EXTREME POLICIES MODELED WITHIN THE LANDSCAPE MANAGEMENT POLICY SIMULATOR (LAMPS)

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ABSTRACT

Several variations on the current behavior of four major landowner groups in the Coast Range of Oregon were simulated using the LAMPS model. The simulation of current and future behavior is termed the Base Case, and assumptions regarding this behavior were derived from numerous meetings with landowner groups associated with the management of Coast Range forests. The extreme policies we model are deviations from the Base Case: limit the maximum clearcut size to 40 acres; set a minimum harvest age of 80 years; assume that entire Coast Range forests are managed by a single landowner group. Results show that minor reductions in harvest levels and net present value are projected when the 40-acre maximum clearcut size is assumed. When the 80-year minimum harvest age is assumed, major reductions in both harvest levels and net present value are projected from Base Case levels. Significant increases are projected for both harvest levels and net present value when we assume that the entire Coast Range is managed by either industrial or non-industrial landowners. These results may follow intuition, but until now have not been quantified for such a large area and long time frame.

INTRODUCTION

The LAndscape Management Policy Simulator (LAMPS) was developed within the CLAMS project (CLAMS 2003) to evaluate alternative forest management policies within the Coast Range of Oregon. The Coast Range analysis area of CLAMS contains about 2.8 million ha of land, spanning the area from the Columbia River south to the northern edge of the Siskiyou National Forest, and from the Pacific Ocean east to the Willamette River. The area contains a patchwork of land ownerships, most notably the Siuslaw National Forest, a significant portion of the of the Bureau of Land Management forests in Oregon, the Tillamook State Forest, several large industrial tree farms, and 400,000 ha of small, non-industrial private forestland.

LAMPS was initially designed to enable the simulation of the “Base Case” forest management strategy of four major landowner groups: federal, state, industry, and non-industrial private. Over the past five years, 75-100 meetings with industrial, federal and state stakeholders were held to determine their current and future management intentions and to assess whether the LAMPS simulation process was adequately modeling their behavior. In addition, surveys of industrial and non-industrial management behavior, conducted by the Oregon Department of Forestry, provided valuable information regarding the behavior of these ownership groups.

In addition to modeling the Base Case, much of the CLAMS modeling work over the past five years has been devoted to modeling minor variations to these policies. This work has been guided by the Oregon Department of Forestry and the Oregon Board of Forestry. Emphasis has been placed on understanding the impacts of potential changes to policies, to allow both managers and policy makers to think through the policies prior to making

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decisions. LAMPS simulations along with subsequent geographic information system (GIS) analysis provide stakeholders with a spatial perspective on forest policies, which should supplement the typical tabular analyses that describe potential harvest levels and acres treated for various forest policies.

This research was aimed at exploring unfamiliar areas of the solution space that might be considered extreme points in the solution space. The policies modeled here are neither Law, nor likely to be implemented any time soon, if ever. They include a major diversion from the maximum clearcut size allowed on private lands, a restriction requiring a high minimum average age of harvested stands on all lands, and an examination of the capability of the landscape to produce timber volume if one were to assume that a single landowner group managed the Coast Range using the current and future management assumptions contained in the Base Case policy scenario.

METHODS

LAMPS is a simulation model that allows one to simulate separately the policies of the four major landowner groups in the Coast Range of Oregon. Details of the processes and opportunities for devising alternative management policies in LAMPS can be found in Bettinger and Lennette (2004). Details regarding the mathematical structure of the LAMPS simulation processes can be found in Bettinger and others (2005). We next briefly describe the spatial database structure required for LAMPS simulations as well as a brief description of the scheduling pro-cesses for federal, state, industrial, and non-industrial management.

The level of spatial detail required for a scheduling process such as LAMPS is generally negotiated among planning teams. Within the CLAMS project, it was deemed important to maintain fine spatial detail to facilitate modeling of wildlife habitat and geomorphological processes. Therefore, the team decided to recognize aggregations of pixels that had the same vegetation structure, distance from the stream system, and land allocation. These basic simulation units averaged approximately 2 pixels in size. The number of original pixels available from a raster GIS vegetation database developed using a gradient nearest neighbor approach to classification (Ohmann and Gregory 2002) was in excess of 45 million. The number of basic simulation units modeled in LAMPS is about 23 million. Associated with each basic simulation unit were a number of forest structural conditions, including timber volume, average tree age, quadratic mean diameter, average log diameter, and vegetation class. Management units were created by combining watersheds (developed using a 10 m digital elevation model) with land ownership boundaries and aggregated vegetation polygons (large areas of similar vegetation), and subsequent parcelization of the landscape based on the stream system and ridge lines. This process resulted in the development of approximately 441,000 management units. On average, each management unit contains about 50 basic simulation units.

Management units, containing land managed by a single landowner, can be aggregated up into either clearcut harvest blocks or interior habitat areas using a process based on the area restriction model presented by Murray (1999). The area restriction model is a concept related to the spatial aggregation of management units for spatial forest planning processes. Here, any combination of management units that are considered adjacent for planning purposes (sharing a point, line, or within some proximity of each other) can be combined for simultaneous treatment as long as the combined size does not exceed some threshold. Green-up periods, the time it takes regenerated trees in clearcut areas to reach a certain size, are used in conjunction with spatial scheduling rules to control the placement of activities across a landscape. For example, while we may control the maximum size of clearcuts with an area restriction model, we may also control the placement of subsequent clearcuts by preventing their placement next to previous clearcut until some time has passed (the length of the green-up requirement). Area restriction models have thus been used extensively to control the maximum clearcut size in tactical forest planning. They have also been used to build and maintain habitat for which habitat models suggest need be of a certain size (Bettinger et al. 2002).

Management units may also contain multiple land allocations associated with a single land owner. For example, some of the state management land allocations are based a distance from the stream system. In the case of state management, a single management unit may contain three or more land allocations. The level of forest management allowed is assigned at the land allocation level. For example, one land allocation may allow both clearcutting and thinning, partial cutting within riparian areas, and minimal residual legacy trees in regenerated stands. Another land allocation may only allow thinnings to occur, and no activity in riparian areas. The potential timber harvest volume (and hence net revenue) is assessed by determining the level of allowable activity for each basic simulation unit (based on the basic simulation unit's land allocation), and summed to the management unit level for scheduling of activities.

At a higher level of spatial aggregation, LAMPS recognizes land ownerships (federal, state, industrial, and non-industrial), each of which is simulated separately. And finally, “megasheds,” ranging in size up to about 0.65 million ha, are recognized. Given the amount of data tracked at the basic simulation unit level (timber volumes, land allocation, and others, and the status of each land allocation in each time period) and the type of computer available (one with 2 Gb RAM), this disaggregation of the Coast Range into reasonably sized megasheds was necessary. Results are then generated for each megashed, then aggregated to describe the impact of policies for the entire Coast Range.

LAMPS modeling processes

LAMPS utilizes a different modeling process for simulating the behavior of each landowner group. After attempts to understand the goals and objectives of each landowner group when viewed in aggregate (e.g., all of the industrial landowners in the Coast Range viewed as a single group), a modeling process was chosen to best represent those goals and objectives. For example, on federal land, under current policy, it is unclear whether an objective exists. A number of constraints were identified, such as (1) only a certain percentage of matrix land could be clearcut each year, (2) each watershed needed to contain a minimum percent of older forest prior to scheduling clearcuts within that watershed, and (3) clearcuts should be relatively small. Therefore, we use a Monte Carlo simulation to spatially simulate forest management activities over time on federal land, subject to the constraints. We also use a unit restriction model to control adjacency, as described in Murray (1999). State land management seeks to achieve the highest even-flow timber harvest volume over time, subject to several ecological constraints (related to achieving forest structural conditions, and maintaining a distribution of interior habitat areas). LAMPS uses binary search to simulate this behavior, and unit restriction adjacency to control clearcut sizes.

Industrial behavior is also modeled using binary search. Here, we noted that over the last 20-30 years, industrial landowners (as a whole) have tended to harvest a relatively even amount of timber each year, even though individual companies may be seeking to maximize other economic goals. In the industrial management simulation model, management units are blocked to create clearcuts that seek to fit a distribution of clearcut sizes using a dynamic deterministic process (Bettinger and Johnson 2003), which uses the area restriction model described in Murray (1999). The non-industrial simulation process also uses this blocking approach to develop clearcuts of certain sizes, yet schedules activities using Monte Carlo simulation. The best we can gather from the behavior of non-industrial landowners is that their tendency to harvest is either based on timber prices (difficult to project a long way into the future) or landowner age (impossible to determine). The Oregon Department of Forestry developed some relationships that show the probability of harvest as a function of stand age, and we use these relationships in LAMPS to decide whether or not to harvest a management unit each time period.

A number of other aspects of management behavior are modeled in LAMPS. These were determined as important via our discussions with the landowner groups, and can be considered a brief description of the Base Case policy for the Coast Range (Table 1).

The extreme policies are modeled by changing some of the assumptions contained in the Base Case scenario. For example, to model the 40 acre maximum clearcut size policy, we simply limit all clearcuts in each of the simulation processes to a maximum of 40 acres. Previously, clearcuts were allowed to be as big as 120 acres. To model the 80-year minimum harvest age, all other Base Case policy assumptions were held constant while a minimum harvest age of 80 years was imposed on all ownerships. Previously under the Base Case, the minimum harvest ages ranged from 35-80 years, depending on the land allocation. To model the policies where we assume that the Coast Range is managed by a single landowner, we first specified that all of the land in the Coast Range was contained within one landowner group, then applied the management behavior described in the Base Case for that landowner group to the land. The only exception was that Congressionally reserved lands (wilderness areas) were maintained in federal ownership. Making this change in land ownership was relatively easy for industrial and non-industrial scenarios. The federal scenario was problematic - we could not identify late successional or riparian reserves on areas that (in the Base Case) were identified as industrial, non-industrial, or state land. State management behavior requires identifying land allocations as a function of distance from the stream system, which would require significant GIS work. Therefore, modeling all lands as if under state ownership was not pursued here. Further, in the forest industry scenario, the forest industry management intensities, which are generally higher on forest industry land in the Base Case, were applied to all lands (except those mentioned above that were not given a new ownership status).

Table 1—Major assumptions in the Base Case policy, by landowner group.

	Landowner group			
Assumption	Federal	State	Forest industry	Non-industrial private
Minimum harvest age (yrs)	50	45	35	35
Green-up period (yrs)	5	5	5	5
Maximum clearcut size (acres)	—[a]	—[a]	120	120
Riparian option[b]	1	2	3	3
Leave tree option[c]	1	2	1	1

[a] Limited to the maximum size of a single management unit

[b] Riparian options: 1 = No harvest within Oregon Forest Practices Act buffers, no harvest of hardwoods within 100 feet of a stream; 2 = allow partial harvest within Oregon Forest Practices Act buffers, yet no harvest of hardwoods within 100 feet of a stream; 3 = allow partial harvest within Oregon Forest Practices Act buffers.

[c] Leave tree options: 1 = leave two trees consistent with the Oregon Forest Practices Act; 2 = leave 5 or 14 trees per acre per Oregon state lands forest plans.

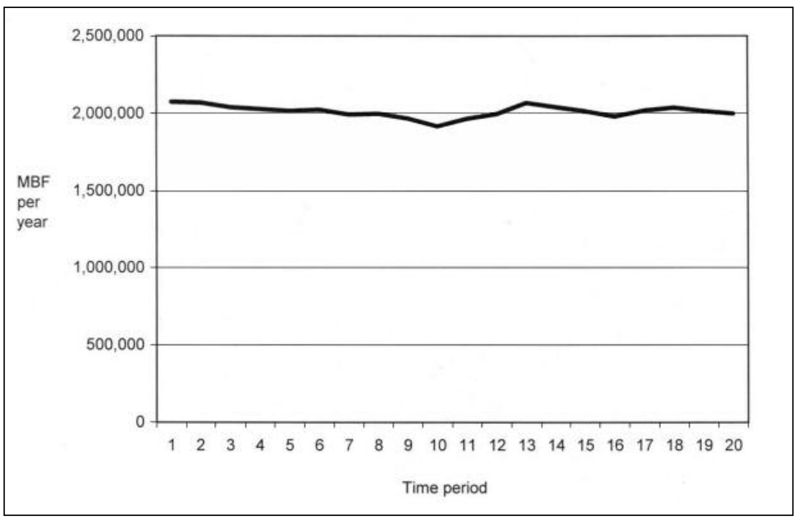

Figure 1—Projected timber harvest levels from the Base Case forest landscape policy for the Coast Range of Oregon.

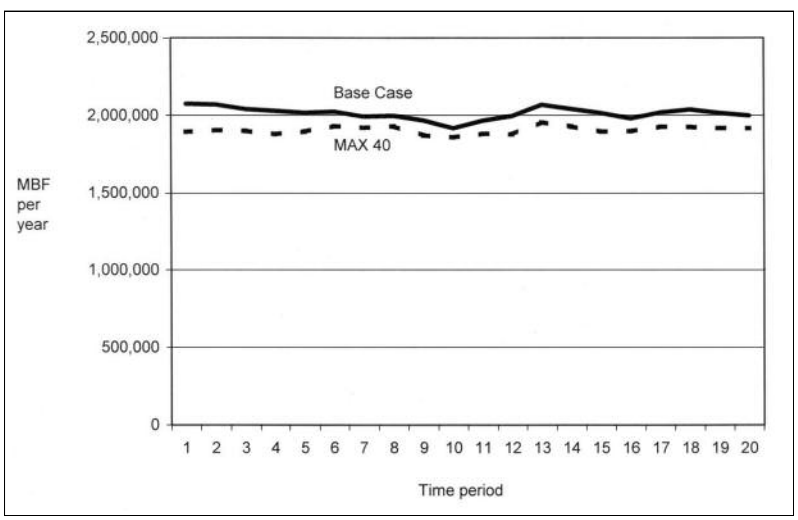

Figure 2—Projected timber harvest levels from the Base Case and the 40-acre maximum clearcut size forest landscape policy for the Coast Range of Oregon.

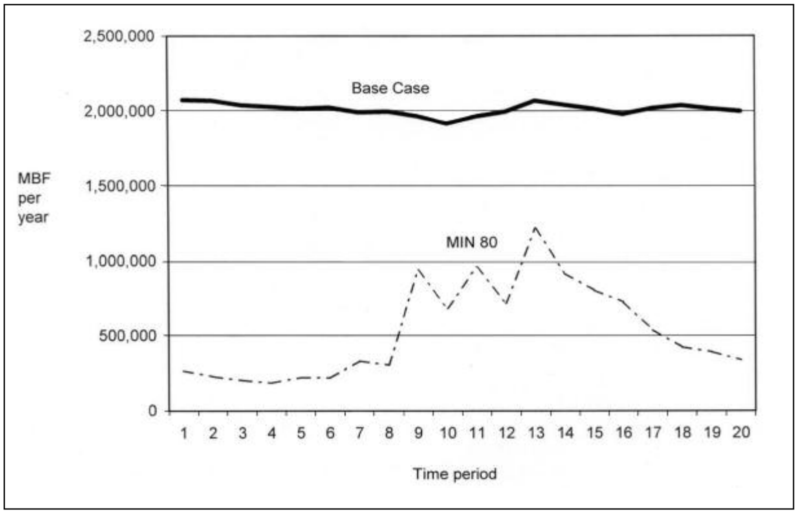

Figure 3—Projected timber harvest levels from the Base Case and the 80-year minimum harvest age forest landscape policy for the Coast Range of Oregon.

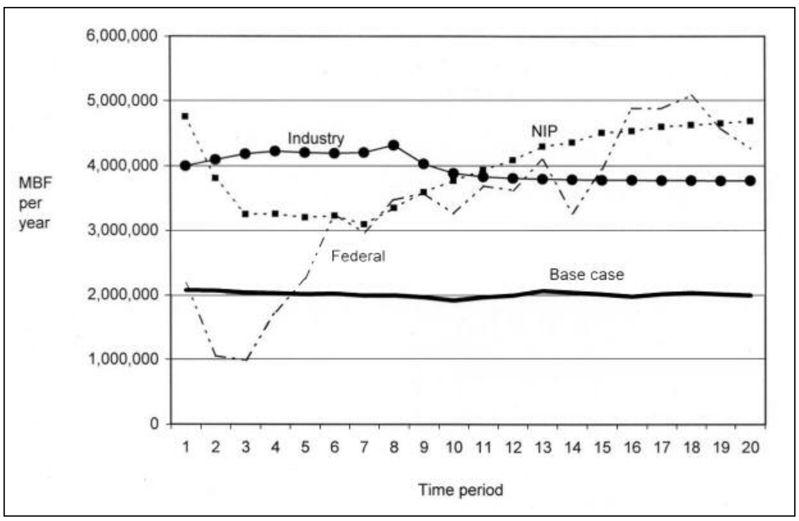

Figure 4—Projected timber harvest levels from the Base Case and the forest landscape policies related to single landowners for the Coast Range of Oregon.

RESULTS

Timber harvest volumes for the Base Case were projected to be around 2 billion board feet per year for the next 100 years (fig. 1), although only two of the landowner groups simulated had even-flow goals (forest industry and state). The net present value of the Base Case policies for the Coast Range is projected to be approximately $12.765 billion. This takes into account harvest revenue, logging costs, site preparation costs, reforestation costs, and weed control and fertilization costs (where appropriate), and uses a 6% discount rate for each landowner group. When clearcut sizes are limited to a maximum of 40 acres, the harvest levels dropped slightly more than 5% (fig. 2), and net present value declined about 7%, to $11.816 billion. One of the reasons that the maximum clearcut size did not have much of an effect is that the average clearcut size in the Base Case was about 40 acres. Increasing the minimum harvest age to 80 years had a more significant effect on the Base Case (fig. 3), since much of the forest in this area of the Coast Range is significantly less than 80 years of age. The even-flow objective of the industrial land, given the harvest constraints in the first few time periods (due to the increased minimum harvest age), significantly constrained projected industrial harvest volumes. While timber harvest levels fell, on average, about 73% from the Base Case harvest levels, net present value fell almost 86%, to $1.846 billion, due to the low harvest levels in the early time periods.

When the entire Coast Range was assumed to be under the management of a single landowner, some interesting results were noted (fig. 4). First, when simulated as being managed under an industrial management regime, projected harvest levels were significantly higher than the Base Case,

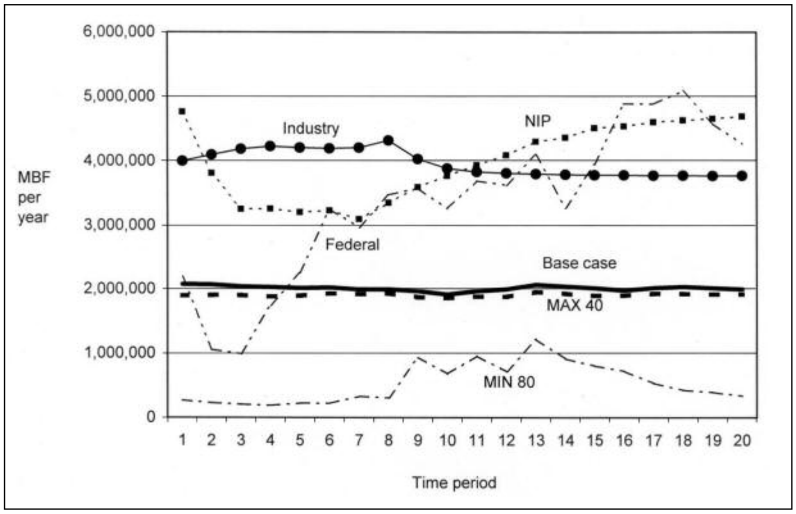

Figure 5—Projected timber harvest levels for all forest landscape policies for the Coast Range of Oregon.

as the older forests on federal and state land now facilitate higher near-term harvest levels, allowing for a high even-flow harvest level. Further, potential harvests on formerly state and federal lands are not as constrained by ecological goals as they were in the Base Case. Harvest levels were projected to be almost double the Base Case, and the net present value of the industrial ownership scenario was projected to be about 119% higher than that of the Base Case. The net present value of the non-industrial ownership scenario was projected to be about 74% higher than the Base Case, and harvest levels, while higher than the Base Case, fall from initial relatively high levels, then increase again in later time periods. We believe this to be a function of the probability of harvest process used in the non-industrial case, which is a function of the average age of the timber in each management unit. Here again, potential harvests on formerly state and federal lands are not as constrained by ecological goals as they were under the Base Case.

When the entire Coast Range was assumed to be managed under federal ownership, we find that projected harvest levels initially decline (from Base Case levels), then increase significantly in later time periods. The federal management scenario is not constrained by an even-flow goal, as are the forest industry and state management policies. The main constraint related to harvesting is that more 15% of a watershed needs to be in "older" forest before any clearcut harvesting can occur. Once this happens (after about time period 4), clear-cut harvests are only constrained by the 15% older forest goal, a limit on the total amount of clearcutting per time period (1%), and unit restriction adjacency constraints, thus projected harvest levels are very high in the later time periods, at times higher than any other scenario we modeled (fig. 4). In addition, all "federal" lands that were not previously in federal ownership were modeled as matrix land allocations, so the true federal restrictions (related late successional reserves and riparian reserves) may have been underestimated here. The projected net present value, in fact, of the federal management scenario, is about 7% higher than the Base Case. Figure 5 shows a composite of all of the extreme policies modeled with the LAMPS simulation model.

DISCUSSION

LAMPS is a simulation model designed to assist managers and policy makers in thinking through potential forest landscape policies prior to implementation. It uses a hierarchical structure to model large-scale, long-term policies, and does so for all landowners contained in a landscape. The modeling framework is, of course, a simplification of reality. However, we have conducted numerous meetings with landowner groups who manage land in the Coast Range to determine the most appropriate course of action for modeling their behavior. Although validating such a complex simulation model is problematic, modeling current and future management behavior as close as possible to the actual behavior lends credibility to the results.

One of the major concerns of the LAMPS modeling process is the use of an even-flow goal on state and industry land. The even-flow goal significantly constrains harvest levels in some of the scenarios modeled. Standing timber volumes, in fact, generally increase over time on lands simulated with this goal. Higher total timber harvest volumes may be simulated if the even-flow goal was relaxed. Most of the simulations show a "bottleneck" period that constrains higher even-flow harvest levels. We are currently developing and testing processes to allow upward deviations in even-flow harvest levels, leaving the constraining time period at perhaps lower harvest levels. These variable harvest levels will first ensure that the maximum even-flow volume can be achieved, then allow additional harvest without sacrificing volume from any even-flow constraining time period.

Neither the even-flow assumption nor the constraints modeled here as "extreme policies" (40-acre maximum clearcut size or 80-year minimum harvest age) are Law. The even-flow goal was obtained from evidence of recent landowner behavior. Therefore, it seemed to be an appropriate indicator of the behavior of two large landowner groups. Some might argue that in the past, industrial landowners in Oregon had the ability to use federal timber sales to buffer changes in timber markets. It remains to be seen whether this is still possible given the sharp, and recent, decline in federal timber sales. Therefore, the even-flow behavior modeled on state and industrial land may, in the future, change, and give way to a more erratic level of harvest based on maximization of economic or ecological criteria.

These extreme policies that we have modeled with LAMPS provide a perspective on a portion of the solution space that usually goes unexplored in policy analyses. More likely, when developing long-term strategic plans or evaluating the potential effects of new policies, a Base Case is modeled, and minor variations around the Base Case are examined, each reflecting likely changes to regulatory or organizational policy. We feel that by exploring other areas of the solution space, a more complete picture of the productive capacity of the Coast Range forests can be understood.

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