ENVIRONMENTAL PERFORMANCE INDEX FOR THE FOREST

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ABSTRACT

Comparative environmental performance indices for energy use, global warming potential (GWP), air, water, and solid waste emissions covering the stages of processing from the harvesting of wood and the extraction of non-renewable materials to the construction of a house using different materials are developed in other articles. Developing performance indices that compare renewable resources and their environmental impacts on the land base to the depletion of non-renewable resources is problematic. Materials that involve mining are inherently not renewable compared to forest resources, which are renewable over some rotation age of the forest. The environmental impacts on the forest are dynamic and are impacted by landscape changes with some related to the production of wood for markets. Forest ecology metrics are developed to show the impact of management alternatives based on changing stand structures. Forest diversity, measured by structure classes, is impacted by longer rotation and thinning alternatives as well as preservation and protection policies.

Management alternatives can contribute to some restoration of pre-settlement conditions of forests and provides a benchmark from which to evaluate reduced stand structure diversity and loss of habitat. While a century of commercial management has reduced the diversity in the forest and in particular has increased the share of acres in both the stand initiation stage and the closed canopy or stem exclusion stage, the trend has already turned in response to demands for more forest acres under increased protection and preservation status. Increased thinning from more intensive management and policies to protect threatened species are both contributing to increased understory reinitiation and ultimately more complex old forest structures. Longer rotation management could add to this effect but at a substantial cost since the economics of long rotation management falls below acceptable levels for economic investments.

Keywords: Biodiversity, forest management, intensive management, forest diversity, restoration, environmental performance.

INTRODUCTION

Comparing life-cycle inventories for wood materials and other competing materials such as steel and concrete becomes difficult when aspects of sustainability or renewability are considered. Wood materials are renewable like agricultural crops although over longer rotations. The impacts of activities like harvesting and mining on the land base are generally omitted from life-cycle inventories since the impacts are difficult to quantify and not very comparable for

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different materials. The land use activities have caused substantial conflict between producers and environmental advocates. Differences of opinion have dominated the discussion on the impact that growing wood as a renewable resource has on the environmental performance of the forest as it also provides for many non-timber values such as clean air and water, habitat, and recreation. These values are not provided by iron and steel in nature, i.e. while in the ground. Concerns over endangered species have contributed to this debate with the protection of the spotted owl and salmon in the Northwest of greatest concern. While we may not be able to make direct value comparisons between the impacts of managing forests while producing wood to mining and the depletion aspects of nonrenewable products, we can develop environmental performance indices of forest attributes as a function of changes in forest management objectives and intensity. As a case study example, different management strategies are applied to each owner group for Western Washington including the impacts of regulations to protect species at risk. Stand structures are used as the surrogate for forest diversity since habitat models and riparian functions for at risk species are largely based on stand conditions and particularly, on structures that show complexity similar to old forests.

MANAGEMENT STRATEGIES

Long rotations were shown not to be complementary with increased carbon sequestration since deferred harvests shorted the product stream causing substitution of fossil-intensive steel and concrete (Perez-Garcia et al. 2004). While carbon objectives almost always seek short-term improvement, habitat objectives are more likely to be characterized in terms of longer-term restoration. It was noted in the carbon analysis that more intensive management not only produced more products, the extra product volume also substitutes for fossil-intensive products producing greater carbon storage. Changes in management also alter the structure of forest stands, which in turn impact habitat and affect restoration objectives. Since the impact on habitat and biodiversity is through the changes in stand structure, we can simulate these impacts by modeling changes in structure under different management alternatives.

The benefits one might expect from introducing some longer rotations would be more complimentarity in producing old-forest-sensitive habitat, thereby maintaining greater biodiversity. The benefits of more intensive management on short rotations may be less obvious but include stands taking on older forest characteristics more rapidly as a consequence of thinning treatments.

The impacts for four different forest management strategies are evaluated: (1) a base case with a short economic rotation appropriate for growing timber for log markets, (2) a longer rotation, i.e. twice as long as the base case with treatments designed to accelerate the creation of old forest attributes, (3) more intensive management for accelerated production of timber for log markets, and (4) no-management to demonstrate the impact of preservation strategies on aging of forest stands without disturbances. Combinations of these strategies applied to different ownership groups provide a range of future conditions for the forest. Changes in management alter the structure of forest stands, which in turn impacts habitat and affects forest protection and restoration objectives.

The benefits expected from preserving more acres under the no-management alternative include more acres taking on old-forest attributes. This provides a degree of restoration of historic conditions. Since nearly all species at risk in the region are believed to depend on old-forest attributes, recent regulations have constrained the harvest on more acres such that even a baseline trend will reflect this changing paradigm. Introducing some longer rotations provides the opportunity to accelerate the rate that stands take on old-forest attributes, albeit at a substantial loss in economic return. The benefits of more intensive management on short rotations may be less obvious but does result in stands taking on somewhat older forest characteristics more rapidly as a consequence of thinning treatments.

ENVIRONMENTAL PERFORMANCE INDICES

Many studies indicate that the characteristics of old-growth forests are not likely to be emulated by the no action alternative when applied to stands that have already been commercially stocked as there were generally much lower densities during the younger period for stands now identified as natural old forests or "old-growth" (Churchill 2003; Garman et al. 2003; Poage and Tappenier 2002; Tappenier et al. 1997). Thinning young managed forests puts them on a pathway to take on the characteristics of older forests more rapidly. Commercially regenerated forests are heavily stocked and grow rapidly until the crowns overlap, blocking sunlight to the understory. Once the sunlight is blocked, these stands essentially kill most of the vegetation in the understory and support the least number of wildlife species. These stands identified by the stem Exclusion Structure (ES) label are in surplus supply compared to pre-settlement forests as a consequence of the higher stocking levels associated with commercial management and the short rotations that prevented them from disturbances and natural aging. As a consequence, thinning treatments on commercially stocked stands, while not being sufficient to create old-forest conditions, do increase stand diversity more quickly while reducing the ES structures in greatest surplus.

We use the stand classification system developed by Carey et al. (1999).

- Stand Initiation (SI): the open structure during the early regeneration process.
- Exclusion Structure (ES): when the stands canopy closes until some disturbance allows Understory Reinitiation.
- Understory Reinitiation (UR): when the understory is maintained (or reappears) by thinning, mortality or reduced stocking.
- Developed Understory (DU): when the developing understory takes on increased diversity from downed logs and snags, with variable density and multiple developing canopy but lacking the large trees that characterize old-forests.
- Botanically Diverse or Niche diverse (BD or ND): increased diversity including some larger trees as the consequence of natural disturbances (BD) or thinning treatments that retained downed logs, snags and some understory hardwoods (ND).
- Fully Functional or Old-Growth (FF or OG): mature diverse stands with downed logs, snags, some trees over 31 inches with variable densities and multiple canopies with some vigorous understory as the consequence of natural disturbances (OG) or treatments designed to produce old-forest attributes (FF).

Since the treatments are focused on the impacts of longer rotations, and/or more intensive management which fundamentally increase the stand taking on the characteristics of UR or ND while decreasing the stands in SI and ES, we have collapsed the DU stage in with UR and FF in with ND. This combined category of FF and ND have been equated (Carey et al. 1999) with the broader and more generally used classification "late-seral structure" (LS) albeit potentially created by active management rather than natural aging and mortality. Increases in UR and LS, with decreases in SI and ES provide a directional pathway toward some restoration to pre-settlement structures.

Management strategies and treatments by owner

The alternative management strategies were simulated for all of the acres of forestland in Western Washington. The initial forest inventory data by age class, forest type, geographic region and ownership were taken from the Forest Inventory Analysis (MacLean et al. 1992). The findings should also be representative of Western Oregon collectively making up the Pacific Northwest Supply region. Landscape Management System (LMS) (McCarter et al. 1998) simulations were used to evaluate alternative strategies. By grouping acres in age classes by ownership, large acreages can be evaluated. Harvesting on the 2.054 million acres of federal lands has largely been eliminated over the last decade hence a no-action alternative (i.e. natural growth with no disturbances) was used on federal lands in each simulation. Harvesting on state lands continues at a reduced rate and with longer than commercial rotations (about 80 years on average) for the 1.401 million upland acres and with minimal entries (no-action) on another 0.262 million acres of riparian zones. No change in the management on state lands was introduced since the strategies would be different than those that might be implemented on private lands, complicating the analysis. The 5.712 million acres of private lands provide the primary opportunity for management change. The 0.811 million acres in riparian zones are largely constrained by regulations to protect salmon habitat and were left unmanaged. The impact of management changes on the remaining 4.901 million acres of private land becomes the primary focus. The management simulations are somewhat simplified versions of a more complex analysis for these lands provided in Lippke et al. (2002).

The treatment changes were limited to lengthening the rotation and more intensive management via thinning and fertilization. For the longer rotation strategy 1/3 of the upland acres, 1.714 million acres, were extended to an 80-year rotation; with another 0.206 million acres extended to a 120-year rotation so that 11% of the long rotations exceed 100 years. These long rotations result in substantially less present value to the landowner and for a 120-year rotation the return falls below a 5% rate of return, which should be considered below sustainable economics, as a key criterion for sustainable forestry. For the intensive management strategy, 35% of the upland acres received a fertilizer treatment and commercial thinning.

BIOLOGICAL AND HARVEST IMPACTS

Table 1 summarizes the integrated impact on the Western Washington landscape for the management changes applied to the private acres. Figure 1 shows the harvest levels over the 160-year planning period for each strategy and Fig. 2 (A-C) shows the changes in stand structure distributions.

TABLE 1. *Average bio-index shares and harvest levels under management alternates.*

	Base	Long rotation	Intensive mgt.
Late seral average	32%	37%	32%
Stand initiation average	32%	28%	32%
Stem exclusion average	30%	28%	26%
Reinitiation average	5%	7%	10%
Harvest billion bdft/yr	5.4	5.2 (−4%)	5.8 (+6%)

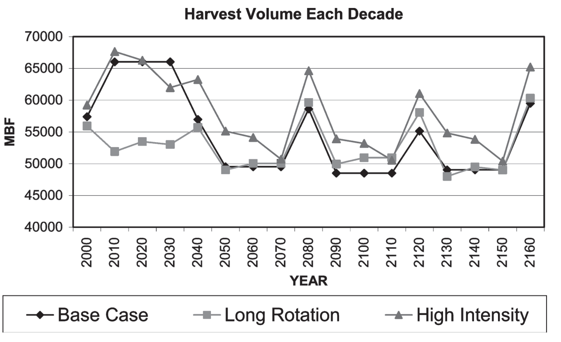

FIG. 1. Harvest Volumes each decade for the Base Case, Long Rotation and High Intensity Scenarios.

The impact of longer rotations

The long rotation strategy reduces harvest 16% over the first 3 decades but only 3.8% over 160 years (Fig. 1). The harvest level will eventually increase with longer rotations since the mean annual increment of growth is larger than short rotations. The deferred harvest to transition more acres to long rotation pathways largely impacts the first few decades. The long rotation increases the share of acres in Late Seral structures from 32% to 37%, a 15% increase; however, there is only a 7% increase in the first 3 decades as most of the restoration takes a long time (Fig. 2 A vs. 2 B). It should be noted that the share of Late Seral structures increases in the base case from 26% share in the first decade to 35% share in the last decade as a consequence of the near elimination of harvesting on federal lands and the reduced harvest in riparian buffer zones on private lands (Fig. 2A). This share is increased to 40% in the last decade with the longer rotations (Fig. 2 B).

Understory Reinitiation structures increase from 5% to 7%, a 33% increase. However, all of

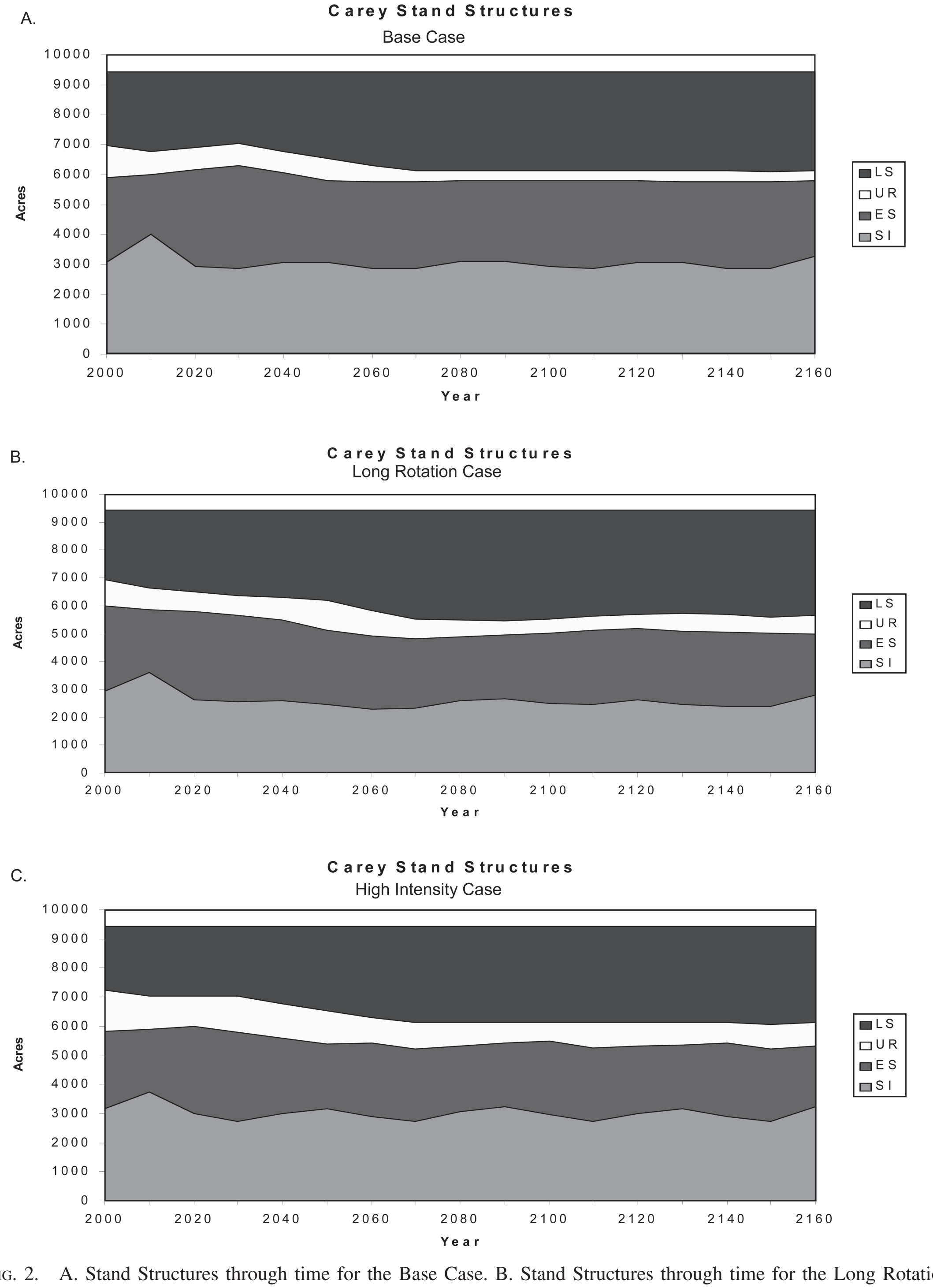

FIG. 2. A. Stand Structures through time for the Base Case. B. Stand Structures through time for the Long Rotation Case. C. Stand Structures through time for the High Intensity Case. LS – Late Seral; UR – Understory Reinitiation; ES – Exclusion Structure; SI – Stand Initiation.

the gain is long term as there is a 5% decline in the first 3 decades. Over the 160-year period, Exclusion structures are reduced from 30% to 28%, a 7% decline, and Stand Initiation structures are reduced from 30% to 26%, a 15% decline. The long rotation strategy on private lands has a smaller impact on restoration than the constrained harvesting on federal lands and the riparian buffers on private lands. The economic impact would also be substantial with the bare land values falling substantially for the lands converted to long rotations. The longer rotations are not economically viable without substantial incentives to the owner or other compensation for the increased diversity produced.

The impact of more intensive management

The more intensive management strategy increases harvest 2% over the first 3 decades and 6% over 160 years (Fig. 2 C vs. 2 A). More intensive management has very little impact on the share of acres in Late Seral structures but does have a substantial impact on the share of acres in Understory Reinitiation, which increase from 5% to 10% (Fig. 2 C vs. 2 A). There was a comparable decrease in Exclusion Structures from 30% to 26%, a 13% decline. In effect, more intensive management contributes to reducing some of the stand structures that are in excess supply versus the pre-settlement period as a result of commercial management. Unless the rotations are lengthened, however, more intensive forest management does not contribute significantly to the old forest structures. Since the economics are close to optimum, the trend toward more intensive management provides a biological improvement over the base case while also placing more acres on a pathway suitable for longer rotations.

Trends and changes in forest biodiversity

While a century of commercial management in the West has reduced the share of more complex structures, e.g. Late Seral, while increasing the share of Stand Initiation and Exclusion Structures, the latter supporting the least number of species, the trends are all in the direction of some restoration. Increased thinning activities supported by better technology and economics are reducing the surplus of acres in Stand Initiation and Stem Exclusion stages while increasing Understory Reinitiation. The changed federal harvest policies and regulations imposed to protect endangered species, are also reducing the Stand Initiation surpluses and over a longer period of time increasing the Late Seral structures. Long rotation management on private lands could add to these impacts but at a substantial cost, requiring incentives to support economic viability. Long rotations on federal lands could accelerate the trend to older forest attributes and with a reduction in cost since long rotations are more cost-effective than no-management. The changing trends are contributing to improved restoration of the pre-settlement conditions both through increased thinning and protection policies. Even the substantial changes in management strategies provided by the simulations produce only a modest change in structural diversity with Late Seral structures increasing from 35 to 40%.

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REFERENCES

Carey, A., B. Lippke, and J. Sessions. 1999. Intentional ecosystem management: Managing forests for biodiversity. J. Sustain. For. 9(3):83–125.

Churchill, D. 2003. Fact Sheet 24: The emerging consensus for active management in young forests. Rural Technology Initiative, College of Forest Resources, University of Washington, Seattle, WA. http://www.Ruraltech.org. (25 Feb 2005)

Garman, S. L., J. H. Cissel, and J. H. Mayo. 2003. Accelerating development of late-successional conditions in young managed Douglas-fir stands: A simulation study. General Technical Report PNW-GTR-557. USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

Lippke, B. R., B. B. Bare, W. Xu, and M. Mendoza. 2002. An assessment of forest policy changes in Western Washington. J. Sustain. For. 14(4):63–94.

McCarter, J., J. Wilson, P. Baker, J. Moffett, and C. Oliver. 1998. Landscape management through integration of existing tools and emerging technologies. J. For. 96(6):17–23.

MacLean, C. D., P. M. Bassett, and G. Yeary. 1992. Timber resource statistics for Western Washington. USDA Forest Service Pacific Northwest Research Station, Resource Bulletin PJNW-RB-191, Portland OR.

Perez-Garcia, J., B. Lippke, J. Comnick, And C. Manriquez. 2004. Tracking carbon from substitution in the forest to wood products and substitution. In CORRIM Phase I Final Report Module N. Life-cycle environmental performance of renewable building materials in the context of residential construction: University of Washington, Seattle, WA. http://www.corrim.org/reports/. 27 pp.

Poage, N. J., and J. C. Tappeiner. 2002. Long-term patterns of diameter and basal area growth of old-growth Douglas-fir trees in western Oregon. Can. J. For. Res. 32(7): 1232–1243.

Tappeiner, J. C., D. Huffman, D. Marshall, T. A. Spies, and J. D. Bailey. 1997. Density, ages, and growth rates in old-growth and young-growth forests in coastal Oregon. Can. J. For. Res. 27(5):638–648.