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Science

FINDINGS

“Science affects the way we think together.”

Lewis Thomas

BIOLOGY, ECOLOGY, AND ECONOMICS AT PLAY: LAND USE AND LAND COVER CHANGES IN THE 21ST CENTURY

IN SUMMARY

In making choices about how to manage the country’s wealth of forest land, stakeholders—including U.S. taxpayers—have many choices, all of them with ripple effects that extend far beyond the immediate stands of trees. In the Pacific Northwest, as elsewhere, biophysical, ecological, and socioeconomic factors combine to influence the areas of forest cover types and their fragmentation. How do we take all these factors into account as we make sustainable natural resource management decisions?

Past studies have tended to view only subsets of the whole set of factors and also have tended to examine changes in land use at relatively small scales. Outcomes over large geographic areas, including privately owned land, have not been closely monitored. Clearly, large-scale and interrelated studies are needed to address net changes in forest cover types that result from natural and human-caused forces.

The Resources Planning Act’s 2000 assessment provides this type of large-scale, cross-sectoral study; scientists from the Pacific Northwest Research Station contributed to the findings about land use changes and their complex interactions across the country. The renewable resource assessments analyze present and anticipated uses of, demand for, and supply of the renewable resources, with consideration of the international resource situation and an emphasis of pertinent supply, demand, and price relationship trends. Land managers and policy analysts can now use the information from the historical analysis and associated projections of forest cover changes in planning for wildlife habitat, carbon sequestration to address global climate change, timber supply, and other goods and services from our forests.



Credit: J. Kline

Loss of forest land to development continues apace across the United States and is expected to continue as the U.S. population grows to more than 400 million by 2050.

*“The future ain’t
what it used to be.”*

Yogi Berra

The new housing development, the new poplar plantation, the new timber harvest, the new land use laws. No matter how complacent we are about the places we live, the patchwork that is land cover in the United States is changing more rapidly than ever.

How do we want to live on the land? With the backdrop of dynamic supply and demand for renewable resources,

uncertain national and international timber market shifts, unknown climate change potentials, and social values demanding a sustainable future, how can we know what choices to make? Coupled with population increases and income growth, the prospect of making sense of our options is daunting indeed.

Throughout the 20th century, the United States has developed periodic assessments of future supply and demand prospects for timber that have helped frame forest policy and shape questions about future resource needs. The passage of the Forest and Rangeland

Renewable Resources Planning Act (RPA) in 1974 formalized that process, and the fifth RPA assessment has recently been completed. It considers a broad set of resource situations that go beyond timber.

Following the trend of the last few decades, it's not all good news.

"Findings from the 2000 RPA assessment indicate that approximately 20 to 25 million acres of forest land could be converted to urban and other developed uses over the next 50 years if historical trends continue," says Ralph Alig. "The rate of conversion of U.S. rural land to developed uses increased in the 1990s, and future increases are projected to be substantial due to U.S. population and income growth. Such land use conversions would further fragment forests, reduce opportunities for storage of carbon in forest, and also impact provision of other forest-based goods and services."

Add to this population projections that suggest another 120 million people by 2050, with relatively fast growth rates in key timber-producing areas of the Pacific Northwest

KEY FINDINGS

- Timber harvests are more frequent on private lands than on public lands. Current financial incentives encourage private owners, especially industrial ones, to convert naturally regenerated stands to plantations. More frequent harvest can increase "age-class fragmentation" even if the land remains in forest cover.

- A significant shift on PNW timberlands has been from hardwood and other softwood types to the Douglas-fir type, mainly on industrial lands. Commercial preference is likely to continue this trend, although markets for alder have improved recently.

- Opportunities exist to expand short-rotation forest cover, such as hybrid poplar on nonforest lands, through conversion of agricultural lands.

- In cases where forest is converted to nonforest through development, the reduction in forest cover may essentially be permanent.

and the South. The implications get quite serious fast.

"As the human population increases, competition among forest, agricultural, urban, and other developed uses for a fixed land base will intensify. Increasingly, economic

and ecological compatibility issues will need to be examined and analyzed," says Alig, a research economist with the Pacific Northwest (PNW) Research Station. Alig was a key contributor to the RPA assessment through a variety of research studies.

THE COMPATIBILITY BALANCE

Compatibility of ecological and economic issues is a linchpin to sustainability, and it is intensely complicated. It is what demands that today's assessments are no longer only about one region, or about one sector, such as agriculture or forestry alone, or one group of owners, such as federal or state. Linking research efforts, linking models, and thereby linking outcomes across the whole landscape and all its owners, tells a much richer story of present status and future options than a single focus ever could.

"The U.S. has a long history of forest policies designed to jointly pursue both economic and ecological objectives. Examples abound of policies affecting water quality, timber, fish and wildlife habitat, recreational opportunities, erosion control, and other environmental services. Unfortunately, the ecological and economic impacts of these measures are usually analyzed in isolation," Alig says.

He notes that policies frequently have unintended consequences, and an integrated economic-ecological approach can identify more than direct or first-round effects of policies

targeted at improving environmental conditions. For example, policies affecting public lands usually receive the greatest coverage in the popular press, and yet some 75 percent of U.S. timberland is in private ownership. Private owners, including the large nonindustrial segment, respond in a variety of ways to forest and natural resource policies.

"The efficacy of a policy may be adversely affected if owners react differently than originally envisioned, leading to outcomes markedly at odds with intended aims," he explains. Ripple effects of policies could include changes in owner behavior in non-targeted regions, long-term effects on investment in private timberland management, effects on both forest and nonforest land uses, and ecosystem changes at scales above the forest or landscape levels at which policies are often viewed.

And neither economic nor ecological conditions stand still for planners or researchers: the projections have to be long term, but the cycles and dynamics can be crushingly short term.

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PRIVATE LAND-USE DECISIONS

Landowners making decisions about use of their lands for forestry or agriculture face a variety of physical, ecological, and economic considerations. They continually choose whether to keep land in its current state, convert it to another use, or intensify management, such as in shorter rotation ages, Alig explains.

Alig and his colleagues used a linked model of forest and agriculture sectors to simulate both a minimum harvest age limitation—proposed ostensibly to increase forest carbon sequestration—and a further ratcheting down of a reduced public harvest policy that is already in play.

“Private responses to both policies indicate that landowners could undertake a range of adjustments to minimize their welfare impacts, but imposing constraints on how they manage existing timber stocks could have particularly potent effects,” he says.

The environmental outcomes range across issues such as biodiversity, age-class dis-

tributions, sequestered carbon, and climate change mitigation. Interregional economic impacts include higher prices for private forest land and timber products in the Southern United States owing to a reduced harvest policy concentrated in the West, Alig says.

When economic incentives prompt planting trees on cropland in the North and less conversion of hardwood forest types to softwood plantations in the South, private land management decisions affect biodiversity trends and wildlife habitat conditions. Biodiversity changes in the short term do not necessarily stay on their initial trajectory, however, as changing market prices for the plantation-grown softwoods could in subsequent decades again alter economic incentives.

Meanwhile, natural regeneration could become a greater player in areas not designated either for plantations or agriculture. The effects on numbers of species of plants and animals, on species populations, and on species viability, could be significant through time.

“This is where the interaction of economics and ecology, of public and private ownerships, of agriculture and forestry, and of one region with another, becomes obvious,” Alig says. “Consequences and ripple effects across regions, owner groups, and sectors might not have been anticipated with traditional, input-oriented policy analysis.”

The changes in age class distributions and forest structure that might result from the paired policies in this study are fairly obvious: with more intensive forest management across regions, age classes are “shortened” as a larger timber inventory is compressed into fewer, younger age classes. This curtails the development, across regions, of younger successional stages in forest development, with habitat implications.

When private forest investment responds to changing public forest policy, it doesn’t just shift the money around.

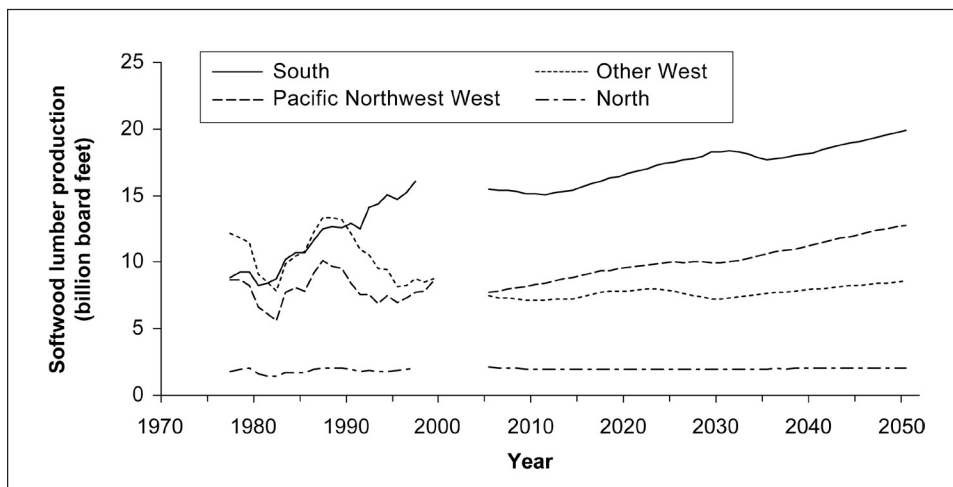
TRACKING THE LEAKAGE

When cross-regional, cross-sectoral changes such as this begin to affect prices and land markets, as they surely will, it becomes crucial to keep both forested and agricultural land in the analysis picture,” Alig explains.

The cross-regional exchanges between the Pacific Northwest and the South illustrate this point. As public timber harvest has been reduced, the South has developed its timberland base—ten times more of it in private

hands than in the Northwest—to the point that it harvests more timber than any country outside the United States.

Immediate implications for the rest of the country include less focus on timber growing in regions such as New England and the Midwest where production costs cannot be competitive, and opportunities to look at those marginal timberlands for alternative natural resources, Alig explains.



Projections of softwood lumber production by United States regions reflect maturation of second-growth timber on forest industry lands, as well as gradual growth of nonindustrial private harvests as their timber inventories expand by more than 20 percent.





Expanding pine plantation areas in the South have helped turn that region into a larger softwood producer than any country outside of the United States.

In the Northwest, another scenario could unfold. “Timber harvest activities are more frequent on private lands than public lands and also often can involve forest cover changes at time of regeneration. The current economics of forestry in the Pacific Northwest are providing substantial incentives for private landowners to harvest naturally-regenerated stands and convert them to planted stands, including genetically improved Douglas-fir,” he says.

Even under this scenario, many planted acres that are harvested then not artificially regenerated can revert via succession to a variety of natural forest covers, especially on nonindustrial private lands. They could also be turned over to agriculture or development, depending on location and other market factors. In cases where forest is converted to nonforest through development, the reduction in forest cover may essentially be permanent.

A concomitant shift on industrial lands has been from hardwoods and other softwood types to Douglas-fir, with implications for

 LAND MANAGEMENT IMPLICATIONS 
<ul style="list-style-type: none">• Changes in forest cover types have important implications for biodiversity trends and for habitat conditions over time and space for a wide range of wildlife species. Policies in one region designed for habitat or carbon sequestration have significant “spillover” effects in other regions.
<ul style="list-style-type: none">• Recent changes in public forest policies in the West are related, via market signals, to shorter timber rotations on private lands. Shorter rotations compress a larger forest biomass volume into fewer, younger age classes.
<ul style="list-style-type: none">• Economic attractiveness of land management options in other regions can have substantial consequences for timber production options and forest cover in the PNW and other regions through induced changes in land use, forest cover types, and intensity of land management.

future land cover. “Projections of long-term changes in areas of forest cover types suggest that areas of Douglas-fir may increase under several scenarios,” Alig explains. “At the same time, opportunities exist to expand

short-rotation forest cover, such as hybrid poplar, on other lands through conversion of agricultural lands.”

CONNECTING HABITAT, CARBON, AND CLIMATE

According to the Santiago Declaration, authored by the United States and nine other countries in 1995, indicators such as total forest area over time, forest species composition, and the extent of area by forest type, age class, or successional stage all suggest coming trends in biodiversity.

Specific effects vary. Hardwood-dependent species would be affected if the decline in hardwood area on private lands continues, whereas those species associated with Douglas-fir would be affected positively. The compression of age classes, resulting from shorter rotations, and changes in the forest structure have significant implications for wildlife species dependent on habitat in later age classes.

The potential for more short-rotation woody crops such as hybrid poplar may also translate into forest habitat on former agricultural lands and could provide relatively immediate or at least interim cover around some riparian areas. If that’s not interconnected enough, the short-rotation woody crops have at least a support role to play in carbon sequestration. And they are at the mercy of world markets just as all other fiber is, so may by default become variable-rotation crops that could

feed veneer markets as well as pulp markets.

The connectedness also works in reverse. “Policies in the West designed to affect habitat conditions for wildlife species could have significant ‘spill-over’ implications for forest cover and forest carbon sequestration in other regions,” Alig says. Think northern spotted owl. Policies aimed solely at carbon sequestration, in turn, can have significant ripple effects across sectors, according to findings of the RPA assessment.

Data pertaining to all these issues are contributing to policy deliberations by the U.S. Department of Agriculture, the Environmental Protection Agency, and other government bodies investigating mitigation strategies for global climate change.

“As a joint product in the timber production process, sequestered forest carbon in the forest system could rise if economic incentives lead to continued growth in the forest inventory in the United States,” Alig explains. “Some of this growth could result from conversion of nonforest land to forest cover, and in conversion of species such as hardwoods to planted conifers, designed to increase the area of faster growing forest cover types.”

Although current assumptions and modeling suggest that aggregate economic impacts of climate change over the next several decades may involve positive timber market effects, they are estimated to be relatively small from a national perspective.

Carbon sequestration and habitat conservation can work hand in hand to good ends, Alig notes. Through more trees we can sequester more carbon, and if we choose the right species in the right time and place, wildlife habitat can benefit markedly. If we reduce forest fragmentation, we can use timberlands more efficiently. If we consider timber growth within wetlands restoration, we’re storing carbon and improving flood control.

Questions, such as how long we want minimum timber rotations to be and which species to favor in carbon sequestration policies are matters of choice, Alig reminds us: What does society want to favor?

WRITERS’ PROFILE

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CROSS-FUNCTIONAL RESEARCH CHALLENGES

The size and nature of the assessment seem to grow each time the assessment comes due under the requirements of the RPA. Preparing projections at regional and national scales to cover multiple sectors and ownerships is no small undertaking. Primary among data sources are the Forest Inventory and Analysis units across the United States, including the associated program within the Pacific Northwest Research Station and the Forest Products Laboratory in Madison, WI. Data support not only the RPA assessment, but the National Global Change Analysis, analyses for the next national Farm Bill, and other policy deliberations. State foresters and the American Forest and Paper Association provided estimates of the likelihood of forest type transitions on private lands.

Challenges are many. Crossing sectors means crossing time horizons: forestry might look at a **minimum** of three to six decades' rotation time, agriculture looks at one year. The unwieldiness of multimodel operations, such as the EPA wanted, push the limits of research and computing capabilities. To stay timely, the assessment needs to take into account genetically improved materials, new harvest methods and rotations, and market adjustments that happen in real time.

Compatibility options for land management, including interregional comparative advan-

tages, are taken into account to investigate the broader scale implications of particular management options. Sustainability options across the entire land base, not just the forested subset, reveal important clues for social and economic adaptability. The truth for researchers, Alig acknowledges, is that they are trying to do long-term projections while grappling with short-term changes.

“However, there is a useful shift in thinking about resources away from potential future shortfalls in timber quantities toward a focus on future price trends and impacts, and most recently towards concerns over the conditions of the land and societal and ecosystem sustainability. This shift has implications for future assessments under the Resources Planning Act.”



Changes in land use among agriculture, forest, and urban areas will continue to affect land prices and markets across regions.

ASSESSMENT DATA FOR FACING THE FUTURE

Alig believes, however, that the resulting assessment findings can be applied creatively to resolving some of the many challenges posed by the interaction of national, regional, and international forces, whether they are economic or ecological in nature.

In addition to changes in the biological composition of forests, changing landowner demographics include increasing numbers of owners and changing management objectives. Investments in forestry on private lands stand to change quite literally the face of the Nation's land cover.

“Additional work remains to better integrate analyses of coarse-scale measures such as those provided by the RPA assessment with those at finer scales of resolution, such as fragmentation of forest types,” Alig says. “As the data develop, we'll probably find ourselves going back and forth between scales to adjust in both directions.”

FOR FURTHER READING

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The uncertainty levels in all such assessments require that we rerun the assessments and update the data constantly, he says. What we do know is that land use and land cover dynamics will contribute, directly and indirectly, to sustainability of forest resources. The dynamics of human development guarantee changing cycles, with components such as tradeoffs between sectors, less land for growing trees, a dramatic need for fire planning in the urban-wildland zone, a call to revisit land use planning laws, and an investigation of how private markets can help in natural resource management issues.

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years, he has continued that research, and has developed land use and land cover models that have been applied in policy analyses involving timber supply, wildlife habitat, global change, and conservation programs. He is the USDA Forest Service's national coordinator for projections of land use and land cover changes for RPA assessments and also has helped develop a national model of land allocation for the forestry and agriculture sectors.

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