PNW
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Science FINDINGS

INSIDE

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"Science affects the way we think together."
Lewis Thomas

FINITE LAND, INFINITE FUTURES? SUSTAINABLE OPTIONS ON A FIXED LAND BASE

Land use goals seek to conserve farm and forest lands while designating limited areas for urban expansion, however, unintended effects can still reach across sectors.

IN SUMMARY

The United States is expected to add around 120 million, an additional 40 percent, to its population in the next 50 years and personal incomes are generally projected to rise. This will inevitably intensify land use pressures. Between 1992 and 1997, USDA's National Resource Inventory estimated that 2.2 million acres of rural land were developed each year, with forest land being the largest source. Sustainability options for agriculture, forestry, residential communities, biodiversity, and employment are worth exploring.

Forest and aquatic ecosystems are shaped by interactions that cross major land use boundaries and ownerships. Policy decisions in the forest or agriculture sector, made with the best of intentions, can have unintended consequences in other sectors. It is crucial therefore that policymakers understand the potential impacts of their choices, and new modeling capabilities developed by PNW scientists are helping to make that possible.

"In nature there are neither rewards nor punishment—there are consequences."
Robert G. Ingersoll 1833-1899

Fifty years from now, according to the U.S. Census Bureau, the United States could be home to as many as 120 million more people, a 40-percent increase over the current population. Given the land use and natural resource issues we already face with today's population of about 285 million people, are policymakers ready for this increase?

Or, put another way, how can progress toward sustainability be maintained in the face of needing more land to serve a lot more people in the future? To help evaluate progress, we need a definition of sustainability and indicators that reflect something basic and fundamental to the long-term ecological, economic, and social well being of our land base and residents over generations. Examples are indicators used to reflect "sustainable forest management" based on the Montreal international process. Such efforts are still in their infancy, but we can examine tradeoffs among alternative future scenarios.

Potentially, many future paths could lead to societal improvements, however, and the development of sustainability indicators is a challenge because of the complexity of the economic-environmental-social relations involved and because of the absence of a commonly understood measurement unit comparable to monetary units used in economic indicators. We can evaluate ecological and economic tradeoffs among different alternative paths, and can increasingly examine those across different sectors of the economy such as for forestry and agriculture.

"The forestry and agriculture sectors compete for the same, fixed land base, with both generally being dominated by the demand for land for housing, infrastructure, and other development uses," says Ralph Alig, a research forester with the PNW Research Station in Corvallis, Oregon. "Taking a systems viewpoint, they are not separable, and policies designed to target one issue in one sector can have substantial implications for other parts of the sector and for other sectors."

Alig points out that different "sustainable" futures are possible, but each is associated with tradeoffs, such as different price levels and economic benefits faced by consumers, amounts and quality of habitat for wildlife and fish, and living and recreational space that affect quality of life for U.S. citizens. Knowledge of potential tradeoffs can aid policymakers, who assign weights to different tradeoffs and may have to utilize multiple decision criteria for complex issues.

"Public forest land policies, centered in the Pacific Northwest, can have substantial consequences for the forest and agriculture environments in other regions, through induced changes in land use, forest cover types, and intensity of land management," he says.

Alig has worked with colleagues to provide land use and cover projections to various analyses of global climate change, timber supply prospects, wildlife habitat, and other natural resource-based activities that draw on the fixed land base. The zero-sum nature of land use changes on a fixed land base is a key component in investigating sustainability across the entire land base, not just the forested subset.

KEY FINDINGS

- Public forest land policies, centered in the Pacific Northwest, can have substantial consequences for the forest and agricultural environment in other regions, through induced changes in land use, land cover types, and intensity of land management.
- Links among major land uses are important when considering sustainability and global-change analysis. Policies targeted at one issue in a sector can have substantial economic implications for other parts of the sector and other sectors.
- Some policies may induce changes in land use and management that act in some cases to counter the intended effects of the policy.
- Policies in the West aimed solely at habitat conservation could directly affect forest carbon sequestration in other regions. Likewise, policies aimed only at carbon sequestration goals could have significant ripple effects across sectors.

FIRST-ROUND EFFECTS AND RIPPLE EFFECTS

In the Pacific Northwest, we are well familiar with forest policies designed to achieve habitat conservation, and the social debates associated with job loss owing to reduced timber harvest. We are less familiar with the results of our policies in more distant regions, or across the fence in the agricultural sector.

It is not new to the United States to pursue policies with both ecological and economic objectives, Alig points out. Consider the common goals of improved water quality; timber, fish, and wildlife habitat; recreational opportunities; erosion control; and more.

And although policies affecting public forest lands get the most press, the largest part of U.S. timberland, about 75 percent, is privately owned, and the responses of these owners are also important considerations for policymakers. Further population increases are likely to lead to less U.S. timberland area per capita in the future, thereby resulting in increased demands on a smaller timberland base.

"Unfortunately, the ecological and economic impacts of forestry and agricultural policies are usually analyzed in isolation," Alig says. "Efficacy of policies may be adversely affected if owners do not react as anticipated, which can lead to outcomes very different from the intended aims." Revealed behavior also may highlight hidden links and spill-overs within the system.

Purpose of PNW Science Findings

To provide scientific information to people who make and influence decisions about managing land.

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Typical ripple effects include changes in owner behavior and forest conditions in nontargeted regions, external pressures on forest and nonforest lands, unintended and potentially long-term effects on investment in private timberland management, and ecosystem changes at scales beyond the forest and landscape levels at which policies often are viewed.

LAND MANAGEMENT IMPLICATIONS

- Changes in public forest policies in the West could affect the economic welfare of private landowners and consumers of forest products across the country.
- Changes in public land management policies can affect private land use management decisions, both within the region and in other regions, and in some cases it can alter management pressures for federal land managers.
- Policymakers now have decisionmaking tools available to consider cross-sectoral effects of policies, allowing integrated assessments not previously available.

THE MISSING FACTORS

Until recently, most timber supply, forest carbon, and wildlife habitat studies have treated quantities of land and natural resources as fixed, or "not explicitly modeled." The reality, however, is that continued shifting of agricultural lands to forestry use, or vice versa, could act to change potential economic returns from land and land prices in both sectors.

In addition, decisions to expand or maintain current levels of timber stocking may require changing some age-class distributions or species mixes. But the long-term nature of forestry production means that characteristics of existing timber stocks may influence timber flows over the next several decades, Alig notes. The time between planting a tree and its reaching sawtimber size could be 20 to 30 years in the South, which has the shortest forest replacement periods in the country, but still takes much longer than maturation periods for land use competitors such as agriculture.

Furthermore, the interaction between management of existing timber stocks and changing land use has not previously been captured within the model, particularly in private ownerships, where there obviously will be feedback between a new policy action and a new round of land management decisions.

What has been needed, Alig says, is an integrated-assessment approach to studying land use and land cover dynamics: it is crucial to analyze more than just the direct or first-round effects of policies targeted at improving environmental conditions. With university and government colleagues, he developed the forest and agricultural sector optimization model, or FASOM, which aggregates the actions of landowners. Under one of many possible objective functions, owners are assumed to be risk-neutral, and to be in quest of the highest possible value of returns from their lands into the future.

The FASOM allows transfers of private land between sectors, thereby allowing for the typically higher productivity of land recently converted to forestry from agriculture, as compared with land that has been in tree cover for one or more rotations. The bioeconomic model bases the transfers on the profitability of the land in all alternative forest and agriculture uses over the time horizon of the model, Alig explains. Empirical timber yield tables drawn in part from the work of other Station scientists and others allow the model to simulate the growth of existing and regenerated forest stands, based on data from more than 70,000 forest survey plots nationwide.

BILLIONS OF DECISIONS AND CONSEQUENCES OF POLICIES

Alig's team examined the economic and ecological impacts of two forest policies selected to represent opposite extremes in their initial focus. One is a minimum harvest age limitation imposed on private landowners by regulation, the other is a reduced public harvest policy designed to protect and expand areas critical to wildlife habitat.

Consequences of the two land use policies, projected through nine decades, indicated some substantial effects through time, across sectors, and across different regions of the country. A base case, reflecting no change in policy, also was developed for comparison.

"The extended-rotation policy leads to higher timber product prices that boost potential economic returns from forest land through time," Alig explains. "The amount of private land use change under the extended-rotation policy is more than double that of the other scenarios."

Private softwood areas are projected to increase in the short term under all scenarios, reflecting timber investment opportunities primarily in the South and less so in the Pacific Northwest, west side. At the same time, hardwoods would continue to cover most of the southern timberland base. In the longer term, Alig notes, the policy reducing public harvest alters market prices and increases industry plantation area by as much as 10 percent. Higher log prices cause more investment in converting hardwood types to softwoods.

In addition to changes in species composition, what about forest structure? Could that be another possible reflection of human-environment interactions?

"Age class distributions in all regions are 'shortened,' compressing a larger inventory volume into fewer, younger age classes," Alig explains. "However, areas of the earliest forest successional stages are reduced, despite the concentration of timber inventory in these classes, because rising timber management intensity pushes the progression of stands more rapidly through seral stages and into a closed-canopy condition."

Sequestered carbon—an oft-discussed strategy for mitigating global climate change—increases somewhat under both policies. An extended rotation adds 17 percent over the base case in the first decade, then slips below the base case, and reduced public harvest pushes it up 7 percent in the first decade, then by lesser amounts in succeeding decades.

IMPACTS OF POLICIES ACROSS REGIONS AND SECTORS

Economic changes in both agriculture and forest sectors emerge right from the start.

"The two policies both act to reduce the near-term supply of timber, lower total U.S. timber harvest, and raise log prices," says Alig. "In the reduced-public harvest scenario, higher log prices elicit more private forest investment, gradually forcing prices back down and raising total wood consumption."

In contrast, he notes, the major effects of the higher minimum harvest ages postpone harvest of lands that were "financially mature" in the first decades. When they are eventually harvested, their volumes are larger and consumption and prices return to base levels.

Under the extended-rotation policy, however, log prices remain high for the first two decades. "The required lengthening of rotations prolongs the shortage of merchantable timber, thereby muting supply while demand grows. This drives up log prices to almost 70 percent higher than base prices," he says.

And then, in the agricultural world, with all the rapid movement of land into newly forested condition, grain production drops between 1 and 2 percent during the first two decades, forcing up grain prices.

This, of course, is not the end of the links. In the North, where the amount of afforested land increases so substantially, the value of agricultural land that can be converted to forest goes up about 20 percent. In the South, demand and therefore prices for this land drop by about the same percentage. Meanwhile, the policy increases the supply of softwood land relative to hardwood land, with associated price changes.

Extended rotations would produce an 83-percent economic surplus increase for forestry producers, and a 10-percent increase under the reduced public-harvest policy. Consumers of forestry products under an extended rotation would sustain 10-percent losses—that is, they would pay that much more.

In agriculture, impacts are greatest under the extended rotation policy. Although afforestation and higher grain prices lead to a growth in agricultural producer surplus, Alig explains, the larger overall loss by agricultural consumers leads to a $24 billion overall benefit reduction for the agricultural sector.

TECHNOLOGICAL CHANGES AND FINITE NATURAL RESOURCES

More innovative use of land and other factors of production that were unforeseen have in the past resulted in mistaken predictions of large-scale disasters. "For example, due to technological change, food production increased faster than population growth after the 1968 book 'The Population Bomb' predicted starvation for hundreds of millions," Alig recalls. "The Green Revolution saved many from starvation. As a missing factor in some predictions, such technological changes continue and are increasingly important for forestry and agriculture."

In a developing industry scenario, the pulp and paper industry faces the fundamental long-term resource issue of availability of raw material. An 80-percent increase in paper and paperboard production is projected by 2050, given anticipated economic and population growth.

So one technological-change question under current consideration is: Can this challenge be answered by fiber farming on agricultural lands by using fast-growing, high-yield, short-rotation woody crops (SRWCs) such as hybrid poplars? Energy is a coproduct of these crops in many cases, and research suggests that they will begin to be used more in building products and power production.

Modeling and analyses by Alig and others show some promising trends. "Growing wood fiber demand and tightening supply could mean that introduction of SRWCs could act to temper price rises and bolster reliable supplies of fiber," Alig says. "Expanded fiber farming could reduce management pressures on existing forest resources and enhance sustainability prospects in both the agriculture and forestry sectors."

Even without SRWCs, timber management intensification on private lands over the years has resulted in a significant share of U.S. timber harvest coming from plantations. Although the total SRWC acreage projected will be a modest portion of the whole agricultural land base, he continues, expanded SWRC supply could reduce forest plantation area in the United States and lead to lower forest land values. As a double-edged sword from a forestry perspective, however, it also could allow more forest land to be converted for agricultural production to meet expanding world demands for food and fiber.

Future analyses should consider an expanding array of social objectives and how nontimber and conservation concerns factor into management decisions, Alig believes. Nonindustrial private landowners, in particular, respond to economic forces in complex ways. Analysis of time series of data from forest surveys covering several decades indicates that owner behavior needs to be monitored carefully, along with changes in the forest resource.

"For example, some private landowners may be more willing to establish riparian SRWC buffers, including enterprises integrated with agroforestry, if the owners can manage such SRWCs for economic products while providing conservation benefits," he says.

As Alig notes, the potential impacts of SRWCs seem to be potent relative to the land area involved. Thus, the implications of just this small piece of the sustainability puzzle clearly support the need for integrated analyses.

WRITER'S PROFILE

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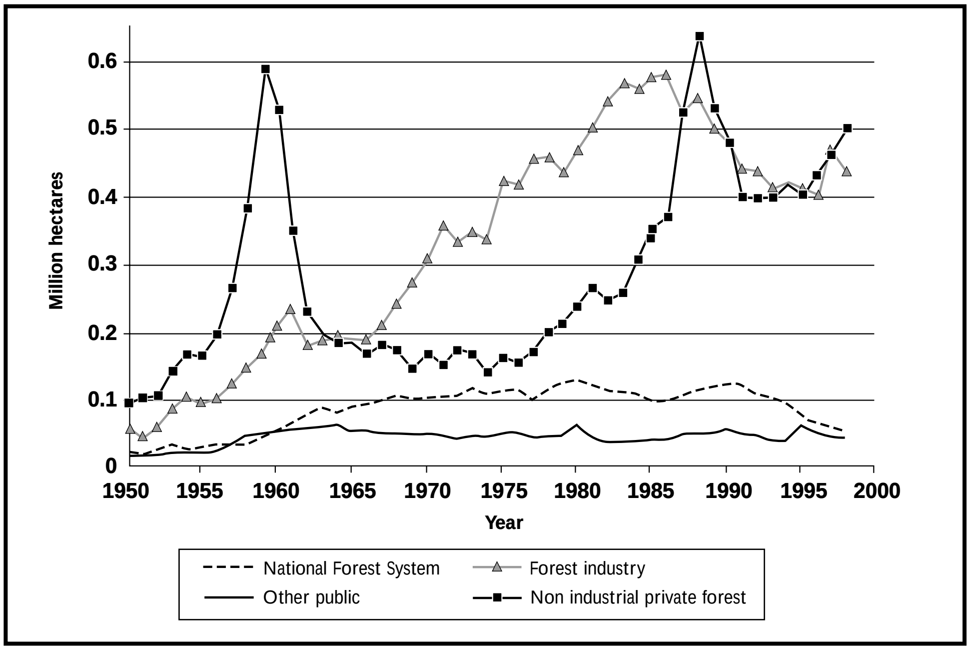
"Land transfers between sectors must be assessed, as they have the undeniable effect of tending to mitigate the intended economic benefit effects of policy shifts," Alig says. "Consider an afforestation policy designed to mitigate climate change effects, for example. Although the amount of forested land might increase under such a planned scenario, after one full forest rotation, much of that land might be converted back to agriculture because of prevailing prices in land markets, thus substantially blunting the originally intended effect of the policy."

The comparisons also clarify the nature of possible reactions within the sectors. "For example, an afforestation policy might alter the use of forest plantations rather than natural forest establishment methods, as well as changing the use of irrigation in agriculture," Alig explains. Interregional effects also can be substantial, as with an increase in southern timberlands should a zero-cut policy be implemented in the West.

"If we ignore land exchanges, we overlook dynamic adjustments to policy impacts. In some cases, we observed both directional and order-of-magnitude differences in estimates of production and consumption impacts, when we incorporated the land exchange effects of policies in our assessments."

A useful complementary approach to land use projections is to project where the path of current policies and behavioral trends would take us, and then develop alternative projections based on opportunities to make improvements from society's perspective, as the FASOM model does. Currently, Alig and colleagues at the Pacific Northwest Research Station, universities, and other Forest Service offices are working on updating a series of national Resources Planning Act assessments that go back several decades. The 2000 assessment is analyzing alternative "sustainable" futures for the nation's forest and rangeland ecosystems. The assessment traces out 100 years, with 50 years of historical data and projections 50 years into the future. A long-time series helps to better provide temporal specificity, sometimes missing in ecological analyses.

What happens as these integrated assessments are completed and brought back to policymakers, Alig has seen, is that the original questions that were posed can then be refined. "It is an iterative questioning process, and our job becomes one of helping policymakers to hone their questions, to stay flexible, to improve their understanding of tradeoffs in the increasingly linked ecological and economic systems, to decide which routes to take. If there is one thing these model results show clearly, it is that there is not only one 'correct' path to sustainability."



U.S. tree planting by forest ownership 1950-1998, with most tree planting by private owners.

"Today, we are coming to realize that our land is finite while our population is growing. The uses to which our generation puts the land can either expand or severely limit the choices our children will have."

Council on Environmental Quality,
Nixon Administration, 1960s

FOR FURTHER READING

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