Final project report to the National Commission on Science for Sustainable Forestry (NCSSF)

NCSSF Research Project C.1
Templates for Forest Sustainability on Intensively Managed Private Forests

July 31, 2005

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The National Commission on Science for Sustainable Forestry (NCSSF) sponsored the research described in this report. The National Council on Science and the Environment (NCSE) conducts the NCSSF program with support from the Doris Duke Charitable Foundation, the David and Lucile Packard Foundation, the Surdna Foundation, and the National Forest Foundation.

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Acknowledgements

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Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the funding organizations or project cooperators.

Abstract

Intensively managed private forestlands are being increasingly called upon to play a larger role in meeting habitat and biodiversity goals. These forestlands have a great potential for contributing to such goals. They are also very sensitive to economic performance, though, and are often under considerable pressure from competing land uses. A key challenge of achieving sustainability on intensively managed private forests is the integration of goals to support increased biodiversity while at the same time maintaining and enhancing the long-term multiple socio-economic benefits derived from harvest activities.

Our approach has been to develop management templates that provide specific but flexible guidelines to help forest managers to successfully meet both economic and biodiversity goals. This approach first identifies desired future stand conditions relative to a given biodiversity goal. Inventory data are then identified that are representative of the desired conditions. A statistical assessment process is used in conjunction with a suitable growth model to evaluate the effectiveness of alternative management pathways in achieving the desired conditions. Combining this assessment with performance thresholds for long-term economic sustainability provides an integrated process that can be used to identify sustainable management strategies that meet both biodiversity and economic goals.

This approach was initially developed to identify sustainable riparian management strategies for young, dense Douglas-fir forests in the Pacific Northwest. Riparian areas are areas of high diversity and thus are of particular importance when managing for biodiversity. Riparian management is also a prominent regulatory issue in the region. The desired riparian forest conditions have been identified as those of mature, natural stands. Literature review findings suggest that repeated, heavy thinnings can accelerate the development of such conditions in dense, intensively managed stands. A draft template identified two riparian management strategies that were likely to achieve long-term desired conditions while protecting short-term functions and maintaining an acceptable economic return. This template has been further developed and tested and shown to perform well under a range of conditions.

This approach was then applied to intensively managed loblolly pine forests in the South. A literature review for this region suggested that open, park-like conditions with rich, herbaceous understories characteristic of historic, fire-maintained pine communities would likely provide high levels of plant and animal diversity while also providing income potential through sawtimber production and hunting leases. Using a reference dataset representative of the desired conditions, a template option was identified that utilizes frequent thinning and prescribed burning over longer rotations to achieve the desired conditions while maintaining an acceptable economic return. While additional data are needed to more fully develop templates for the South, this example template is an important demonstration of how the overall approach can be applied to multiple regions and ecotypes.

Deliverables for this project include this summary report and four technical reports covering literature reviews of both regions and detailed descriptions of the development of both templates. Several presentations will also be prepared to communicate applications of these templates with practitioners in both regions.

I. Introduction

Intensively managed private forestlands are being increasingly called upon to play a larger role in meeting habitat and biodiversity goals. There are a significant number of acres under intensive management in regions such as the South and the Pacific Northwest, and these forestlands have a great potential for contributing to biodiversity goals (Hartley 2002, Wigley et al. 2000). Intensively managed forests already make significant contributions to biodiversity by simply providing forest cover that would be lost with alternative land uses (Hayes et al. 2005). Stand-level management changes can be implemented that can greatly increase the biodiversity that these forests can potentially support (Hartley 2002, Moore and Allen 1999).

An important consideration, though, is that private forestlands, especially those that are used for intensive forest management, are also very sensitive to economic performance and are often under considerable pressure from competing land uses (Murphy et al. 2005). In rapidly urbanizing areas such as western Washington, for example, family-owned Douglas-fir (*Pseudotsuga menziesii*) plantations are being converted to development at a rapid rate (MacLean and Bolsinger 1997, WADNR 1998). Several industrial tree farms in this region have recently been sold as well, further suggesting that economics does and will play an important role in the long-term presence and sustainability of these forests.

With these tensions in mind, one of the key challenges of achieving sustainability on intensively managed private forests is the integration of the Montreal Process goals of conserving biological diversity while at the same time achieving the maintenance and enhancement of long-term, multiple socio-economic benefits derived from harvest activities. The accomplishment of these diverse goals can assisted on both industrial and family ownerships with the development of templates that provide specific but flexible management guidelines for practices that are likely to support both increased biodiversity and favorable economic returns.

An approach has been developed for creating such templates that are designed to enable forest managers to successfully meet both economic and biodiversity goals. This approach identifies desired future stand conditions relative to a given biodiversity goal and establishes inventory data that represent the desired condition. A statistical assessment process is then used in conjunction with growth model projections to evaluate alternative management pathways designed to achieve desired future stand conditions while maintaining a target level of economic return. This integrated assessment process can be used to identify sustainable management strategies that meet both biodiversity and economic goals.

This approach was initially developed in response to riparian management challenges in the Pacific Northwest. Riparian forest management plays a key role in the conservation of biodiversity as well as another Montreal Process goal, the conservation of water resources. This is a particularly critical issue in the Pacific Northwest, where several salmon and steelhead runs have been listed under the Endangered Species Act. However, management limitations designed to protect salmon also limit the use of active management to improve riparian conditions and can result in unsustainable economics, particularly for small landowners. Under these circumstances, there will likely be increased rates of forest conversions (Zobrist et al. in press, Zobrist 2003). Templates were needed that would effectively foster the development of desired structural conditions in young, dense forests while maintaining an economic motivation for landowners to continue managing for forestry. A draft riparian management template was developed that demonstrated how both biodiversity and economic goals could be achieved concurrently (Zobrist et al. 2004, 2005).

The template approach described above has potentially much broader applications for identifying management strategies that support increased biodiversity both in riparian and upland areas. Other regions could also benefit from this template management approach, such as the South where there is interest in the ability of intensively managed loblolly pine (*Pinus taeda*) plantations to function similar to the diverse, fire-maintained longleaf pine (*Pinus palustris*) ecosystems that historically dominated the area (Bragg 2002, Hedman et al. 2000, Noss 1988). Given the declining pulpwood stumpage prices for this region, there is a need for longer-rotation management strategies that produce higher value sawtimber as well as opportunities for supplemental income from hunting leases. Since open stand conditions with rich, herbaceous understories that are characteristic of historic longleaf pine forests favor both game and non-game species, a management template for establishing these conditions could be highly compatible with both economic and biodiversity goals.

II. Purpose

The purpose of this study was twofold:

1. To identify management practices for supporting increased biodiversity in intensively managed Douglas-fir forests in the Pacific Northwest and loblolly pine forests in the South.
2. Demonstrate how these practices could be synthesized into working templates that minimize economic costs and provide specific but flexible implementation guidance for practitioners.

A literature review has been completed for each region. These literature reviews identify the basic principles of managing for increased biodiversity and establish a spectrum of practical management steps that can be applied in both riparian and upland areas. The draft riparian management template for the Pacific Northwest has been refined and more fully developed. A new template has been created for loblolly pine stands, which demonstrates how the template approach can be applied to southern conditions. This report summarizes the findings of both literature reviews, describes the template approach as applied to the Pacific Northwest and the South, and discusses the applications and results for each template.

III. Summary of results

1. Key findings of the Pacific Northwest literature review

A number of changes in stand-level management practices can support significantly increased biodiversity in intensively managed Douglas-fir plantations in the Pacific Northwest. The key to providing for a diversity of species and processes is to develop more diverse and complex stand structures (Helgerson and Bottorff 2003, Muir et al. 2002, Spies 1998). Using heavy, repeated thinnings minimizes the dense stem exclusion stage, stimulates the understory, and accelerates the development of complex, old forest structure. Favoring multiple species and sizes when thinning can enhance structural diversity. Variable density thinning, which creates a mosaic of different densities along with unthinned patches and small openings, also works well for enhancing structural diversity.

When harvesting, biological legacies such as large, live trees, snags, and downed wood should be retained to mitigate harvest impacts and provide structure for the new stand. Retention can be left dispersed throughout the stand, in aggregate clumps, or a combination (Franklin et al. 1997). Riparian areas should be protected, as these are areas of particularly high diversity. Underplanting, selective fertilization, and pruning can also be used to add structural complexity. All of these strategies work best over longer rotation that allow enough time for complex structure to develop and minimize cumulative harvest impacts on the landscape.

These different practices for increasing structural complexity and biodiversity can be combined into overall management strategies called biodiversity pathways (Carey and Curtis 1996, Carey et al. 1996, Carey et al. 1999). Examinations of biodiversity pathways for coastal hemlock forests have been promising, and similar pathways can be developed for Douglas-fir plantations. There are economic costs to these pathways that must be considered in order to ensure successful adoption by private landowners and minimize unintended consequences such as forest conversion. Competitive incentive programs using both education and financial assistance can offset private costs. Identifying management strategies that target both biodiversity and competitive economic returns will likely be the most successful regardless of who bears the costs.

A complete review and reference list is available as a technical report (see Deliverables).

2. Refined Pacific Northwest riparian management template

This project was based on a draft template that comprised two variations of a riparian management plan designed for overstocked Douglas-fir stands on site class II. Both options performed well in accelerating the development of stand structures similar to the reference conditions of mature, natural riparian stands while also maintaining a target rate of return of 5% in the long term (coarse filter analysis). Both options were also projected to provide high levels of potential large woody debris (LWD) recruitment over time, which was a specific function of interest (fine filter analysis).

The next step was to further refine and validate this draft template. Using Drew and Flewelling's (1979) density management diagram for Douglas-fir, crown closure, imminent competition mortality, and the maximum size-density relationship (3/2 thinning law) were estimated in relation to the draft template density targets over time. These relationships suggested that the template allowed density to remain too high at some points in time. There was also concern that the last thinning was too heavy and left the remaining overstory too sparse. The draft template was refined in response to these concerns by tightening the allowable density range and by increasing the target density of the last thinning from 25 trees per acre (TPA) to 35 TPA.

The final template options were as follows:

- *Option A*
  - 25-foot bank stability zone with the following prescription:
    - Thin to 180 TPA at age 20
    - Thin to 60 TPA at age 50
    - No further entries to retain shade and bank stability
  - 55-foot additional buffer (80-feet total) with the following prescription:
    - Thin to 180 TPA at age 20
    - Thin to 60 TPA at age 50
    - Thin to 35 TPA at age 70
    - Clear-cut and replant at age 100
- *Option B*
  - 25-foot bank stability zone with the following prescription:
    - Thin to 180 TPA at age 20
    - Thin to 60 TPA at age 50
    - No further entries
  - 25-foot additional buffer (50-feet total) with the following prescription:
    - Thin to 180 TPA at age 20
    - Thin to 60 TPA at age 50
    - Thin to 35 TPA at age 70
    - No further entries

A range of ± 10% around the target density was allowed for operational flexibility, and a range of ± 5 years was allowed for timing flexibility. A range of candidate stands that would likely benefit from the template was then established using the imminent competition mortality relationship. This was done in recognition that stands which have been growing at a high density for a long time such that there is already significant competition-related mortality may no longer have the growth capacity or stability to respond well to the template prescription and thus additional factors need to be considered before pursuing the template. *Figure 1* is the resulting management diagram and illustrates the target density range for both options over time. The shaded area represents stand conditions that would be good candidates for the template.

The key outcomes of the template are summarized in *Table 1*, with the default regulatory option in western Washington included as a reference point. Over a 140-year simulation, the template options achieved the desired conditions more than twice as long as the default regulatory option. This reflects the effectiveness of the repeated, heavy thinnings for accelerating the development of old forest conditions. At the same time, the thinnings generated significant revenue, resulting in a positive return to land (soil expectation value or SEV) of over $200, up from a net loss of $215 under the regulatory option. To validate the results of this template under a range of conditions, additional simulations were done that managed along the boundaries of the target region instead of the midpoint. Additional test stands, representing a range of starting conditions, were also simulated. In all cases the template consistently performed well relative to both criteria.

The results of this template demonstrate how both biodiversity and economic goals can be achieved together. The template format also offers straightforward implementation for practitioners. The conditions of a young overstocked stands (limited to site class II for this example) can be located by age and density on the management diagram in *Figure 1*. If they fall within the candidate stand region, they can be thinned to within the target density region. Subsequent thinnings can then be done over time to maintain a trajectory within the target density region. Timing and operational flexibility are built into the template, as well as additional flexibility by offering two options. While this template has not yet received regulatory approval, which is necessary before actual implementation, it provides a valuable example for landowners and regulators to work with.

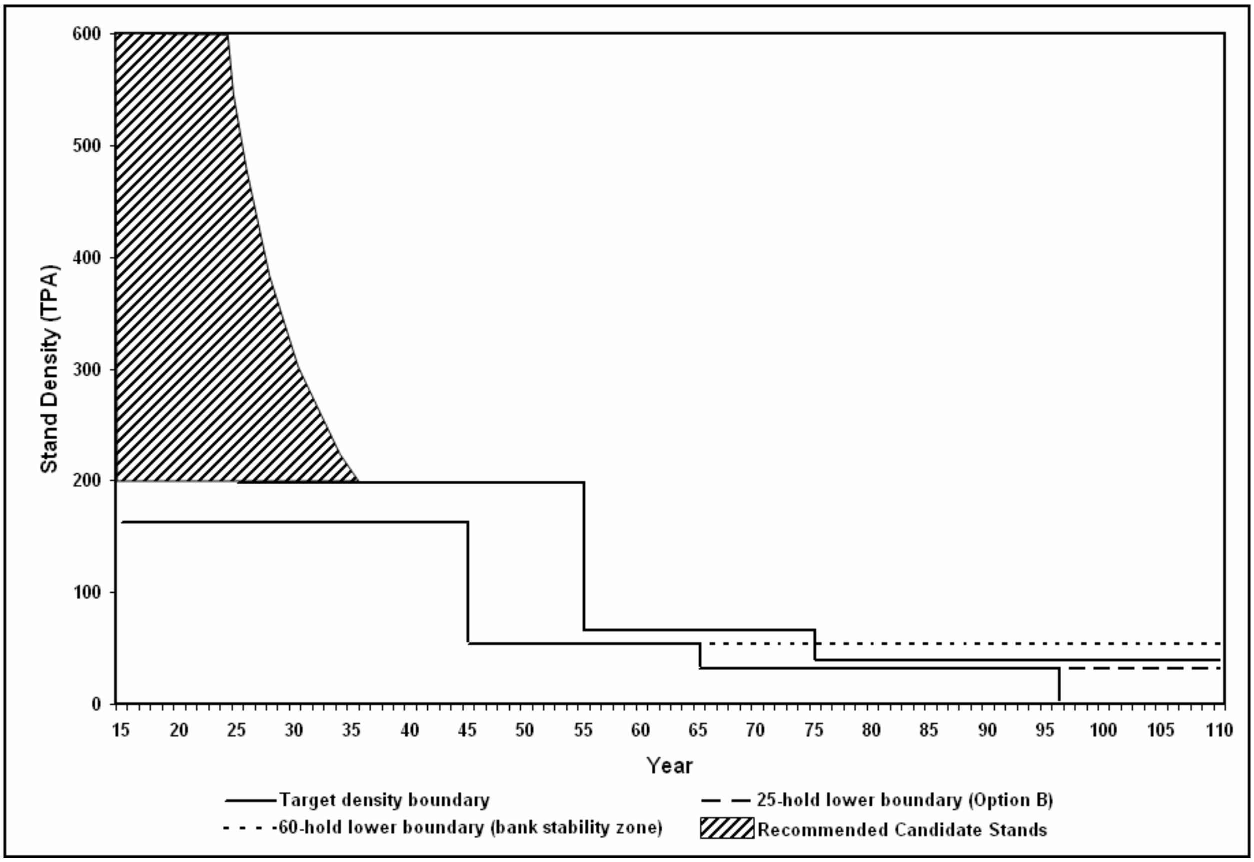

Figure 1: Management diagram for the riparian template. Stands that fall in the shaded candidate stand region can be thinned such that their trajectory follows the target density region. The dashed lines indicate density floors for the bank stability zone and the remaining buffer under Option B.

Table 1: Template results for the key criteria: percent time in the desired structure target over a 140-year simulation (biodiversity performance metric) and return to land or SEV per riparian acre (economic performance metric). Both template options resulted in significant improvement for both criteria relative to the default Washington regulatory option.

Template Option	% of time over 140 years that desired conditions are achieved	Return to land (SEV) per riparian acre
Option A	70.2%	$208
Option B	64.9%	$207
WA regulations	32.1%	-$215

3. Key findings of the southern literature review

As with Douglas-fir forests in the Pacific Northwest, the overall key to providing for biodiversity in southern loblolly pine plantations is to provide structural diversity (Allen et al. 1996, Marion et al. 1986, Sharitz et al. 1992). An open stand structure with a diverse, productive grass-herb understory is more similar to the natural, fire-maintained pine communities that were historically present and can support a broad suite of plants and wildlife (Bragg 2002, Hedman et al. 2000, Noss 1988).

Maintaining an open canopy with a diverse understory can be achieved with heavy thinnings early and often in the rotation. This may allow a dense hardwood midstory to develop, though, which would shade out the understory and negate the benefits of thinning. Consequently, hardwood control will be necessary either by prescribed burning or with mid-rotation herbicide applications. Hardwoods should not be eliminated entirely. A mast producing component should be maintained to provide wildlife food and structural diversity.

Light to moderate site preparation is best for biodiversity, and mechanical methods may perform better in this respect than herbicides. Fertilization can benefit wildlife by increasing understory growth, but it should be done in conjunction with thinning to maximize benefits. Key structural features such as snags, coarse woody debris, and mature trees should be maintained, along with riparian buffers to protect aquatic areas and provide for habitat connectivity. Long rotations are necessary to provide a broader range of age classes, though the economic impacts may be a consideration.

Biodiversity is ultimately achieved at the landscape level, but stand-level changes can go a long way towards making improvements and can be implemented regardless of ownership pattern. Land use history is an important consideration, as old field sites are unlikely to support a diverse stand structure regardless of management practices. Economics should also be considered, as management practices to increase biodiversity need to be economically viable if they are to be successful on private lands. Opportunities for hunting lease revenue may offset some of the costs of managing for biodiversity.

A complete review and reference list is available as a technical report (see Deliverables).

4. Southern template results

In the South, open, park-like stands with rich, herbaceous understories characteristic of the longleaf pine/wiregrass communities that historically dominated the region are recognized to provide for high levels of biodiversity (Bragg 2002, Hedman et al. 2000, Noss 1988). Using the same overall approach as the Pacific Northwest riparian template, we developed an example southern template was designed to achieve these conditions while maintaining acceptable economic returns through the production of high-quality sawtimber and increased potential for supplemental income through hunting leases. A dataset of “benchmark” stands representative of the desired conditions (collected by Hedman et al. 2000) was used as a target against which to assess potential template options. The percentage of time over a 100-year rotation that the desired conditions target was achieved served as the biodiversity performance metric. The net return to land or soil expectation value (SEV) was used as the economic performance metric.

Nine potential options were examined, with rotation lengths ranging from 25 to 55 years and different frequencies and intensities of thinning (*Table 2*). The results of each alternative are summarized in *Table 3*. Three of the 55-year rotations (alternatives 6-8) resulted in the highest percentage of time in the desired stand structure target over a 100-year simulation (48%). These alternatives did not achieve the highest SEV, which implies an opportunity cost relative to the alternative that performed the best economically (alternative 5). However, the economic performance of these three alternatives was still competitive, especially if it is assumed that hunting lease premiums are associated with higher time in target scores. Of these three alternatives that had high time in target scores, alternative 7 had the lowest SEV cost per percent time in target, producing the desired structure very efficiently. For supporting significantly increased biodiversity while maintaining a competitive economic performance, this emerged as the overall most desirable template option.

Table 2: Timelines for the nine potential southern template alternatives that were examined. Each alternative included a commercial thin at age 15 that removed 30% by volume. Subsequent commercial thins were either to 60 or 80 ft^2 of basal area (BA). Rotation lengths ranged from 25 to 55 years.

Alt	**Year**								
	15	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**
1	Thin 30%		Clear-cut						
2	Thin 30%		Thin 60 BA		Clear-cut				
3	Thin 30%		Thin 80 BA		Clear-cut				
4	Thin 30%		Thin 60 BA			Clear-cut			
5	Thin 30%		Thin 80 BA			Clear-cut			
6	Thin 30%		Thin 60 BA		Thin 60 BA		Thin 60 BA		Clear-cut
7	Thin 30%		Thin 80 BA		Thin 80 BA		Thin 80 BA		Clear-cut
8	Thin 30%		Thin 60 BA			Thin 60 BA			Clear-cut
9	Thin 30%		Thin 80 BA			Thin 80 BA			Clear-cut

The full prescription for alternative 7 is as follows:

- First commercial thin at age 15, removing 30% of the volume
- Prescribed burning starting at age 20 and repeated every 5 years
- Next commercial thin at age 25 to 80 ft^2 of basal area (BA), repeated every 10 years
- Maintenance of a mast-producing hardwood component throughout the rotation
- Clear-cut harvest at age 55

Table 3: Results of the nine template alternatives, including the percent time in the desired structure target over a 100-year simulation (biodiversity performance metric) and SEV/acre (economic performance metric) with and without hunting lease premiums. Alternative 7 emerged as the preferred alternative, achieving the highest time in target score at a relatively low cost.

Alternative	% Time in Target	Without hunting lease premium			With hunting lease premium		
		SEV/Acre	**SEV Cost**	**Cost/% in target**	**SEV/Acre**	**SEV Cost**	**Cost/% in target**
1	0%	($20)	$639	N/A	($2)	$639	N/A
2	14%	$423	$196	$14	$442	$195	$13.93
3	14%	$480	$139	$9.93	$499	$138	$9.86
4	24%	$466	$153	$6.38	$503	$134	$5.58
5	14%	$619	$0	$0	$637	$0	$0
6	48%	$305	$314	$6.54	$360	$277	$5.77
7	48%	$413	$206	$4.29	$469	$168	$3.50
8	48%	$382	$237	$4.94	$438	$199	$4.15
9	38%	$415	$204	$5.37	$452	$185	$4.87

The results of this template demonstrate how the same approach used in the Pacific Northwest can be used to achieve biodiversity and economic goals in southern loblolly pine plantations. One difference in the southern template process was that the coarse filter analysis using time in target and SEV provided good discrimination between alternatives such that a fine filter metric (e.g. LWD in the Pacific Northwest) was not necessary to identify a preferred alternative. One of the challenges in developing the southern template was that data were not as readily available. The Hedman dataset was adequate to develop an example template, but it was fairly small and should be augmented with additional data points for a more robust template development process. Given the "proof of concept" established by this example template, once additional data is available it should be straightforward to create additional southern templates for a range of conditions and with a range of outcomes.

IV. Approach

The overall approach for developing templates is illustrated in *Figure 2*. The foundation of the approach was a review of scientific literature to identify desired structure conditions that were likely to support high levels of biodiversity. The desired conditions for riparian Douglas-fir stands in the Pacific Northwest were identified as those of mature, natural stands that are characterized by large conifers and high structural diversity. For southern loblolly pine stands, the desired conditions were identified as open, park-like conditions with rich, herbaceous understory vegetation characteristic of the fire-maintained longleaf pine forests that historically dominated the region.

The next step was to quantify the desired conditions using a reference dataset of actual stands that are representative of the desired conditions. The simultaneous distributions of key structure variables from the reference dataset can be used to establish a management target. A statistical assessment procedure can then be used to determine whether or not the structure attributes of an observed stand fall within that target. Observed stand conditions that fall within the target are statistically similar to the reference dataset (Gehringer in press).

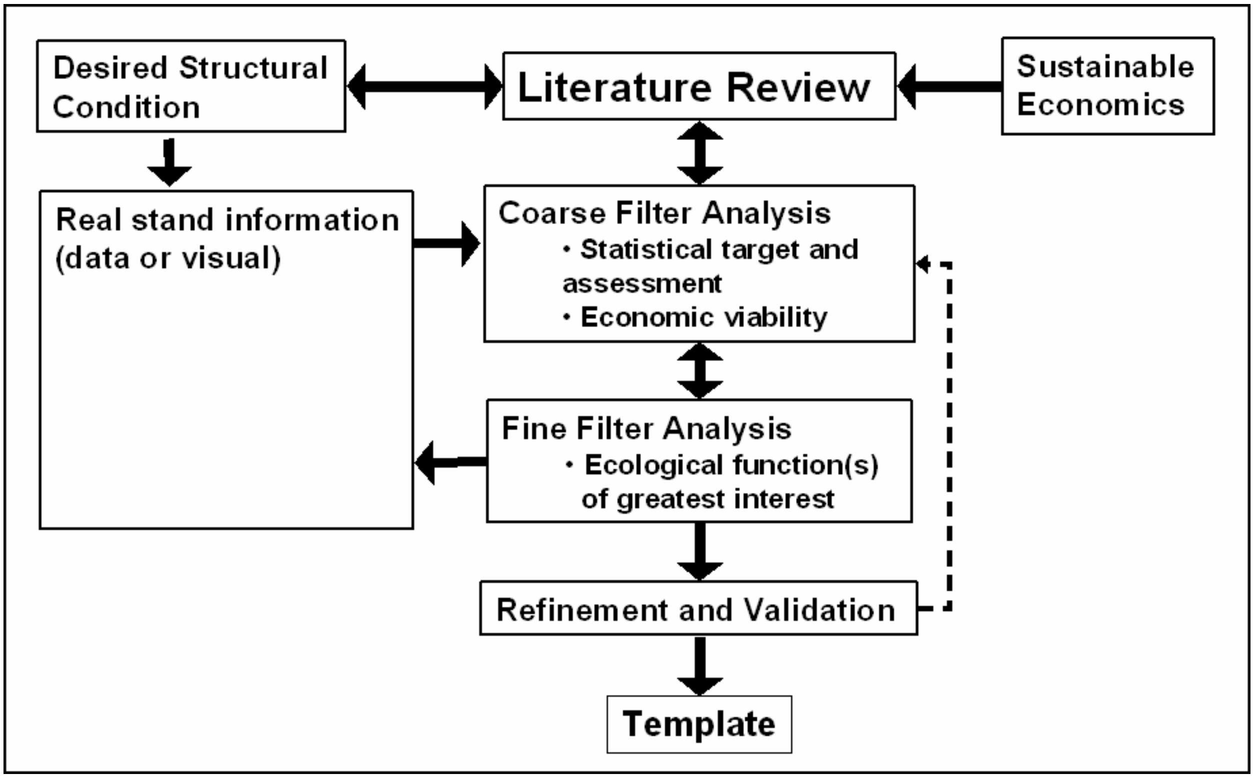

Figure 2: An illustration of the overall approach for this project. A literature review is the foundation for identifying desired stand conditions and generating potential management alternatives. These alternatives are then put through several levels of analysis to identify preferred template alternatives.

For the Pacific Northwest template, a reference dataset was established using subplots from the Pacific Resource Inventory, Monitoring, and Evaluation (PRIME) database, which is part of the USDA Forest Service's Forest Inventory and Analysis (FIA) program. Subplots were selected that were representative of mature, unmanaged, riparian stands based on their age, distance from a stream, and management history. Three attributes were used to describe the structure of this dataset: stand density in trees per acre (TPA), quadratic mean diameter (QMD), and average height computed using only trees greater than 12 inches in DBH. The distribution of values for these attributes, when considered simultaneously, established a three-dimensional target region. This target region was then refined by identifying a 90% acceptance region around the mode (the most likely value of the data distribution) to reduce the influence of the most extreme or outlying data points(*Figure 3*).

A dataset collected by Hedman et al. (2000) of "benchmark" plots that were characteristic of historic, open longleaf pine stands was used to represent the desired conditions for the southern template. Four key structural attributes were identified from this dataset: the density and quadratic mean diameter (QMD) of larger trees, and the density and QMD of smaller trees. The distributions of values for these four attributes were used to create a four-dimensional target region. The four-dimensional target can be represented visually by splitting the large tree and small tree density and QMD components into sub-targets that can be plotted in two dimensions

(*Figure 4*). Because of the small size of this dataset, a 95% acceptance level was used to refine this target.

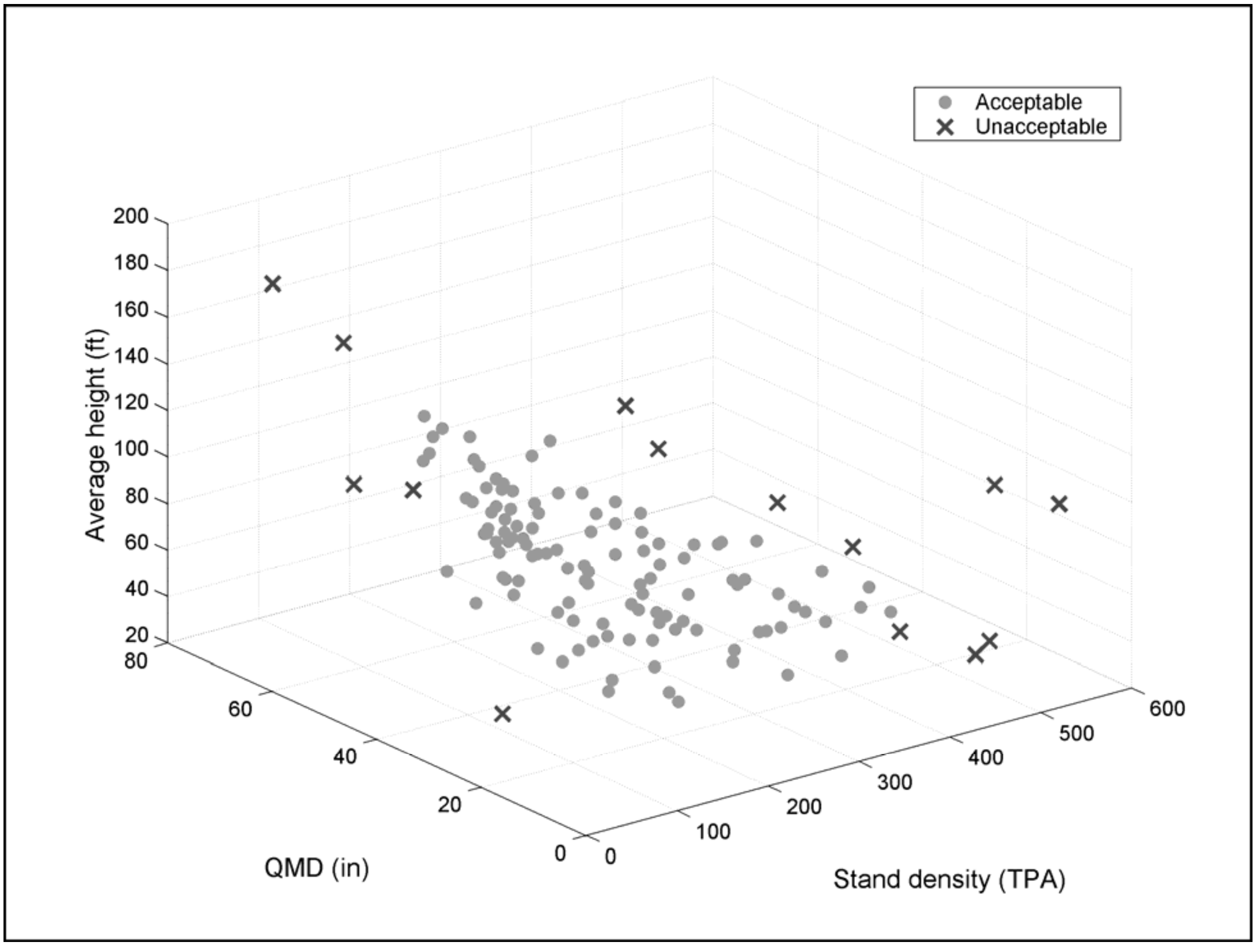

Figure 3: The three-dimensional management target for the Pacific Northwest template. The grey dots represent the 90% acceptance region. A stand whose observed attributes fall within this cluster is statistically similar to the reference dataset of desired conditions.

The literature was then used to identify management strategies that were likely to achieve the desired conditions, with an emphasis on practices that were also compatible with timber production and economic goals. A series of potential template options was then developed for simulation using the Landscape Management System (LMS). LMS is a program that integrates growth, treatment, and visualization models under a single, user-friendly interface (McCarter et al. 1998). LMS includes a number of regional variants of publicly available single-tree growth models. The Stand Management Cooperative (SMC) variant of the ORGANON growth model (Hann et al. 1997) was used to simulate the Pacific Northwest template options. The southern simulations were done using the Southern Variant of the USDA Forest Service's Forest Vegetation Simulator (FVS) (Donnelly et al. 2001, Stage 1973, Wykoff et al. 1982).

Alternatives were simulated using actual inventory data that were representative of the starting conditions to which the template was intended to be applied. A 20-year-old Douglas-fir plantation in southwest Washington that was representative of a dense plantation approaching its first commercial thinning was used as the test stand for the Pacific Northwest template. A 10-year-old loblolly pine plantation from southwest Georgia (part of the dataset collected by Hedman et al., 2000) was used as the test stand for the southern template.

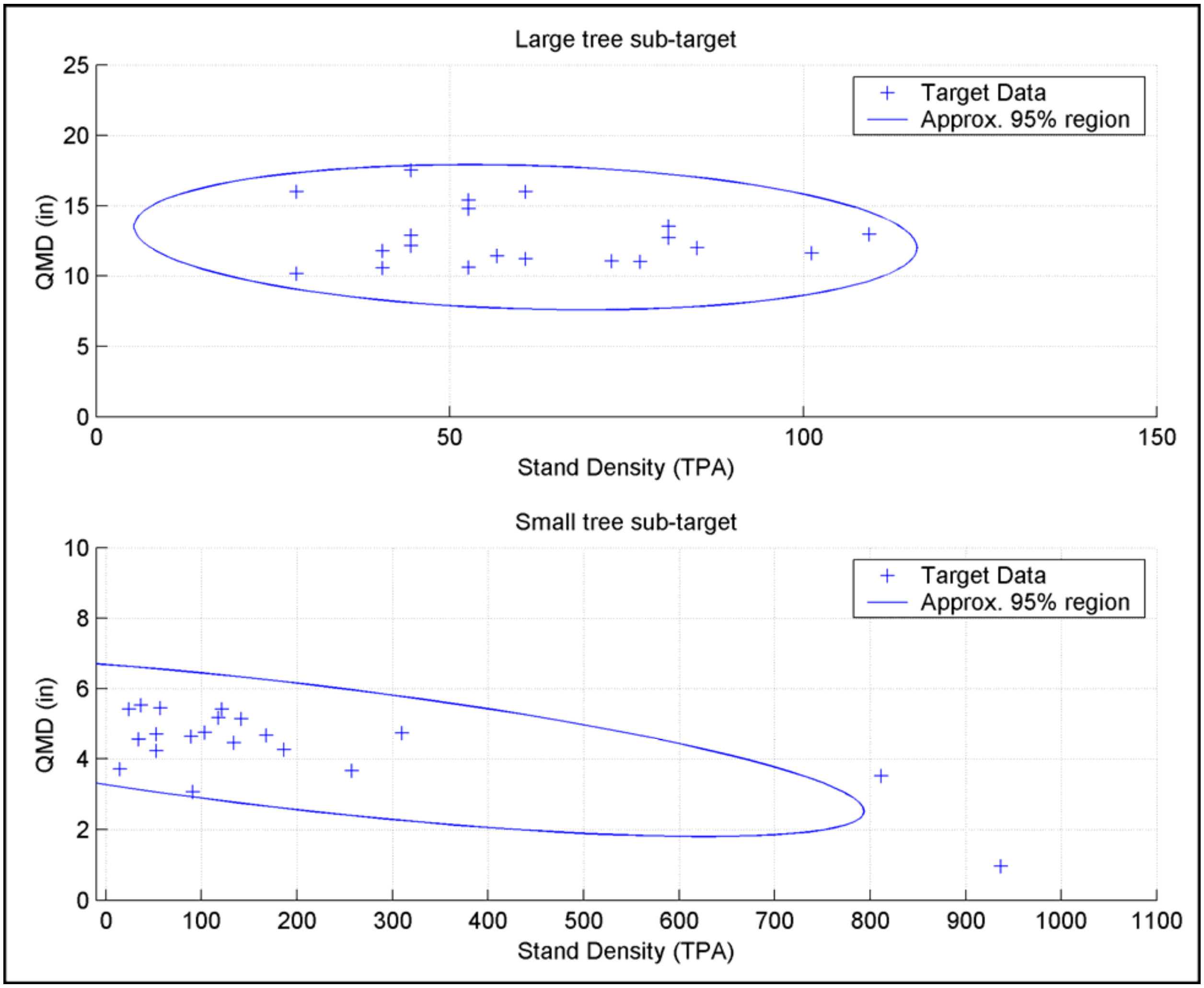

Figure 4: The 4-dimensional management target for the southern template is split into larger tree and smaller tree stand density and QMD sub-targets that can each be plotted visually in two dimensions. A stand whose observed attributes simultaneously fall between both of these ellipses is statistically similar to the reference dataset of desired conditions.

A “coarse filter” analysis of each alternative was done by evaluating projected outcomes relative to specific performance criteria for both biodiversity and economics. The percent of time that the target conditions were achieved over the simulation period (140 years for the Pacific Northwest; 100 years for the South) was used as the biodiversity performance criterion. Soil expectation value (SEV) was used as the economic performance criterion. SEV represents the net return to bare land for a complete management rotation repeated in perpetuity (Klemperer 1995). SEV was used as the criterion in recognition that the long-term (multiple rotation) application of a template requires achieving an acceptable rate of return when starting from bare land. A 5% target real rate of return was used, which is typical for financial analysis calculations.

The coarse filter analysis was used to identify viable template options that met minimum criteria for sustainability. In the case of the southern template, the coarse filter analysis offered enough discrimination between alternatives such that a preferred alternative emerged. For the Pacific Northwest template, there were several viable options and so a "fine filter" analysis was done by evaluating template performance relative to an ecological function of particular interest. In this case, potentially available LWD volume was chosen as a fine filter criterion. LWD provides important in-stream functions, and long-term sources of LWD are typically lacking in areas of intensive management (Bilby and Bisson 1998). Conditions that provide for a long-term source of LWD recruitment are also likely to provide for other important functions such as shade, bank stability, and organic inputs, as well as streamside habitat. The potential LWD volume was simulated for the 12 viable template alternatives using a potentially available LWD model (Gehringer 2005). Based on the fine filter analysis, two preferred alternatives emerged.

Once preferred template alternatives are identified, they can be further refined and validated as needed. Management pathways can be adjusted and tested to see if performance can be further improved. Template options can be simulated using additional test stands to evaluate a range of starting conditions. Finished templates become the basis for a set of specific but flexible management steps and implementation guidelines for practitioners.

V. Deliverables

The deliverables for this project include four technical reports:

1. *A literature review of management practices to support increased biodiversity in intensively managed Douglas-fir plantations*

2. *A template for managing riparian areas in dense, Douglas-fir plantations for increased biodiversity and economics*

3. *A literature review of management practices to support increased biodiversity in intensively managed loblolly pine plantations*

4. *Management templates for increased biodiversity and economics in intensively managed loblolly pine plantations*

The technical reports are intended for use by practitioners and provide detailed information about the four main parts of this project. The literature reviews identify a wide spectrum of different management practices that can be used to support increased biodiversity in intensively managed forest plantations. These literature reviews are the foundation of the templates, and they include extensive reference lists. The template reports include detailed descriptions of the methods and results of each template, including diagrams and implementation guidelines.

Several presentations will be delivered to help communicate the results of this project. A presentation covering the southern template process and applications will be given at the NCSSF Sustainable Forestry Tools and Applications Workshop in Washington, DC in September 2005.

A presentation giving an overview of the entire project, including both templates, will be given at the Society of American Foresters (SAF) National Convention in Dallas, TX in October 2005. Additional presentations will be given to regional forester and landowner groups as opportunities arise, and streaming video of key presentations will be made available online to a worldwide audience through the Rural Technology Initiative (www.ruraltech.org).

A paper corresponding to the SAF convention presentation will be submitted for publication in the convention proceedings. An article specifically covering the southern template will be submitted to a refereed, scientific journal. A refereed journal article on the Pacific Northwest template has already been published (See Zobrist et al. 2004). While this article predates the sponsorship from NCSSF, it was the basis for this project and is thus an important associated deliverable.

VI. References

This list of references includes literature cited in this report as well as selected key references from the four technical reports.

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