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CORRIM: Phase I Final Report

Module O

ENVIRONMENTAL PERFORMANCE INDEX FOR THE FOREST

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EXECUTIVE SUMMARY

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 were developed in Module J. Developing similar performance indices that compare the depletion of non-renewable resources with the regeneration of renewable resources and their environmental impacts to the land base are much more difficult. Materials that involve mining are inherently not renewable compared to forest resources, which generally are renewable over some rotation. The environmental impacts from mining operations and managing forests are not very comparable since there are no common metrics. This module develops environmental impacts on the forest for a range of management alternatives. 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 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 affect but at a substantial cost since the economics of long rotation management falls below acceptable levels for economic investments.

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1.0 INTRODUCTION

As shown in module J, wood used in construction generally produces less environmental emissions than competing materials. The impacts of activities like harvesting and mining on the land base are omitted from these measures. The land use activities have caused substantial conflict between producers and environmental advocates. Differences of opinion have dominated the discussion on the impact of growing wood as a renewable resource 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. 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 management. There have been efforts to quantify the public's value of non-product uses of the forest using contingent valuation (CV) techniques (Xu et al. 2003; Perez-Garcia 2001). These studies still depend upon biological and aesthetic metrics to characterize these non-market values, and we are not aware of comparable studies that have developed the public's willingness to accept depletion of non-renewable resources along with their additional mining burdens on the land as a comparison with the impacts of renewable resources on the land. The two concepts are sufficiently different that it would be difficult for the public to understand them sufficiently to participate in experimental choice experiments to develop comparative values. We will however develop the metrics used in the Northwest to characterize the changed biological structure of the forest under different management strategies.

1.1 MANAGEMENT STRATEGIES

Module N extended the carbon analysis from managed forests including product flows over time and demonstrated the impacts for three different management strategies; (1) a base case with a short economic rotation, (2) a longer rotation i.e. twice as long, and (3) more intensive management. We can also analyze the impact these strategies have on the forest's structure as a measure of its ecological attributes.

It was noted earlier that long rotations were not complementary with increased carbon sequestration since deferred harvests shorted the product stream causing substitution of fossil intensive steel and concrete. 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 complimentarily 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.

1.2 ENVIRONMENTAL PERFORMANCE INDICES

A number of research studies summarized by Churchill (2003) 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 was generally much lower densities during the younger period for stands now identified as natural old forests or “old-growth”. 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. 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 comparative 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): as 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 SE, 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.

1.3 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 was taken from the Forest Inventory Analysis (McLean 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 longer than commercial rotations (about 80 years on average) for the 1.401 million upland acres 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 .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 .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. Appendix 1 provides a more detailed description of these treatments.

2.0 BIOLOGICAL AND HARVEST IMPACTS

Table 2.1 summarizes the integrated impact on the Western Washington landscape for the management changes applied to the private acres. Figure 1.1 shows the harvest levels over the 160-year planning period for each strategy and Figure 1.2 A-C shows the changes in stand structure distributions. Table A.1 (Appendix 1) shows the decadal shares for each stand structure class that has been summarized in table 2.1.

Table 2.1. 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%)

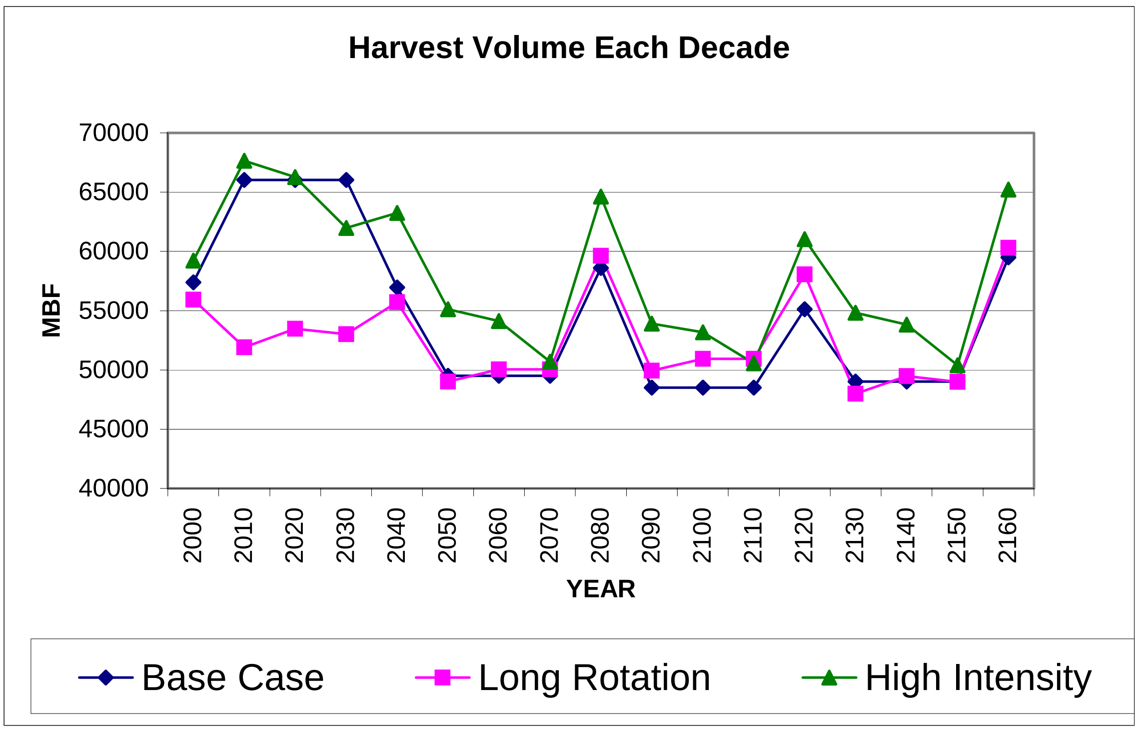

Figure 1.1. Harvest Volumes each decade for the Base Case, Long Rotation and High Intensity Scenarios.

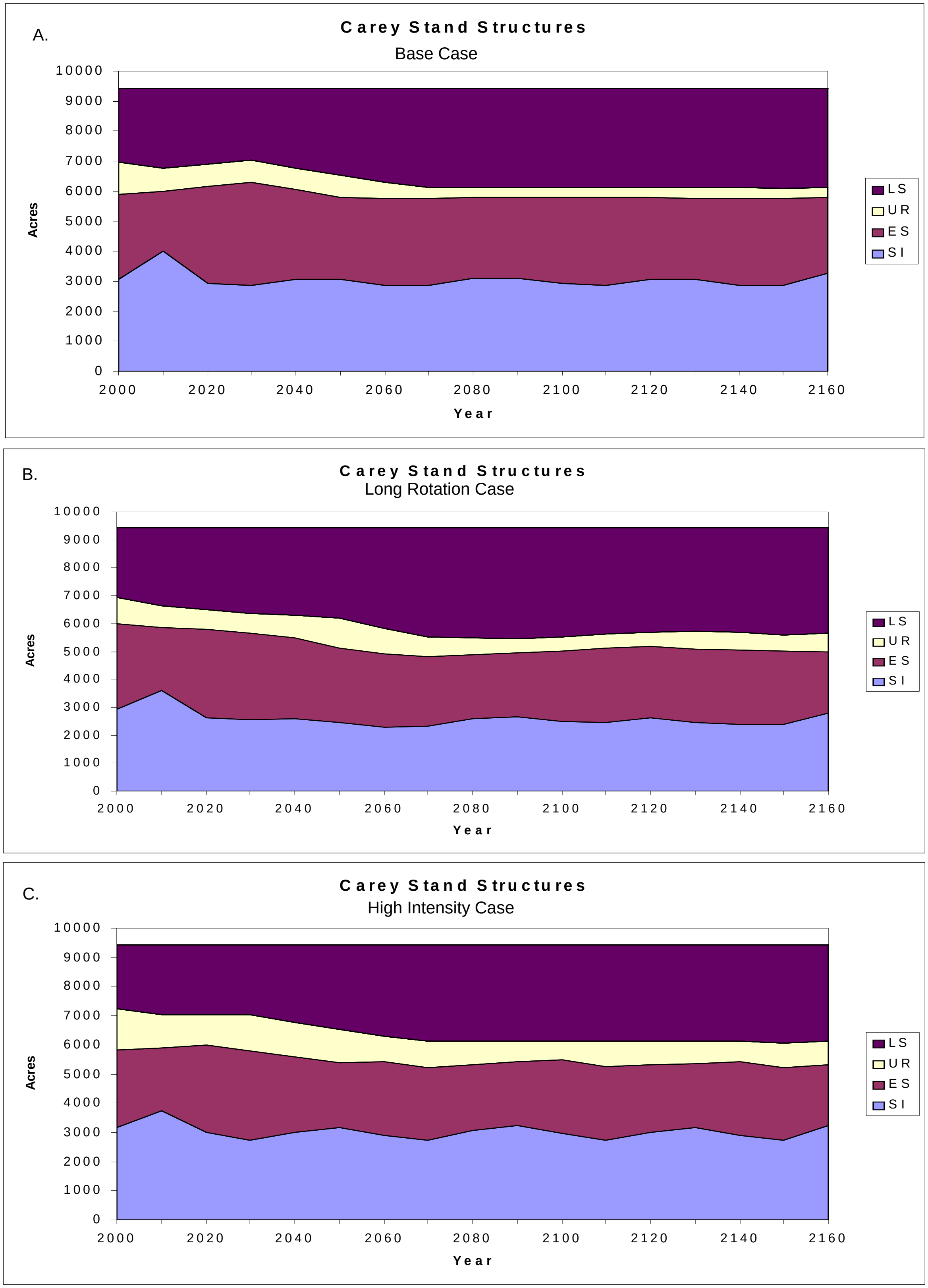

Figure 1.2. **A. Stand Structures through time for the Base Case.**
B. Stand Structures through time for the Long Rotation Case.
C. Stand Structures through time for the High Intensity Case.
Note: LS – Late Seral; UR – Understory Reinitiation; ES – Exclusion Structure; SI – Stand Initiation.

2.1 THE IMPACT OF LONGER ROTATIONS

The long rotation strategy reduces harvest 16% over the first 3 decades but only 3.8% over 160 years (Figure 1.1). The harvest level will eventually increase with longer 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 (Figure 1.2 A vs. 1.2 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 (Figure 1.2 A). This share is increased to 40 % in the last decade with the longer rotations (Figure 1.2 B).

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

2.2 THE IMPACT OF MORE INTENSIVE MANAGEMENT

The more intensive management strategy increases harvest 2% over the first 3 decades and 6% over 160 years (Figure 1.2 C vs. 1.2 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% (Figure 1.2 C vs. 1.2 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, but unless the rotations are lengthened, 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.

2.3 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 later 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 is reducing the surplus of acres in Stand Initiation and Stem Exclusion stages while increasing Understory Reinitiation. The low timber prices experienced in the current recession have perhaps slowed down this trend change but hopefully only temporarily. 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. 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%.

3.0 REFERENCES

Carey, Andrew, Bruce Lippke, John Sessions. 1999. Intentional Ecosystem Management: Managing Forests for Biodiversity. Journal of Sustainable Forestry Vol. 9.

Churchill, Derek, 2003. Fact Sheet 24: The Emerging Consensus for Active Management in Young Forests. Rural Technology Initiative, College of Forest Resources, University of Washington. www.Ruraltech.org

Lippke, Bruce R., B. Bruce Bare, Weihuan Xu, Martin Mendoza. 2002. An Assessment of Forest Policy Changes in Western Washington. Journal of Sustainable Forestry Vol. 14(4) pp63-94

McCarter, James, Jeremy Wilson, Patrick Baker, Jeffrey Moffett, and Chadwick Oliver. 1998. Landscape Management through Integration of Existing Tools and Emerging Technologies. Journal of Forestry, Vol. 96, No 6, June 1998. pp17-23

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.

Xu, Weihuan, Bruce R. Lippke, and John Perez-Garcia. 2003. Valuing biodiversity, aesthetics and job losses associated with ecosystem management using stated preferences. Forest Science, 49(2) pp. 247-257.

Perez-Garcia, John. 2001. Cost Benefit Analysis for New Proposed Forest Practice Rules Implementing the Forest and Fish Report. Report prepared for the Washington Department of Natural Resources (Agreement #FFY00-133). College of Forest Resources, University of Washington. Seattle WA. pp16

APPENDIX 1: DESCRIPTION OF TREATMENTS, MANAGEMENT ALTERNATIVES AND STAND STRUCTURE STAGES

Treatments

Treatments varied in number of years until final harvest and management intensity, including number of commercial thinnings and fertilization:

No Action:
Simulated with site index 175, 130, and 110

40-Year Rotation Base:
Simulated with site index 175
Plant 770 trees per acre (tpa) of DF
Pre-commercial thin (PCT) at age 15 to 275 tpa from below by diameter
Final harvest at age 40 to 3 tpa from below by diameter

40 Year Rotation High Intensity:
Simulated with site index 175
Plant 770 tpa of DF
CT at age 20 to 100 BA from below by diameter
Fertilize at age 20 and 30
Final harvest at age 40 to 3 tpa from below by diameter

80-Year Rotation:
Simulated with site index 175 and 130
Plant 770 tpa of DF
PCT at age 15 to 275 tpa from below by diameter
Final harvest at age 80 to 3 tpa from below by diameter

120-Year Rotation:
Simulated with site index 175
Plant 770 tpa of Df
PCT at age 15 to 275 tpa from below by diameter
Final harvest at age 120 to 3 tpa from below by diameter

Alternatives

Treatments were simulated for 10-year age classes from age 5 to 115 to represent management alternatives for private, National Forest, and other public ownerships. Each treatment was simulated for 120 years. Private land was modeled with the no action, 40 year Base, 40 year High Intensity, and 80 year simulations with a site index of 175. National Forest land was modeled with the no action simulation with a site index 110. Other public land was modeled with the no action and 80 year simulations with a site index of 130.

The three alternatives developed with the simulated treatments were Base, Long Rotations, and High Intensity. For each alternative, the National Forest land and the Other Public land simulations did not change. The National Forest land was modeled with 2.054 million acres following the no action with site index 110 treatment. The Other Public land was modeled with 1.401 million acres following the 80-year rotation with site index 130, and 262,000 acres following the no action with site index 130 treatment.

The Base, Long Rotations, and High Intensity alternatives differed in how the private lands were modeled. For the Base alternative, 4.901 million acres followed the 40-year Base treatment and 811,000 acres followed the no action with site index 175 treatment. For the Long Rotations alternative, 3.085 million acres followed the 40-year Base treatment, 1.610 million acres followed the 80-year rotation with site index 175, 206,000 acres followed the 120-year rotation treatment, and 811,000 acres followed the no action with site index 175 treatment. For the High Intensity alternative, 3.185 million acres followed the 40-year Base treatment, 1.714 million acres followed the 40 year High Intensity treatment, and 811,000 acres followed the no action with site index 175 treatment.

Table A.1. Decadal shares of acreage in each Forest Structural Class.

	ACRES			
YEAR	Stand Initiation	Exclusion Structure	Understory Reinitiation	Late Seral
		Base Case		
2000	3068	2810	1077	2474
2010	4017	1971	769	2672
2020	2939	3230	717	2543
2030	2857	3455	711	2406
2040	3053	3015	714	2648
2050	3053	2740	728	2909
2060	2857	2885	571	3116
2070	2857	2885	387	3300
2080	3109	2689	336	3295
2090	3109	2689	336	3295
2100	2913	2885	336	3295
2110	2857	2941	336	3295
2120	3053	2745	336	3295
2130	3053	2689	392	3295
2140	2857	2885	392	3295
2150	2857	2885	336	3351
2160	3277	2521	336	3295
		Long Rotation Case		
2000	2919	3075	944	2491
2010	3607	2242	769	2812
2020	2621	3159	717	2932
2030	2547	3122	711	3050
2040	2586	2915	797	3131
2050	2470	2637	1091	3231
2060	2277	2655	896	3602
2070	2307	2504	712	3906
2080	2598	2269	617	3945
2090	2648	2300	497	3984
2100	2494	2535	497	3903
2110	2468	2641	497	3823
2120	2625	2567	497	3740
2130	2470	2625	634	3700
2140	2404	2655	634	3737
2150	2385	2631	577	3834
2160	2810	2179	661	3778

High Intensity Case				
2000	3167	2659	1413	2189
2010	3721	2162	1156	2388
2020	2981	3015	1030	2401
2030	2735	3041	1246	2406
2040	3009	2579	1192	2648
2050	3174	2230	1115	2909
2060	2899	2527	885	3116
2070	2735	2471	922	3300
2080	3065	2253	814	3295
2090	3230	2179	724	3295
2100	2955	2527	650	3295
2110	2735	2527	871	3295
2120	3009	2309	814	3295
2130	3174	2179	780	3295
2140	2899	2527	706	3295
2150	2735	2471	871	3351
2160	3233	2085	814	3295

Structural Stages

The Carey system for stand development classifies stands into one of eight development stages. These are Stand Initiation (SI), Exclusion State (ES), Understory Reinitiation (UR), Developed Understory (DU), Botanically Diverse (BD), Niche Diversification (ND), Ecologically Fully-Functional (FF), and Old-Growth (OG). Measurable criteria for the Carey classification system was developed using QMD, a species diversity value, canopy closure, conifer snags, and logs. The species diversity value was calculated as the number of species that account for at least 10% of the stand by tpa. Due to the lack of species other than Douglas-fir and the lack of snags and logs in the simulation dataset, it was only possible for stands to be classified as SI, ES, UR, and BD. If the simulation dataset had included multiple species, snags, or logs, stands currently in the BD stage may have been classified as DU, ND, FF, or OG.

The measurable criteria for each development stage is provided below:

Old Growth:
The OG stage requires a minimum QMD of 24”, at least two species, at least three conifer snags with a minimum DBH of 20” and a minimum height of 12’, at least six logs with a minimum diameter of 12” and a minimum length of 20’, and a minimum canopy closure of 30% in an unmanaged forest.

Ecologically Fully-Functional:
The FF stage requires a minimum QMD of 21”, at least two species, at least two conifer snags with a minimum DBH of 20” and a minimum height of 12’, at least six logs with a minimum diameter of 12” and a minimum length of 20’, and a minimum canopy closure of 35% in a managed forest.

Niche Diversification:
The ND stage requires a minimum QMD of 21”, at least two species, at least two conifer snags with a minimum DBH of 20” and a minimum height of 12’, at least two logs with a minimum diameter of 12” and a minimum length of 20’, and a minimum canopy closure of 35% in a managed forest.

Botanically Diverse:
The BD stage requires a minimum QMD of 21”, one species, at least two conifer snags with a minimum DBH of 20” and a minimum height of 12’, at least two logs with a minimum diameter of 12” and a minimum length of 20’, and a minimum canopy closure of 35% in an unmanaged forest.

Developed Understory:
The DU stage requires a minimum QMD of 21 and a minimum canopy closure of 40% in an unmanaged forest or after thinning of a managed forest.

Understory Reinitiation:
The UR stage requires a minimum QMD of 16 and a minimum canopy closure of 40% in an unmanaged forest or after thinning of a managed forest.

Exclusion State:
The ES stage requires a minimum canopy closure of 60%.

Stand Initiation:
All stands that do not classify as one of the other stages are classified as SI to represent stands that are essential an open structure as a consequence of management activities or disturbances.