this study, though the means to achieve this is left up to individual landowners. The basic measure that will be used to judge success is whether or not the reforested stand is on trajectory to meet Desired Future Condition (DFC). To achieve DFC it is expected that converted stands will be tracked until conifers reach a free-to-grow condition and are on track to occupy > 50% of the dominant/co-dominant canopy when mature stand conditions exist (total age 100+). It is expected that conifers need to dominate the site, generally making up > 50% of the dominant/co-dominant canopy position by basal area and/or stems per acre, depending on age/size, while always meeting the requirements of WAC (cite specific WAC) (requires a minimum of 190 well-distributed, vigorous, undamaged seedlings per acre). "Well-distributed" means that less than 20% of the harvest area has fewer than 150 seedlings per acre on average. Satisfactory reforestation of a clear-cut occurs if within three years of harvest completion, the site is restocked with at least the minimum stocking levels. For this study, however, seedling survival and stocking level will be tracked for longer than this minimum rule requirement. Core and inner zone areas will be calculated according to current (FFR derived) rules.

The prescriptions landowners develop must achieve the minimum free-to-grow conifer stocking requirements specified above. It is expected that most landowners will opt to control competing vegetation using herbicides. Some landowners, however, may use manual control of competing vegetation. If regeneration failure is imminent, remedial action will be required which could consist of additional competing vegetation control, animal damage control, re-planting, etc.

We will rely on landowners (or their representatives) to alert us of chronic and/or acute changes affecting the study sites. Several treatments may be necessary to ensure conifer establishment. Site specific data evaluation and a narrative describing pre-and post-treatment condition will be recorded to fully document treatment effects and changes over time.

INDIVIDUAL STUDY PLANS

There are three study plans that describe how the project will be implemented, one for each of the primary study objectives: riparian silviculture, economic analysis, and stream temperature response.

Riparian Silviculture

We will describe and quantify the silviculture of doing hardwood conversions, including logistical considerations when laying out and harvesting riparian trees, paying particular attention to the work done to ensure regenerating conifer trees and maintaining them until they are on trajectory to form the dominant stand component.

Objectives

The objectives of the project related to riparian forest vegetation are to:

- Describe the condition and characteristics of the riparian stands used in the study.
- Describe how trees in the RMZs were harvested and the resulting configurations of the buffers.
- Monitor, quantify and describe post-treatment growth and survival of planted conifer trees for the duration of the study.
- Quantify and describe the regeneration strategies employed by landowners that led to successfully regenerating conifers in previously hardwood dominated riparian stands.
- Quantify the amount of windfall that occurred during the length of the study at each site and the number and size of trees that recruited into the streams.

Questions of Interest

Riparian stand conditions

1. What were the conditions and characteristics of the riparian stands pre and post harvest?

Harvest

2. How were the units laid out and harvested?

3. What additional harvest activities resulted from adding riparian hardwood conversion treatments to the harvest prescriptions?
4. What were the primary obstacles that limited landowners ability to harvest trees from the RMZ?

Seedling response

5. What were the growth rates of planted seedlings in the RMZs?
6. What were the survival rates of planted seedlings in the RMZs?

Silviculture

7. What regeneration strategies did landowners use to ensure successful conifer regeneration in the RMZs?
8. What were the primary problems that landowners faced regenerating the RMZs with conifers?

Windfall

9. How much windfall occurred in the retained buffer post-treatment?
10. How many trees recruited to the stream post-treatment?

Methods

Data collection

Data on silviculture will be collected through field sampling and through questionnaires and interviews with landowners. In the field, riparian trees and vegetation will be inventoried to quantify and describe both the pre- and post-harvest stand condition. We will sample the retained buffer trees by conducting a 100% tree cruise to characterize the buffer conditions. We will also do a 100% RMZ stump cruise to quantify tree harvest from the RMZ. To , and by collecting data from 1/50 acre circular plots distributed throughout the planted areas of the RMZ to quantify regeneration success and growth rates.

Questionnaires and interviews will be used to collect data on regeneration strategies from the landowners.

Buffer configuration data will be collected to calculate area of the RMZs that were harvested and to produce maps of the buffer lay-out relative to the stream and upslope harvest unit.

Windfall data will be collected in the RMZ, with particular attention paid to trees that recruit into the stream by breaking the plane of the bankfull channel edge.

100% RMZ standing tree and stump cruise

Both standing trees and stumps data will be collected once, at post-harvest year 1.

Standing trees

The primary purpose of this sampling design is to quantify merchantable volume and also describe other attributes pertaining to large tree stand structure in both the retained and harvested portions of the core and inner zones of the riparian buffer (RMZ). All trees greater than or equal to 5.0” will be tallied by species and diameter-class. A sub-sample of the trees will be measured within each species and diameter class to gather volume, grade and defect statistic’s. A sub-sample routine protocol will be developed on a site-by site basis. This routine will establish a height sample frequency (HST) that attains a minimum of 150 HST trees per site for the predominate species. Special attention will be given to large trees, unique residual tree components, and minor species in order to achieve adequate HST sample. The tree data will be compiled in Atterbury’s SuperACE 04 using the Stand Table Adjustment routine which expands the HST sample into the actual stand table tally.

Table 2 displays data entry fields used when measuring 100% trees.

Table 2. Tree attributes measured in 100% cruise.

Field	**Description**
Species	Tree Species
DBH	Diameter at Breast Height (Minimum 5.0” DBH)
Form Factor	16 foot form factor
TD	Top Diameter Factor (Fixed DOB top or fractional portion of Form Point)
Bole HT	Merchantable Height
Total HT	Total Height
Sort	Domestic sorts only
Grade	Log Scaling Bureau Grade
Length	Log Segment Length 12-40 feet
Defect	Log Segment Defect (deduction in feet/inches or percentage)

Data on dead trees will also be collected, including DBH, total height, species (if identifiable, and decay class (see Table 3 for decay class criteria).

Table 3. Decay Class Codes And Defining Criteria.

CODE	BARK	TWIGS	TEXTURE	SHAPE
1	Intact	Present	Intact	Round
2	Intact	Absent	Intct-soft	Round
3	Trace	Absent	Hard, large	Round
4	Absent	Absent	Small,soft	Oval

Merchantability and Volume Utilization Specifications

Consistent with the WDOR reporting standards being used to summarize timber value in this study the official log scaling and grading bureau rules used in Western Washington will be applied to determine grade with some modifications to better reflect real world utilization. The smallest sawmill grade log considered will have a 5-inch minimum D.I.B. top and be at least 12’ feet plus trim long. The minimum utility log considered will have minimum gross diameter of 3-inches and be at least 12 feet long.

Stumps

In the harvested portions of the RMZ all stumps 6-inches and larger (approximately 5" at DBH) will be tallied by species and diameter to generate a harvest area stand table. The HST sample trees used in the 100% cruise will also be used to reconstruct and expand volume into the harvested portion of the RMZ. To accurately estimate stump to DBH ratios an adequate number of estimated stump diameters will also be measured when collecting standing 100% tree measurements. Stump to DBH ration measurements will be sufficient to capture variation across all species and diameter classes.

Regeneration

Regeneration data will be collected by installing regeneration plots in the planted portions of the RMZ and from questionnaires and interviews with landowners.

The primary purpose of the field sampling is to measure and track trees planted in the RMZ. Regeneration will be measured every other year, at post-harvest year 1, year 3, and year 5. In this survey lesser vegetation information will also be collected to categorize and describe site conditions and identify possible competition to seedling survival and vigor. This sample design will employ 1/50th acre fixed-radius circular plots, located well-distributed throughout the planted portion of the management RMZ.

Table 4 lists the data that will be collected in the regeneration plots.

Table 4. Data measured in regeneration plots.

Field	**Description**
Tag	Tag number on planted seedlings only
Species	Tree Species
Group	"Live" or "Dead"
DBH	Diameter at Breast Height (maximum 4.9" DBH)
Tree Count	Count of trees used on natural regeneration only. Planted trees will be recorded separately.
Height	Total Height – Natural seedlings are measured to the nearest foot. Planted trees are measured to the nearest 1/10th of a foot. (minimum 0.5 feet)
Height Code	1 = Normally Formed, 2 = Atypically Formed
Crown Ratio	Live crown ratio
Crown Class	Crown class code or tree position.
Damage	Damage that may affect tree vigor or volume.
Defect	Defect expressed as percent of missing cubic foot volume
Age	[Optional] Recorded total age
Distance	[Optional] Distance from plot center
Bearing	[Optional] Bearing from plot center
Shrub species	Vegetation species
Shrub height	Record average height
Percent Shrub Cover	The on-plot percent cover
Remarks	[Optional] Comments

Plots will be installed on a set grid based on a sample coverage of one plot every 0.09 acres (a square grid of ~ 60' by 60' – rounded down to the nearest 5-foot increment). It is estimated that this proposed plot size and sample intensity will produce slightly more than 20-percent coverage of the planted portion of the management RMZ at each site.

Table 5 displays the estimated regeneration plot distribution among the 8 study sites:

Table 5. Estimated number of regeneration plots that will be installed at each site.

Site	Stream Reach Length (ft)	Number of Treatment Sides	Estimated Area of Managed Cut (acres)	Estimated Number of 1/50th Acre Sample Points
5	1800	2	4.0	44
8	3500	1	3.0	33
11	2900	1	3.5	39
12	4200	1	2.0	22
13	1700	1	1.4	16
14	1000	1	1.8	20
15	2000	1	2.9	32
23	4300	2	2.0	22
Total			**20.6**	**228**

Plots will be installed and mapped using global positioning system (GPS) technology and lasers. Plot locations, streams, items of significance and a geographic reference to the local area will be shown.

We will use questionnaires and interviews to gather information from landowners on the amount and type of site preparation planning and work that was done for regeneration in the RMZs and in the upslope portions of the harvests. We will ask landowners for information about which planting stocks were planted in the RMZs versus the upslope areas, and request copies of their reforestation maps. Over a five year period we will also ask landowners to describe work done to control brush and animal browse, as well as updates on any supplemental planting work.

Buffer configuration

Buffer configuration data will be collected once, at post-harvest year 1. Traverse interface between RMZ and upland harvest unit and run offsets to locate stream bankfull/CMZ at regular intervals along interface transect line. Map and estimate area of cut, and uncut in RMZ.

Riparian windfall

At post-harvest year 5 of the monitoring all trees in the retained buffer that have blown down will be tallied.

Stream recruitment

At post-harvest year 1, year 3 and year 5, trees that blow down and cross the plane of the bankfull channel edge will be recorded.

Analysis

Riparian inventory data will provide per-acre data on stocking, basal area, age, crown cover, competing vegetation, light intensity, etc. Standard statistics (mean, minimum, maximum, standard deviation, sample size, etc.) will be calculated and reported in tabular and graphic formats. The

Regeneration data will be worked up by plot and combined to estimate stocking (natural regeneration and planted), height growth, competing vegetation, etc. The first sub-plot measurements post-treatment will provide a baseline to which second year post-treatment measurements will be made. Changes in survival, height, DBH and live crown ratio of planted conifers will be the primary emphasis. Changes in competing vegetation, overstory crown cover, light intensity, animal damage and other factors affecting survival and growth of seedlings will also be reported, especially on sub-plots with and without ongoing vegetation management etc. in post-treatment out-years.

Riparian and stream features will be modeled using pre- and post-treatment plot data in the Riparian Aquatic Interaction Simulator (RAIS) (Welty et al. 2002) or similar modeling methodology. RAIS forecasts large woody debris and shade for varying channel widths and riparian widths. Modeling will help determine if desired future conditions can be achieved with post-treatment riparian characteristics and if intervention (inter-planting, competing vegetation control, animal damage control, etc.) may be required.

Economic Analysis

We will analyze the economic viability of converting hardwood dominated riparian areas to conifer. The economic analysis will describe the management and financial context in which decisions to do hardwood conversions occur, and evaluate the incentives landowners respond to when making those decisions.

Objectives

1. Compare and quantify the costs of successfully regenerating conifers in the riparian areas versus the costs of successfully regenerating conifers in the adjacent, upslope areas.
2. Describe the logging costs associated with adding a hardwood conversion treatment in the riparian management zone to a harvest prescription.
3. Quantify the additional amounts of wood (volume, board feet) harvested from the riparian management zone when a riparian hardwood conversion treatment is added to a harvest prescription.
4. Calculate changes to gross and net revenues when riparian hardwood conversion treatments are added to harvest prescriptions.
5. Describe the regulatory, financial, and management context in which the decision to do hardwood conversions occur, and evaluate the factors landowners considers when making those decisions.

Questions of Interest

Regeneration:

1. What were the cost differences between successfully regenerating conifers in the riparian areas versus successfully regenerating conifers in the adjacent, upslope areas?
2. What were the primary reasons for different costs (if any) between regenerating conifers in riparian areas versus regenerating conifers in adjacent, upslope areas?

Harvest:

3. What additional harvest costs resulted from adding riparian hardwood conversion treatments to the harvest prescriptions?

Benefits of riparian hardwood conversion:

4. How much wood (volume, board feet) was harvested from the riparian management zones?
5. How much wood (volume, board feet) was harvested from the upslope portions of the units?
6. What were the net financial gains (or losses) that resulted from adding riparian hardwood conversion treatments to the harvest prescriptions?

Management context for riparian hardwood conversion:

7. How do existing forest practice regulations influence the decision by landowners to do hardwood conversions in riparian areas?
8. How do financial goals influence decisions by landowners to do hardwood conversion in riparian areas?
9. How do land stewardship goals influence decisions by landowners to do hardwood conversion in riparian areas?
10. How do specific site features influence decisions by landowners to do hardwood conversions in riparian areas?
11. Why did the landowners select these sites to do hardwood conversions?

Methods

Data collection

Below is a series of tables that contain data categories and associated sources for those data. Landowners will be asked to help fill out a questionnaire that describes the costs and benefits of the hardwood conversion treatments and will be asked to participate in interview(s) to describe and characterize the management context in which hardwood conversion prescriptions were developed. We plan to fill out as much of the questionnaires that we can for each harvest (based on data collected in the field and from third party reports), with updates as needed, and submit these to the landowners during the course of the study for them to complete and amend as necessary. Other sources of information will include maps, GIS layers, and third party reports.

Economic information is often considered proprietary which complicates collecting it from private interests. Sensitive data include money spent on wages, contracts, salaries, materials, etc. and on the amount of revenue generated from log sales. To address these concerns, we will use the Washington Department of Revenue stumpage value determination tables, adjusted as appropriate, when calculating timber harvest revenues. When calculating regeneration costs, we will use whatever information each landowner is comfortable sharing, and fill in data gaps by assigning dollar amounts to regeneration activities and materials based on information collected from the DNR and from regional service and material providers.

Regeneration

The primary data we will collect for estimating regenerating costs are presented in Table 6.

Table 6. Primary regeneration cost data that will be collected.

Regeneration work	Landowner	Non-landowner
site preparations (Total and RMZ)	surveys, interviews	third party reports, interviews
planting stock (type, species, density)	surveys, interviews	field plot, third party reports, interviews
brush control activity (Total and RMZ)	surveys, interviews	third party reports, interviews
animal control activity (Total and RMZ)	surveys, interviews	third party reports, interviews

If a landowner shares actual regeneration costs with us we will use those values in the financial analysis, otherwise we will assign costs for specific site preparation, planting, and shrub and animal control measures based on the typical fees and rates paid for that kind of work in the area, which we will gather from the DNR and through interviews with local service and material providers.

Harvest

Table 7 lists the data we will collect to describe the lay-out and logging operations. The information will be used to write narratives that describe the harvest operations, including administration and planning, site lay-out, road construction, and yarding. We will highlight the logistics and specific work done that resulted from adding an RMZ harvest to the operations.

Table 7. Primary harvest activity data that will be collected.

Harvest operations	Landowner	Non-landowner
administration/planning	surveys, interviews	
lay-out	surveys, interviews	
road construction/maintenance	surveys, interviews	
yarding/logging plan	surveys, interviews	

We will assess the harvest costs (including road construction and maintenance) using the same assumptions the DOR uses when preparing the state's stumpage value tables (see the analysis section for more information).

Benefits of hardwood conversion

Landowners will provide data on the timber harvest in terms of board feet and volume by species and sort/grade harvested (Table 8). We will use stump cruise data from the RMZ to separate out timber harvested from the RMZs versus timber harvested from the upslope portions of the units. In the financial analysis we will use information gathered from the surveys and interviews to adjust the DOR stumpage values to more closely reflect the site specific conditions and operations of each harvest (see the analysis section for more information).

Table 8. Primary harvest benefit data that will be collected.

Timber harvest values	Landowner	Non-landowner
harvest (b.f. and volume) by species (Total and RMZ)	questionnaire, interview	field plots
grades of wood harvested	questionnaire, interview	
stumpage values, by species and grade	questionnaire, interview	third party reports

<u>Management context for riparian hardwood conversion</u>

Gathering information from landowners on the factors affecting decisions about riparian hardwood conversions will be an iterative process. The themes listed in Table 9 are starting points for discussions that will occur through interviews with the landowners. The goal is to understand and define the factors landowners consider when deciding to implement hardwood conversions on their properties. Are the decisions based primarily on short-term financial goals? Long term financial goals? Stewardship goals? How do specific site conditions influence the decision to include a hardwood conversion? Eventually we would like to be able categorize responses, but given the exploratory nature of this part of the study the questions posed in the interviews will be open ended. We will also describe the size, the ownership basis (privately held, publicly traded, managed, agency, tribal, etc.), corporate culture, and management objective of each landowner to help explain or categorize the themes and results that emerge from the interviews.

Table 9. Primary factors affecting riparian hardwood conversion planning.

Management objectives (context)	Landowner	Non-landowner
hardwood conversion based on regulatory framework	interview	
hardwood conversion based on financial incentives	interview	
hardwood conversion based on land stewardship goals	interview	
specific site factors that influence management decision	interview	
unexpected operational challenges	questionnaire, interview	
economic profile	questionnaire, interview	third party reports

Analysis

There will be two parts to the analysis. The first analysis will focus on the regeneration costs but will also include financial appraisals of each sale's net gain or loss. The analysis will quantify for each site the costs and benefits of doing an upslope harvest compared with the costs and benefits of doing an upslope harvest combined with a riparian hardwood conversion. The second analysis will pool the results of the individual hardwood conversions to derive means, medians, minimums and maximums for each of the parameters and categories and describe any patterns observed between the different harvests. Depending on the results of the interviews we will summarize the frequency of the factors that led to the hardwood conversion treatments, and/or highlight any patterns that emerged.

As these case studies are primarily descriptive, statistics are a minor component of the analysis. Instead the analysis will primarily consist of organizing the data to be able to answer the questions of interest using means, medians, and ranges, as necessary. The one area where the analysis is more complex is when estimating the financial gain (or loss) associated with adding a hardwood conversion in an RMZ to a harvest prescription using the DOR stumpage value tables (see Question of Interest 7 below).

Analysis 1

Regeneration

1. What were the cost differences between successfully regenerating conifers in the riparian areas versus successfully regenerating conifers in adjacent, upslope areas?
2. What were the primary reasons for different costs (if any) between regenerating conifers in riparian areas versus regenerating conifers in adjacent, upslope areas?

Activities that will be described as part of regeneration:

- Site preparation
- Tree seedling types
- (Re)planting strategies
- Annual brush control
- Annual animal control

We will ask the landowners whether they treated the riparian zones different than the upland areas to determine if there were any additional site preparation, planting or maintenance costs associated with the conversion. If so we will treat the RMZ and upland areas separately when calculating regeneration costs. If landowners did not treat the RMZ different than the upland areas, we will allocate the regeneration costs proportionately between the two according to their areas. Each parameter listed in Table 1 will be analyzed on a per acre, per MBF, or per ton basis and we will compare the cost differences between the RMZ and upland areas by individual parameters (Table 1) and as total costs.

Harvest

3. How were the units laid-out and harvested?
4. What additional harvest activities resulted from adding riparian hardwood conversion treatments to the harvest prescriptions?

Activities that will be described as part of the harvest:

- Administration
- Lay-out
- Road construction/maintenance
- Yarding/logging

We will describe how the units were administered, laid out and harvested. We will quantify how many stations of permanent road were constructed and/or improved for the harvest and what percent of the road work was done specifically to gain access to the trees in the RMZs. We will quantify what percent of the unit was ground logged versus cable logged in both the RMZ and upland portions of the site.

Benefits of riparian hardwood conversion

5. How much wood (volume, board feet) was harvested from the riparian management zones?
6. How much wood (volume, board feet) was harvested from the upslope portions of the units?

Description of harvest:

- Wood volume by species and grade
- Gross income (per MBF, per ton, per acre) for stumpage

We will sort logs according to species and grades and assign revenue amounts to each using the DOR stumpage tables. To calculate the stumpage value of the wood we will assign all price adjustments (volume, logging conditions, remote island, thinning) according to the DOR guidelines except for the logging conditions adjustment. With this adjustment, instead of assigning a fixed value based on the majority logging condition type in a harvest unit, we will calculate the value on a sliding scale based on the percentage of the harvest unit (upland and upland + RMZ) that were logged using tracked or wheeled vehicles (ground-based), on overhead system of winch driven cables (cable-based), and/or yarded from stump to landing by helicopter.

We will use data from the RMZ stump cruise to calculate the amount of wood harvested from the RMZ and deduct these from the unit totals to estimate the revenues associated with the upslope versus riparian portions of the harvest.

7. What were the net financial gains (or losses) that resulted from adding riparian hardwood conversion treatments to the harvest prescriptions?

Timber harvest financial analysis:

- Net income (per MBF, per ton, per acre) from the harvest

We will subtract regeneration costs from estimated revenues to calculate the net financial gain or loss of each harvest. We will compare the net financial gains (or losses) of harvesting and successfully replanting trees in the upland portions of the units versus the net financial gains (or losses) of harvesting and successfully replanting trees in the combined upland plus RMZ portions of the units.

Management context for riparian hardwood conversion

8. How do existing forest practice regulations influence the decision by landowners to do hardwood conversions in riparian areas?
9. How do financial goals influence decisions by landowners to do hardwood conversion in riparian areas?
10. How do land stewardship goals influence decisions by landowners to do hardwood conversion in riparian areas?
11. How do specific site features influence decisions by landowners to do hardwood conversions in riparian areas?
12. Why did the landowners select these sites to do hardwood conversions?

We will use the information gathered from the interviews to summarize the management factors (regulatory, financial, land stewardship, site, other) that influence decisions by the landowner to add riparian hardwood conversions to the harvest prescriptions. Information will be used, as appropriate, to complement, explain or emphasize the regeneration, harvest, and financial analysis results.

Analysis 2

We will pool the results of the individual hardwood conversions to derive means, medians, minimums and maximums for each of the parameters and categories listed above. Depending on the results of the interviews we will summarize the frequency of the factors that led to the hardwood conversion treatments, and/or highlight any patterns that emerged.

Stream Temperature

Two years of pre-harvest stream temperature has been collected at the 8 sites, and will be compared to post-harvest stream temperatures and temperatures in upstream control reaches. We will collect stand conditions in the RMZs one year after harvest, and track regeneration up to 5 years post-harvest.

The stream inventory includes channel characteristics, stream temperature, stream canopy cover and a streamside instability inventory. Details on methods and data collection are presented below.

Objectives

The goal of this proposal is to determine if hardwood conversion rules and alternate plans affect water temperature. Specifically, determine if hardwood conversion:

1) Results in a measurable change in stream temperature.
2) Causes persistent water temperature impacts in the channel below the harvest unit.
3) Determine the maximum length of buffer subject to hardwood treatment that can be allowed without creating a significant temperature impact.
4) Results in measurable changes in shade over the stream channel.

It is difficult to determine if forest practice regulations intended to protect water temperature are effective because: 1) seasonal and daily cycles in the temperature exist, 2) factors other than solar exposure can modify water temperature, and 3) year to year differences in air temperature, flow, cloud cover and precipitation make inter-annual comparisons difficult. In addition, it is difficult to find sites to conduct field trials. It would be a lost opportunity not to use the Hardwood Conversion sites to add to what is known about stream temperature response to riparian timber harvest. Stream temperature data collected at the hardwood conversion study sites can add significantly to understanding the effects of an active management approach to riparian management and its consequent effects. This data may provide conclusive findings concerning water temperature effects on narrow buffers, or contribute to a conclusive meta-analysis at some time in the future.

Questions of Interest

1. How does harvest unit length (along stream) affect stream temperature given a 30' wide minimum buffer and a maximum length of 1500'? Is this substantially different than given a 50' minimum buffer width?
2. What physical and biological characteristics affect the magnitude of stream temperature response to harvest unit length?
3. How does water temperature change as it leaves the harvest unit and how is the change in temperature affected by recovery zone length and the physical/biological characteristics of the stream.
4. Can a matrix be developed of riparian and channel conditions to characterize stream temperature sensitivity to timber harvest and, if so, how?

Methods

In July and August of 2003, 9 sites were flagged at 25 m intervals from the uppermost temperature data logger to the lowermost data logger. Every 25 m transect was monumented with aluminum tags and nails, or PVC poles, with the intent of relocating these sites up to five years later. The channel adjacent to the estimated downstream corner of the harvest unit was flagged as reference point (Station +00). For every 25-meter segment the following measurements were recorded: channel width and depth, wetted width and depth, upstream channel azimuth and measurements of canopy cover (digital hemispherical image).

All dataloggers (TidBit Stowaway) will be calibrated, and launched from the same clock to record every hour. Datalogger placement methods developed by Schuett-Hames et al (1999) will be applied. Two dataloggers will be located 50 meters upstream from the upper harvest unit corner at each site (one for air temperature, one for water temperature), and one each at the lower harvest unit corner, one every 75 meters through the harvest unit (measured from the downstream corner) and at 100 m, 200 m, and 400 m below the downstream corner, except where beaver ponds are present. The air temperature unit will be placed on the north side of a tree 1 m above the ground and 1 to 3 m in the riparian zone from the bank. Water temperature dataloggers will be placed in the thalweg of the channel, secured with rebar (soft substrate) or fastened by wire to a rock (bedrock substrate) and shaded from direct sunlight. These will be placed 15 cm above the substrate or mid-way between surface and bottom, whichever is less. The height will be adjusted in the middle of the season to account for declining flows. Data loggers will be examined and replaced at least once during the season to minimize loss of data from malfunctions, or physical loss of dataloggers. The serial number of every data logger will be recorded both when they are placed and when removed for quality assurance. Digital canopy images will be collected at every 25-meter transect. LWD, sediment wedge dimensions and residual pool depth of the three largest pools per 25 meters segment will be collected.

Bankfull width, wetted width, channel gradient, channel bed substrate and an index of canopy cover will be measured at every stream segment break along the entire length of the conversion area pre- and post-treatment. Segment locations will be determined during the layout of the vegetation sample unit.

Bankfull width and wetted width will be measured with a flexible tape. Stream gradient will be measured with a laser rangefinder and a prism reflector mounted on a stadia rod. The distance between the laser and the target for determining gradient will be approximately the distance of a stream segment. However, if heavy brush or channel bends obstruct the line of sight, a shorter distance or sequence of shots will be used. Canopy cover will be measured at stream center at every segment break using a spherical canopy densiometer using the quadrant method.

Stream temperature will be monitored over the entire study period. Two continuous temperature data loggers will be placed upstream from the beginning of the conversion area and two at the most downstream point of the conversion area. If a significant tributary enters between, two loggers will be placed in the tributary just prior to its confluence with the subject stream. Duplicate temperature loggers will be placed in slightly different areas to help ensure data integrity.

Information about channel characteristics and canopy cover will be entered into a handheld data recorder.

Analysis

Data for each site will be graphically displayed for to facilitate visually interpretation (water temperature vs. date and shade between pre-treatment post-treatment). Data analysis will likely be limited to single site pre-treatment vs. post-treatment comparison of water temperature. I anticipate that there will be considerable site-to-site variability. The key temperature units will be the maximum seven consecutive day mean of maximum temperature (MMM), and the maximum seven consecutive day mean range (MMR). The water temperature dataloggers located fifty meter above the upstream edge of the harvest unit will serve as a reference point from which to determine treatment effects. Four hypotheses will be tested:

1. $H_{o:}$ Pre-treatment and post-treatment stream temperature (MMM and MMR) in the treatment reach are equal.

2. $H_{o:}$ Stream temperature is independent of the upstream length of channel exposed by treatment.

3. $H_{o:}$ Differences between the pretreatment and post-treatment stream temperature at the downstream corner of the harvest unit remain unchanged at monitoring stations downstream from the harvest unit.

4. $H_{o:}$ Shade (total canopy cover and angular canopy density) at each location remains unchanged between pre-treatment and post-treatment data.

Stream temperature data from temperature data loggers will be summarized and presented as daily minimums and maximums in tabular and graphical format for pre- and post-treatment and for the duration of the study. The status and trends of the control and several treatment temperatures will be analyzed to help explain treatment impacts on stream temperature. Changes in canopy density observed from the stream will be used to help explain changes in stream temperature. In a regression analysis, treatment stream temperature would be used as a dependent variable and control stream temperature, stream canopy density, slope, aspect, etc. would be used as independent variables.

CASE REPORT OUTLINE

The following report template shows the information that will be included in a report for a hardwood conversion site. Additional material will be included as deemed appropriate for any given site.

General introduction
- Study and case report objectives
- Brief description of methods
- Key findings from case studies

Introduction to individual site or group of sites (if same ownership) report
- Summary
- Economic profile of landowner
- Factors that led landowner to include a hardwood conversion at this site, or at these sites
- Key findings from site(s)

Site attributes
- Location
  - county, legal, latitude and longitude
- Climate
  - precipitation, temperature
- Stream description
  - gradient, size, type, aspect
- Unit description
  - area, elevation
- RMZ description
  - area, stream length, site productivity, regulatory RMZ width, slope
- Soil description
  - series, geology

Pre-harvest vegetation
- Upslope stand table and description
  - species, BA, TPA
- RMZ stand table and description
  - species, BA, TPA, diameter distribution, tree heights
- RMZ shrub description
  - species, % cover, height
- Stream canopy closure percentage

Pre-harvest stream temperature
  - ??
  - ??

Schedule
- Harvest and regeneration prescription

- harvest dates, site prep work, planting, brush/animal control

Data collection

- pre-harvest vegetation, post harvest vegetation, economic, temperature

Harvest prescription

Site lay-out and road construction/maintenance description

- Site factors that influenced harvest and buffer lay-out
- *Estimated costs of site preparation, including administrative costs (per acre)*
    - *Assumptions*
- *Site preparation costs allocated to RMZ conversion (per acre)*
    - *Assumptions*

Yarding/logging description

- *Estimated yarding/logging costs (per acre)*
    - *Assumptions*
- *Yarding/logging costs allocated to RMZ conversion (per acre)*
    - *Assumptions*

Resulting buffer configuration description

- Map/diagram/stats on buffer

Upslope harvest description

- Grades, volume, board feet
- *Estimated upslope harvest revenue*
    - *Assumptions*

RMZ harvest description

- Grades, volume, board feet
- *Estimated RMZ harvest revenue*
    - *Assumptions*

Regeneration prescription

Upslope site preparation and planting schedule/description

- Upslope planting stock type, species, density
- *Estimated RMZ site preparation and planting costs (per acre)*
    - *Assumptions*

RMZ site preparation and planting schedule/description

- RMZ planting stock type, species, density
- *Estimated RMZ site preparation and planting costs (per acre)*
    - *Assumptions*

Upslope and RMZ brush and animal control strategies and descriptions

- *Estimated upslope brush and animal control costs (per acre, per year?)*
    - *Assumptions*

RMZ brush and animal control strategies and descriptions

- *Estimated RMZ brush and animal control costs (per acre, per year?)*
    - *Assumptions*

Unexpected operational challenges to successful regeneration in RMZ

Post-harvest vegetation

RMZ stand table with description

- Species, BA, TPA, diameter distribution, tree heights, growth, blow-down rate

RMZ shrub description

- Species, % cover, height, change in structure and composition

RMZ seedling description

- Survival, growth rates

Stream canopy closure percentage

Post-harvest stream temperature

- ??
- ??

Economic analysis

Income (Gross and net, per MBF, per ton, per acre?)

- *Upslope income*
    - *Assumptions*
- *Upslope + RMZ income*
    - *Assumptions*

Discussion

1. Summary of regeneration strategy, and evaluation of its success or failure
2. Lesson(s) learned from hardwood conversion
3. Relevant/interesting results not presented earlier in document

DATA COLLECTION SCHEDULE

Site	Harvested	Planted	Spring 2006	Summer/Fall 2006	Spring 2007	Spring 2008	Spring 2009	Spring 2010	Spring 2011
5	Summer 2006	Winter 2007		100% RMZ/stump/blowdown tally					RMZ blowdown tally
					Regen plots		Regen plots		Regen plots
				Buffer configuration					
					Recruitment		Recruitment		Recruitment
8	Summer 2006	Winter 2007		100% RMZ/stump/blowdown tally					RMZ blowdown tally
					Regen plots		Regen plots		Regen plots
				Buffer configuration					
					Recruitment		Recruitment		Recruitment
11	Fall 2005	Winter 2006		100% RMZ/stump/blowdown tally				RMZ blowdown tally	
			Regen plots			Regen plots		Regen plots	
				Buffer configuration					
				Recruitment		Recruitment		Recruitment	
12	Fall 2005	Winter 2006		100% RMZ/stump/blowdown tally				RMZ blowdown tally	
			Regen plots			Regen plots		Regen plots	
				Buffer configuration					
				Recruitment		Recruitment		Recruitment	
13	Summer 2004	Winter 2005		100% RMZ/stump/blowdown tally			RMZ blowdown tally		
			Regen plots		Regen plots		Regen plots		
					Recruitment		Recruitment		
14	Summer 2004	Winter 2005		100% RMZ/stump/blowdown tally			RMZ blowdown tally		
			Regen plots		Regen plots		Regen plots		
					Recruitment		Recruitment		
15	Summer 2004	Winter 2005		100% RMZ/stump/blowdown tally			RMZ blowdown tally		
			Regen plots		Regen plots		Regen plots		
					Recruitment		Recruitment		
23	Summer 2004	Winter 2005		100% RMZ/stump/blowdown tally			RMZ blowdown tally		
			Regen plots		Regen plots		Regen plots		
				Buffer configuration					
					Recruitment		Recruitment		

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APPENDICES

Appendix 1: Relationship of study to Forest and Fish Report

New forest practices rules (hereafter, rules) took effect July 1, 2001. The new rules follow closely to what was negotiated in the Forest and Fish Report (FFR) (USFWS 1999). The FFR proposed that "Provisions are made for the conversion of and/or treatment of riparian forests which may be under-stocked, overstocked or uncharacteristically hardwood dominated while maintaining minimum acceptable levels of function" (FFR Appendix B(I)(b)). To incorporate that intent into rules, a new section to the rules that pertains specifically to hardwood conversion was added (Washington Administrative Code (WAC) 222-30-021(1)(b)(i)). Hardwood conversion is more commonly implemented, however, through alternate plans (WAC 222-12-040 and WAC 222-12-0401)[1]. The qualifying criteria for using an alternate plan is that "In all cases, the alternate planning process will result in a plan that provides protection to public resources at least equal in overall effectiveness as provided by the act and rules while seeking to minimize constraints to the management of the affected lands."

The emphasis of this project on supporting experience-based implementation of hardwood conversion through alternate plans rather than the hardwood conversion rule itself was dictated by the Forest and Fish Policy Group on providing information to (see Forests and Fish Policy Group meeting notes from June 20, 2000, and supporting documentation sent to the Forests and Fish Policy Group by Pete Heide on June 13, 2000). Some elements of project design were also specified, for example the requirement for retaining all conifer trees in riparian areas (guidance which has been interpreted to mean the core and inner zones of RMZs).

The case study approach (operational trials) allows more innovation by landowners and provides information for a greater range of site classes and riparian conditions than would be possible in a controlled experiment[2]. Further, if similar treatments were implemented across all sites economic analyses would not test the response of landowner-selected treatments to meet the required goal of successfully obtaining free to grow conifer regeneration and the implicit landowner goal of minimizing the cost of doing so.

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[1]The DNR (WAC 222-30-021(1)(i)(A)(V)) was tasked with tracking "the rate of conversion of hardwoods in the riparian zone: (1) Through the application process on an annual basis; and (2) at a WAU scale on a biennial basis as per WAC 222-30-120…". Anecdotal information suggests that hardwood conversion under the current hardwood conversion rule is almost never done.

[2] In a controlled experiment treatments would be similar and replicated several times and study sites would be similar to the extent practicable. This design is used to enable robust statistical testing of specific hypotheses but is constraining in that it limits a study to specific site types and allows for comparison of (usually) only one or a few specific attributes.

Appendix 2: Rationale for the treatments selected

All conifers will be retained within RMZs for all treatments. Many understory conifers are likely to become part of the future stand; retaining and releasing existing conifers in riparian areas can be successful depending on tree vigor at the time of release and the gap size created. Tree vigor can be qualitatively assessed using the ratios of live-crown height to total height (H); and total height to diameter at breast height (DBH) (Emmingham and Maas 1994, Maas and Emmingham 1995, Chan et al. 1996, 1997). "Vigorous" trees usually have 30% or greater live crown ratios and relatively small (H/DBH) ratios (<60). Gaps for released trees should allow entry of at least 40% of full sunlight.

With planted conifers, in general, the greater the removal of overstory competition, the greater their survival and growth in riparian areas is likely to be. Where thinning or gaps are created, residual trees need to be spaced a minimum of 30 feet apart or additional removals will be required later to prevent overstory crown closure (Emmingham and Maas 1994, Minore and Weatherly 1994, Maas and Emmingham 1995, Chan et al. 1996, Hibbs and Giordano 1996, Chan et al. 1997).

Some treatments were excluded from consideration because they were unlikely to be economically viable though they may have been ecologically successful. For example, treatments that cut less of the overstory initially but would likely require follow-up treatments were not considered, although it is recognized that there may be ecological advantages to treatments that harvests trees in stages.

All prescriptions recommended for this hardwood conversion study involve partial to complete canopy removal with complete retention of existing conifers. All partial canopy removals will create large gaps in the canopy such that additional future thinning treatments are not likely to be required to ensure that trees are free to grow.

Large stock types (plug +2, 1+1 and 2+1) with good root mass of western hemlock, western red cedar, Douglas-fir and grand fir are recommended away from the coast; western hemlock and Sitka spruce are recommended near the coast (Newton et al. 1993, Emmingham et al. 2000). Douglas-fir should be avoided near the coast, in areas of Swiss needle cast or areas frequently flooded (Minore 1970, 1979, Zaerr 1983).

Appendix 3: DOR stumpage value description

DOR stumpage value description

The DOR calculates stumpage values for Douglas fir and western hemlock differently than it does for other species, what the agency designates as 'minor' species. When calculating the stumpage value for Douglas-fir and western hemlock, the agency gathers timber sales records between harvesters and landowners that include a large component of Douglas fir or western hemlock. When a sale agreement requires the timber purchaser/harvester to construct or upgrade/maintain permanent roads, the DOR adds road costs to the total sales price at a rate of $1,141.69 per station (100 ft) for new road construction and $310.74. per station for road betterment work. To assess the actual stumpage values, the DOR sorts the records by species (Douglas fir and western hemlock) and calculates the average price paid for each by region and grade categories on a per thousand board foot basis. The DOR uses 250 to 270 public (non-federal) and private timber sale records when calculating the stumpage values for a 6 month reporting period. Only timber sales records that meet species distribution and minimum volume size criteria are used in the calculations.

To derive stumpage values for minor species, including cedar and red alder, the DOR uses published delivered log price data (Loglines Log Price Reporting Service) and deducts an assumed logging cost of $150 per 1,000 bf, sorted by region, species and grade.

The DOR updates the stumpage value tables every 6 months, using data from a 12 month period. For example the 'Stumpage Value Tables' for the period July 1, 2005 through December 31, 2005 use sales data from April 1, 2004 to March 31, 2005.

When using the stumpage value tables to assess the timber excise tax on a sale, the tax payer adjusts the stumpage value up or down depending on the hauling distance zone number. The stumpage value can also be adjusted down if the sale is less than 30,000 bf, is a thinning harvest, whether the harvest is cable or helicopter logged, whether the sale occurred on a remote island (surrounded by water with no bridge access), or if the sale included damaged timber.

Appendix 4: Variation on case report outline

I. Site Identification

However the site is identified.

II. Site Description

The research site is a XXXX foot segment of XYZ Creek located in Section XX, Township XX North, Range XX East, W.M. The research segment is a Type F stream that averages XX feet in bank full width. A channel migration zone is not present in the research segment.

The stream gradient in the research segment ranges from X to X percent and averages X over the entire segment. The stream is characterized as being boulder dominated with a pool and riffle morphology. The amount of Large Woody Debris (LWD) ranges from XX to XX cubic feet per linear foot.

Soils in the area are derived from XXX and are typically from the XXX soil series (Soil Survey Citation, 19XX). Generalized productivity from the soil class is considered moderate. The research segment ranges in elevation from XXX to XXX feet and on average receives XX inches of precipitation per year. Most of the precipitation falls in November to March in the form of rain. Average snowfall is XX inches.

The research segment generally flows in a southwest to northeast direction. The stream channel is unconfined in a valley bottom that is generally X.X times the stream width. This would conclude with other physical site characteristics.

This could include pre-harvest stream temperature.

III. Pre-Harvest Riparian Stand Condition

The pre-harvest stand consisted of XX percent of red alder (Alnus rubra Bong.) by basal area. The remaining portion of the stand consisted of XX, XX, and XX (Table 1). Stand stocking and species distribution was fairly uniform throughout the riparian stand adjacent to the research segment.

TABLE 1. Pre-Harvest Stand Table (Data derived for cruise information)

Any other description of the pre-harvest stand would go here including the vegetation surveys, etc.

IV. Harvest Prescription

The riparian stand along the entire research segment was clear-cut to within 25 feet of the bank full stream edge of the stream. The harvest was completed using a rubber tired feller-buncher and forwarder (Equipment models would be nice).

V. Harvest Results and Costs

A total of XXX,XXX board feet was removed from the site (Table 2). Volume removed from the core zone totaled XX,XXX board feet, XX,XXX board feet from the inner zone and XX,XXX board feet from the outer zone. The harvest cost was $XX.XX per MBF and the projected revenue was $XXX.XX per MBF.

TABLE 2. Removal Information. (Landowner Supplied)

This section is greatly influenced by the information supplied by the landowner. I would suggest that in order to try and standardize this section as much as possible the contractor develop a questionnaire that is pre-screened with each of the participating landowners so everybody has an idea of the information that is going to be requested and reported.

This would be the place for the summary of the post-harvest overstory stand composition.

VI. Regeneration Prescription

The prescription is to convert the existing hardwood dominated stand to one that is on trajectory to meet Desired Future Conditions as identified by the Forest and Fish Report.

VII. Regeneration Activities and Costs

It is probably good to summarize activities by year. Much of this is based upon the information supplied from the landowner.

VIII. Growth and Survival

This is the information on overstory growth and survival as well as regeneration growth and survival. The difference from the last section is that this is contractor developed information. This can be summarized in graphs and/pr tables.

IX. Analysis and Summary

This is where any pre- and post-harvest analysis of data is reported. This is where the overall results of the activities can be discussed for this site.

Need exact chronology of study site establishment.