Developing Management Templates for Increased Biodiversity and Economic Viability in Intensively Managed Forests

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Acknowledgements:

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.

The authors are grateful for the additional support provided for this research by Kevin Ceder, C. Larry Mason, and James B. McCarter at the Rural Technology Initiative, College of Forest Resources, University of Washington.

Abstract:

Private forest landowners are increasingly called upon to manage for greater biodiversity. At the same time, these landowners are also facing increasing economic pressures. Sustainable, long term management solutions require the integration of biodiversity and economic objectives. We propose management templates to serve as management models for achieving these objectives. We have developed a framework for creating such templates that integrates biodiversity values with economic viability; utilizes available data and innovative technology; and provides a process that is transparent, adaptive, and flexible. This framework is broadly applicable and has been used to demonstrate example templates for achieving biodiversity and economic objectives in intensively managed forests in the Pacific Northwest and the South.

Key Words: Biodiversity, economics, intensive management

Introduction

Private forest landowners are facing increased demand for non-timber values such as habitat and biodiversity. These changing expectations can lead to conflicts over management practices. Regulatory approaches for dealing with these issues often have unintended consequences. Regulatory prescriptions may be inadequate or too broad to achieve the desired results for the applicable range of sites. Regulatory prescriptions may also have high costs such that the economic viability of forest management is diminished. Diminished economic viability can promote land conversion to non-forest uses (Murphy et al. 2005), which ultimately results in a loss of forest habitat and biodiversity values.

To better incorporate greater biodiversity values in intensively managed forests, new management approaches are needed. These approaches should be outcome-oriented and based on the best available science and technology to better achieve biodiversity goals. They must also be economically viable in order to be sustainable in the long term for private ownerships. Finally, they should be based on a decision process that is transparent to stakeholders and adaptable to new science and information.

We propose developing management "templates," which would outline specific strategies to serve as management models for supporting increased biodiversity while maintaining economic viability. These templates would bring together key management principles of biodiversity and economics as a series of practical management steps, providing clear implementation guidelines and demonstrating expected outcomes. Templates would be designed and rigorously tested to achieve the desired biodiversity and economic objectives within given site parameters. Different templates would be developed for different site parameters, and they would be further adaptable and customizable for site-specific needs.

We have developed a framework for creating such templates. Forest structure conditions are identified that are associated with biodiversity goals for a given forest type. A quantitative assessment of this structure is then developed using a reference dataset, creating a statistical target that can be used as an objective measure of how well biodiversity goals are met. Potential management alternatives can be modeled over time and assessed relative to the percentage of time they meet the target condition as well as economic performance metrics. Alternatives that successfully achieve both objectives can then be used as templates. This framework has been successfully used to create example templates for intensively managed forests in both the Pacific Northwest and the South. It is a promising approach for achieving biodiversity and economic objectives while also minimizing management complexity and the potential for unintended consequences.

Pacific Northwest Template Example

The template framework was initially conceived to develop better management alternatives for riparian stands in western Washington (Zobrist et al. 2004, 2005a). Riparian stands are areas of high biodiversity, providing habitat for a variety of aquatic and terrestrial species as well as important ecosystem processes (Naiman et al. 1993, 1998). New regulations, known as the Forests and Fish Regulations (FFR), have been enacted in Washington State to increase protection for riparian areas. The FFR prescribe no-harvest buffers adjacent to streams, followed by additional partial-harvest buffers. The goal of the buffer prescriptions for western Washington is to develop a riparian stand structure similar to mature, unmanaged riparian forests (Forests and Fish Report 1999). The idea behind this approach is to manage for a "desired future condition" (DFC) that can provide for a suite of associated functions (shade, large woody debris recruitment, bank stability, etc.) rather than trying to manage for those functions individually.

The FFR have posed several challenges. The economic impacts of the regulations are significant, with small forest landowners experiencing greater impacts than larger landowners (Perez-Garcia et al. 2001). Small forest landowners tend to be located in lowland areas in proximity to streams (Rogers 2001). Also, small landowners cannot average buffer impacts over large areas, but rather the impacts are concentrated on ownerships that have significant stream frontage. Case studies have demonstrated that large portions of some small ownerships are impacted by buffers (*Figure 1*), resulting in significantly diminished economic viability (Zobrist 2003, Zobrist and Lippke 2003). These ownerships, which are very important for conservation because of the stream presence, have perhaps the most motivation under the regulations to pursue an alternative land use.

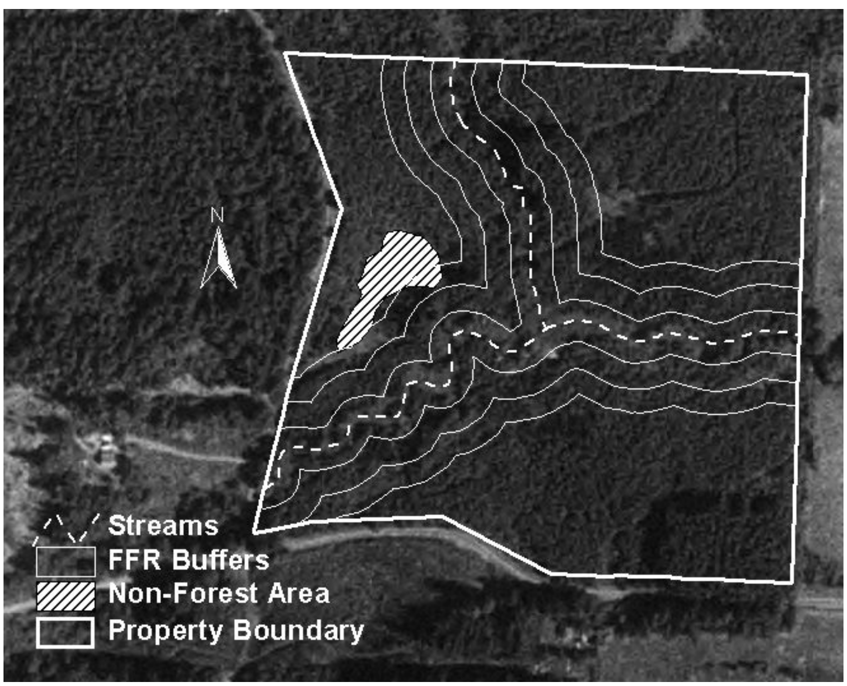

Figure 1: Case studies have demonstrated how small ownerships can be significantly impacted by riparian buffer requirements.

Another challenge is that the desired stand structure may be inhibited by the FFR buffer prescriptions for some forest types. In particular, private ownerships are often characterized by intensively managed Douglas-fir plantations that are established at high densities (*Figure 2*). Under normal management conditions, the densities in these plantations would be reduced by pre-commercial and commercial thinnings. However, thinning in riparian zones is often not permitted or not economical under the regulations. The absence of thinning in these stands will leave them overstocked, which will likely delay or preclude the development of the DFC (Carey et al. 1996, Carey et al. 1999, Chan et al. 2004).

Figure 2: Young, overstocked Douglas-fir stands are common in intensively managed forests in western Washington. The absence of thinning will likely hinder the development of the desired structure in these stands. Photograph taken by Kevin Zobrist.

Landowners may deviate from the prescribed buffers under approved "alternate plans." Alternate plans are intended to provide landowners with flexibility to pursue effective but less costly riparian protection measures.[1] The requirement for alternate plans is that they provide riparian protection "at least equal in overall effectiveness" as the default regulatory prescriptions.[2] The regulations further call for the development of templates to facilitate alternate plan preparation and approval for common situations such as young, overstocked stands.[3]

An overstocked riparian template was needed that would better achieve the DFC of mature forest structure. A targeting and assessment procedure was developed to provide an objective measure of the desired structure (Gehringer in press). With this procedure, the desired structure is quantified using a reference dataset of actual stands that are representative of the desired structure. In this case we used Forest Inventory and Analysis (FIA) data that had been selected based on age, management history, and proximity to a stream. Stand density, quadratic mean diameter, and average height were identified as key attributes that described the structure represented in the dataset and provided good discrimination between the desired structure and other forest structures. The distributions of these attributes, when considered at the same time, provide a quantitative management target. This is represented visually in *Figure 3*, in which the green dots form a three-dimensional target region (the red x's represent outlying data points that have been

[1] See Revised Code of Washington (RCW) 76.13.110.
[2] See Washington Administrative Code (WAC) 222-12-0401
[3] WAC 222-12-0403

filtered to refine the target). A stand whose attributes fall within this target region is statistically similar to the desired structure as quantified by the reference dataset.

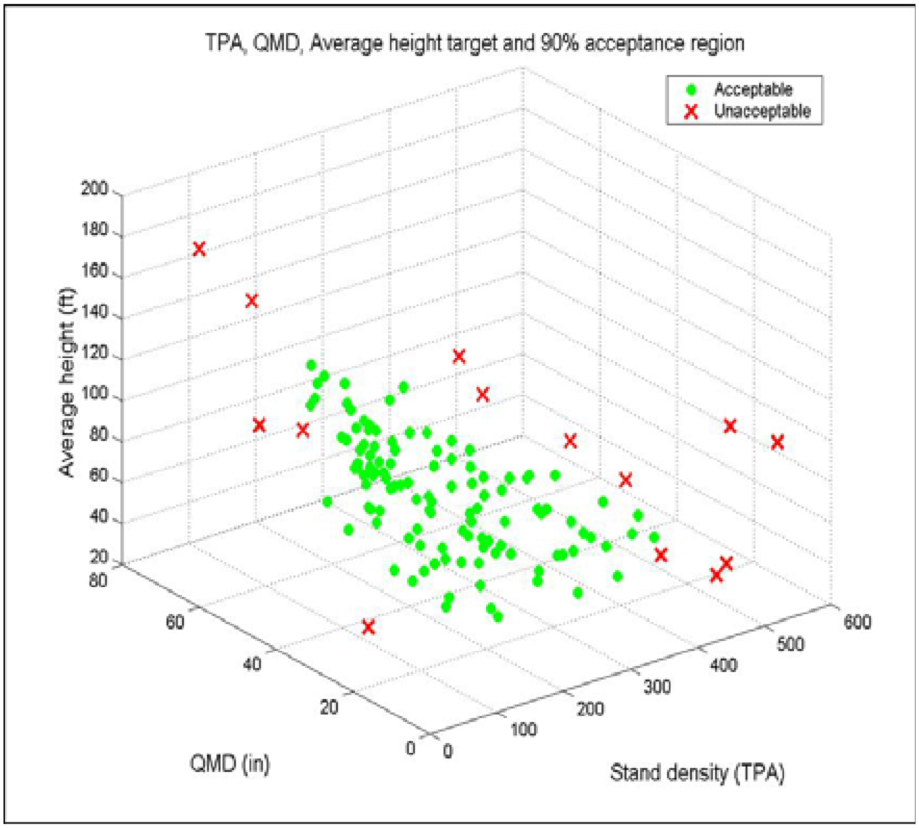

Figure 3: The three-dimensional region represented by the green dots provide a visual representation of the management target. Stands within this region are statistically similar to the desired structure. The red x's are outlying values from the dataset that have been filtered to refine the target.

A set of potential template alternatives was then developed that could be tested relative to the management target. "Biodiversity pathways," which utilize heavy, repeated thinnings over longer rotations, have been proposed as a management approach for accelerating the development of old forest structure while minimizing economic costs (Carey and Curtis 1996, Carey et al. 1996, Carey et al. 1999, Lippke et al. 1996). Using the principles of biodiversity pathways, we developed 18 different test alternatives (see Zobrist et al. 2004, 2005a).

Each alternative was projected over 140 years using the Landscape Management System (LMS). LMS is robust software that combines growth, treatment, and visualization modules under a single, user-friendly interface (McCarter et al. 1998). LMS offers integrated analysis capabilities including forest structure metrics, financial analysis, and others. Using LMS, each alternative was assessed over time relative to the management target. Soil Expectation Value (SEV), the net economic return to bare land, was computed as a measure of the long-term economic motivation for continued forest management.

The percent time the management target was achieved over the 140-year projection (biodiversity criterion) was compared to the SEV (economic criterion) for each alternative. As a baseline, the default regulatory prescription performed poorly relative to both criteria. Of the 18 potential template alternatives, some performed well relative to economics but not biodiversity, some performed well relative to biodiversity but not economics, and still others appeared to perform well relative to both criteria (*Figure 4*).

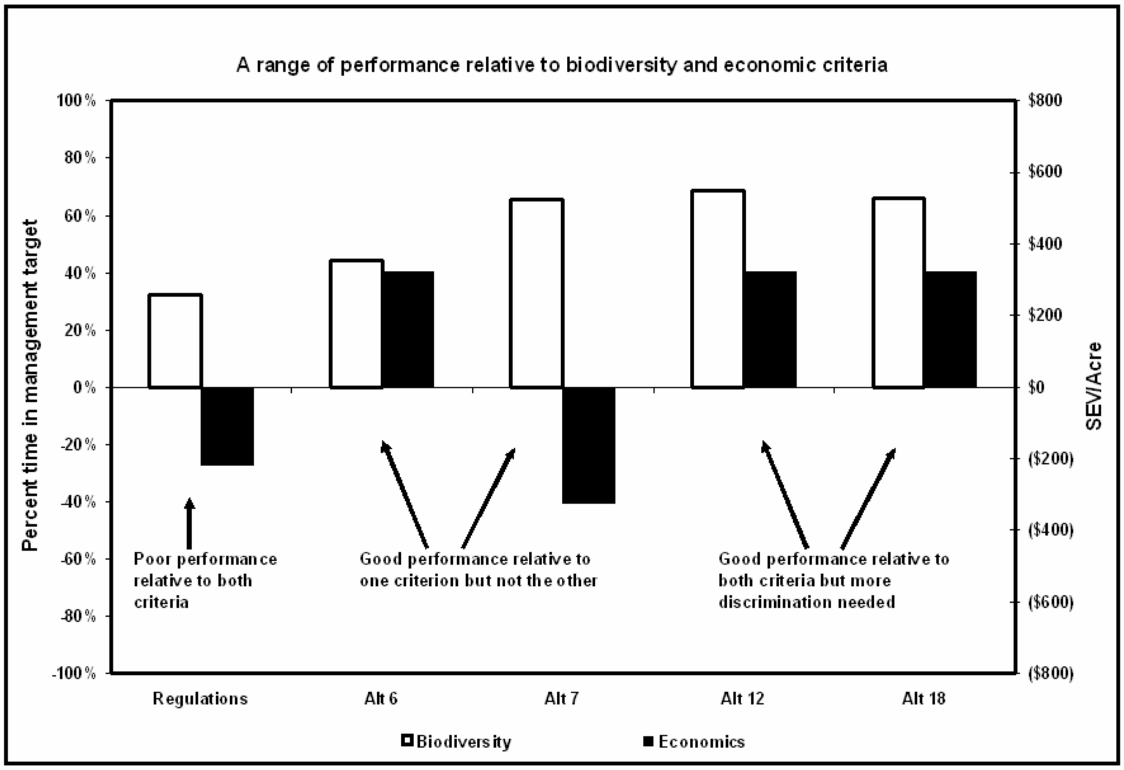

Figure 4: Examples of the range of performance relative to the biodiversity and economic criteria for the tested alternatives. The default regulatory option performed poorly relative to both criteria. Some alternatives performed good relative to one criterion but not the other. Still others performed well relative to both, but further discrimination is needed.

The alternatives that performed well relative to both criteria were viable alternatives, but an additional “fine filter” criterion was needed to provide further discrimination. We chose potentially available large woody debris (PALWD) as the fine filter criterion, as this is a riparian function of particular interest. *Figure 5* shows the predicted volume of PALWD over time for the viable alternatives using a PALWD model (Gehringer 2005). This provided adequate discrimination to select specific template options.

Figure 6 is an example of what a finished riparian template might look like. This management diagram includes a shaded region that suggests overstocked stand conditions that would likely benefit from the template. Using the template as a guide, qualifying stands would be thinned to maintain a density between the solid lines throughout the rotation.

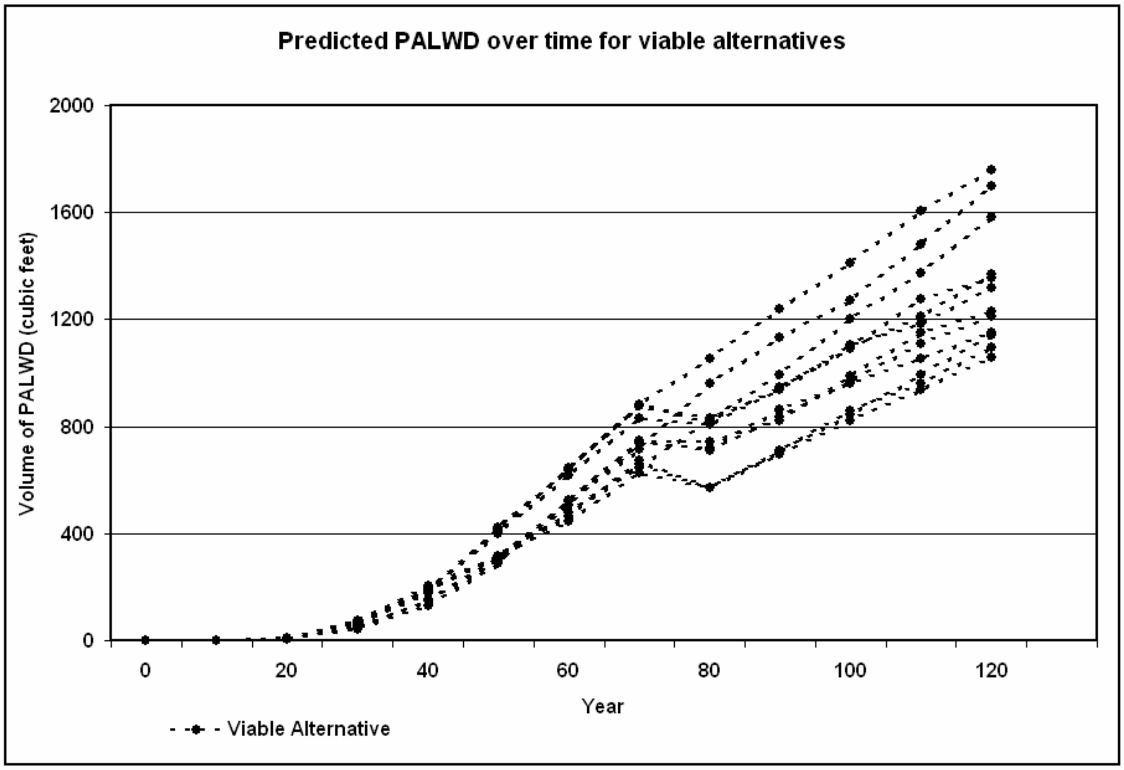

Figure 5: As a function of particular interest, predicted PALWD over time provides fine filter discrimination between viable template options.

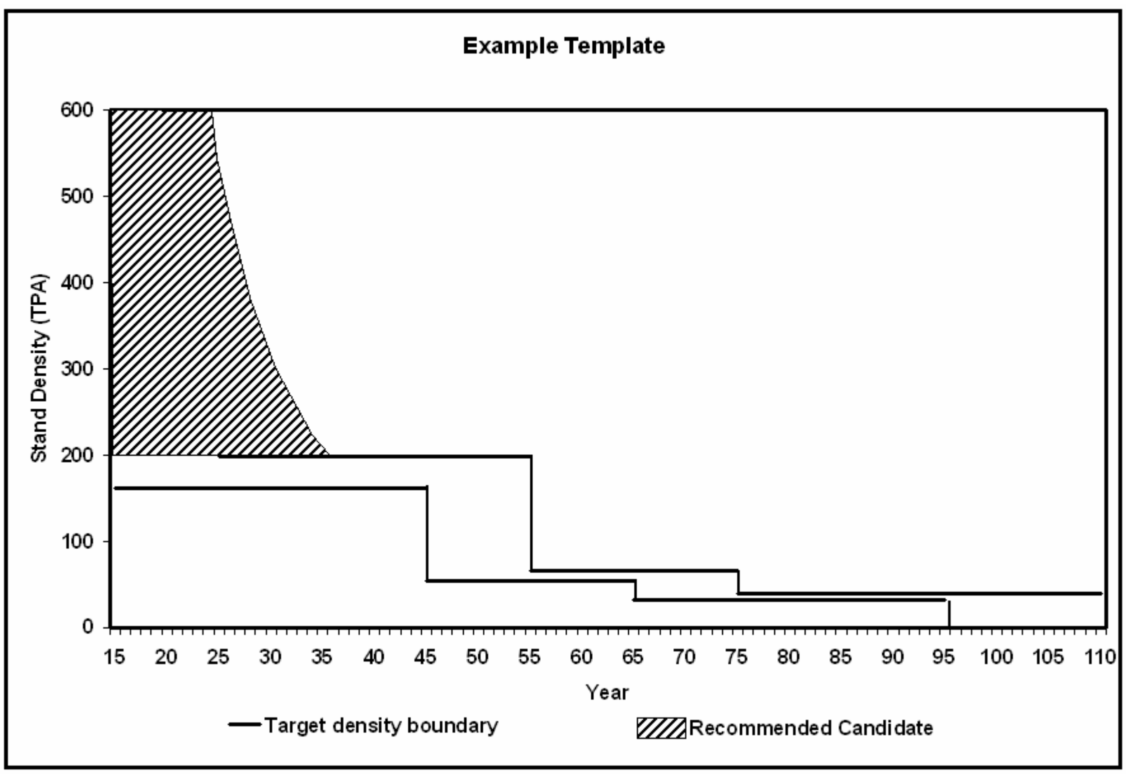

Figure 6: Example of a finished riparian template. The shaded region represents candidate stands that could benefit from the template. Stands would be thinned to stay within the solid lines.

Southern Template Example

The overall framework used to create the example riparian template above is not necessarily limited to riparian stands or the Pacific Northwest region. Rather, any situation in any region in which biodiversity and economic goals could be similarly quantified could benefit from the same approach and tools. To examine the broader applicability of the template framework, we used it to create an example template for supporting increased biodiversity in intensively managed loblolly pine plantations in the South.

A structure that is likely to support increased biodiversity in southern forests is an open, park-like structure with a rich, herbaceous understory. This structure is characteristic of the fire-maintained longleaf pine forests that historically dominated the region and are recognized for supporting high levels of biodiversity (Bragg 2002, Noss 1988).

Figure 7: A "benchmark" stand measured by Hedman et al. (2000). The open, park-like structure of this uneven-aged longleaf pine stand supports a rich, herbaceous understory that provides habitat for a variety of species. Photograph taken by Craig Hedman.

To quantify this structure, a reference dataset was used from a study by Hedman et al. (2000). This dataset was collected at International Paper's Southlands Experimental Forest in southwest Georgia and identified "benchmark" stands of loblolly, longleaf, or slash pine that were characteristic of historic, open stands with rich understories (*Figure 7*). Four key variables described the desired structure and discriminated well against non-benchmark stands: the density and QMD of the larger trees and the density and QMD of the smaller trees. The resulting four-dimensional target can be represented visually with two two-dimensional sub-targets (*Figure 8*). Stands whose attributes can be plotted simultaneously in both sub-target ovals are statistically similar to the desired structure as quantified by the reference dataset.

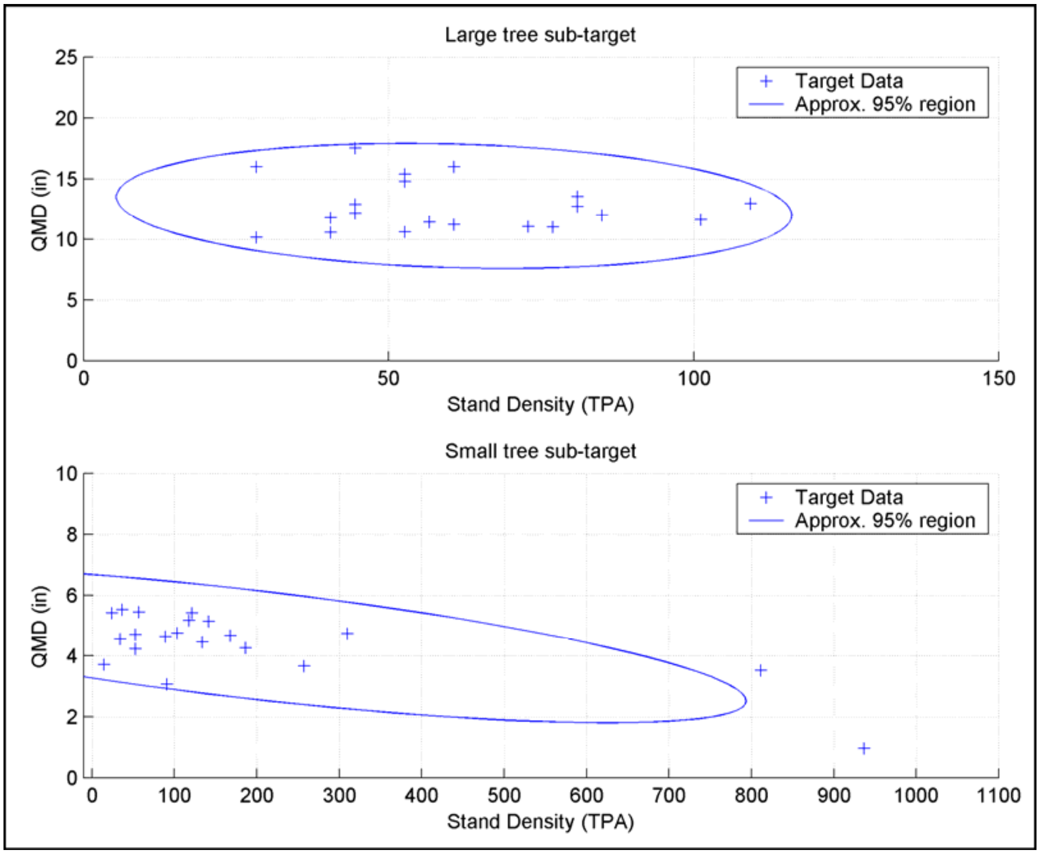

Figure 8: The four-dimensional southern management target represented as two two-dimensional sub-targets. Stands whose attributes are simultaneously within both ovals are statistically similar to the desired structure.

Management practices that are likely to produce the desired structure and favor biodiversity include thinning early and often, frequent prescribed burning to control hardwoods and maintain understory vigor, longer (sawtimber) rotations, and retention of key mast-producing hardwoods for wildlife food (see Zobrist et al. 2005b for a literature review of these and other practices). Using these principles, we established nine management alternatives to test as template options. These alternatives included a 25-year chip and saw rotation along with 35, 40, and 55-year sawtimber rotations. Thinning was done at either 10 or 15-year intervals to a residual basal area (BA) of either 60 or 80 ft^2 (*Table 1*). It was assumed that prescribed burning was done every 5 years starting at age 20. This was not modeled directly, but the effects were modeled indirectly by not including the ingrowth that would occur in the absence of fire.

Each alternative was projected over 100-years using LMS and was assessed relative to the management target and SEV. The results are summarized in *Table 2*. The 25-year chip and saw rotation (alternative 1) performed poorly relative to both the management target and the SEV criteria. The rotation was not long enough to develop the desired structure, and low current pulp prices resulted in a low SEV. Alternative 5, a 40-year rotation, resulted in the highest SEV, but only achieved the target structure 14% of the time. In contrast, alternatives 6, 7, and 8, 55-year rotations, achieved the target structure 48% of the time. The difference in SEV between these alternatives and the higher value that could be achieved with alternative 5 represented the opportunity costs of these alternatives. Of these costs, alternative 7 had the lowest, yielding a reasonably competitive SEV. The cost per percent time in target ratio was particularly low for this alternative, which appeared to be a good balance of biodiversity and economic objectives.

Table 1: Nine potential template alternatives were established based on practices likely to achieve the desired structure.

Alternative	Rotation Length	Thinning Target (ft^2 BA)	Thinning Interval
1	25	NA	NA
2	35	60	10
3	35	80	10
4	40	60	15
5	40	80	15
6	55	60	10
7	55	80	10
8	55	60	15
9	55	80	15

Table 2: Comparison of the percentage of time that the desired structure was achieved and economic performance for nine template alternatives.

Alternative	% Time Desired Structure Achieved	SEV/Acre	SEV Cost/Acre	Cost/% Time Desired Structure Achieved
1	0%	-$20	$639	NA
2	14%	$423	$196	$14.00
3	14%	$480	$139	$9.93
4	24%	$466	$153	$6.38
5	14%	$619	$0	$0
6	48%	$305	$314	$6.54
7	48%	$413	$206	$4.29
8	48%	$382	$237	$4.93
9	38%	$415	$204	$5.37

For the southern template example, the "coarse filter" analysis provided enough discrimination between the test alternatives such that an additional fine filter criterion was not needed. Alternative 7 was identified as the preferred template option. Projections of this alternative suggest that it will develop structural conditions conducive to biodiversity (*Figure 9*) while providing reasonable (though not maximum) economic returns.

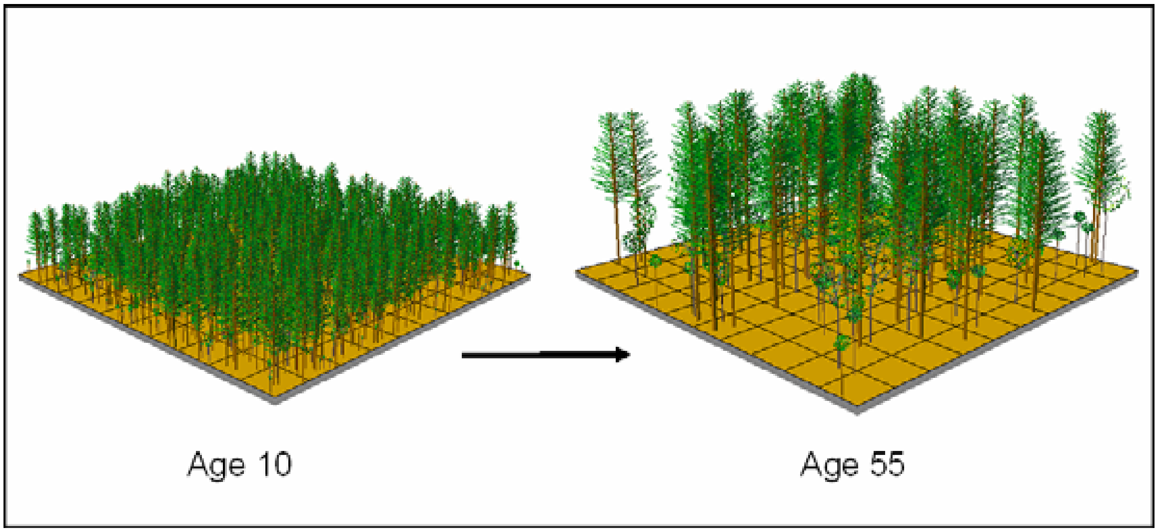

Figure 9: Projected stand development from age 10 to 55 under Alternative 7 for the Southern template example.

Conclusion

Management templates like the examples demonstrated above for the Pacific Northwest and the South can provide useful guidance on implementation and expected outcomes for landowners and practitioners who are interested in managing for increased biodiversity. There are numerous other possible templates that could be created using the same framework. The template examples above do not represent exclusive management options, but rather a demonstration of the template development framework. This framework appears to be useful in multiple regions, and templates could be created for still additional forest types and regions.

For more information regarding this research, a complete report is available from the Rural Technology Initiative (RTI) at http://www.ruraltech.org/pubs/working/ncssf/index.asp

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