STATEMENT OF
DR. BEVERLY LAW
PROFESSOR, GLOBAL CHANGE FOREST SCIENCE
OREGON STATE UNIVERSITY
and
AMERIFLUX NETWORK SCIENCE CHAIR

BEFORE THE
UNITED STATES SENATE
SUBCOMMITTEE ON PUBLIC LANDS AND FORESTS
OF THE SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES
NOVEMBER 18, 2009

CONCERNING

MANAGING FEDERAL FORESTS IN RESPONSE TO CLIMATE CHANGE, INCLUDING FOR NATURAL RESOURCE ADAPTATION AND CARBON SEQUESTRATION

Mr. Chairman and members of the Committee, thank you for inviting me today to discuss managing federal forests in response to climate change for natural resource adaptation and carbon sequestration. I am a Professor of Global Change Forest Science at Oregon State University, and Science Chair of the AmeriFlux network of observation sites that study the effects of climate and disturbance on ecosystems across the U.S. I am also a co-author of the *U.S. Climate Change Research Program's Synthesis and Assessment Product 2.2*, which addressed the "North American Carbon Budget and Implications for the Global Carbon Cycle." I will focus my remarks on current knowledge on forest carbon sequestration and adaptation.

Carbon sequestration

Forests take up carbon dioxide by photosynthesis and store it in biomass and soils, which are both forms of carbon sequestration. Some of the carbon rapidly returns to the atmosphere from respiration by live plants and soil microbes or more slowly through the decomposition of dead material. Fire and harvesting activities also result in carbon emissions to the atmosphere. On balance, forests may be a positive, negative, or neutral contributor of carbon to the atmosphere, depending on variation in climate, land use, wildfires, and harvest activities.

When a mature forest is harvested, much of the carbon that it contains is released back to the atmosphere as carbon dioxide. The disturbance involved in harvesting a forest creates conditions that speed up decomposition; it takes, on average 15 years for a new forest to become a zero net emitter of carbon dioxide (Luyssaert et al. 2008). Harvesting wood increases carbon stores in wood products, but it also decreases live and dead stores in the forest. Thus, it is important to consider changes in all carbon stores (Law et al. 2004).

Today, carbon is accumulating in U.S. forests, offsetting about 16% of the nation's fossil fuel emissions (CCSP 2007). Without forests, atmospheric CO_2 levels would be rising even faster. Over this century, net carbon uptake by terrestrial ecosystems at the global scale is likely to peak before mid-century and then weaken or even reverse, thus amplifying losses associated

with predicted climate change (IPCC 2007b). Part of the reason is increasing loss of soil carbon with increasing temperature and disturbances. Disturbances that release even a small percentage of the soil carbon content could have a large effect on atmospheric CO_2 levels, particularly if the soils contain high concentrations of organic matter, like those in high latitude ecosystems (Schuur et al. 2009).

To manage federal lands in the public interest of carbon sequestration, we should strive to preserve mature and old forests to avoid losses of carbon associated with harvest. Many of the mature and old forests are on public lands, so they are uniquely positioned to act as carbon reserves. For example, in the Pacific Northwest, biomass carbon is usually higher on public lands, primarily because of the younger forests on private lands (Hudiburg et al. 2009). Activities that can contribute to increasing carbon sequestration include: planting forests in areas previously harvested (reforestation), and on lands suitable for growing forests (afforestation). Such forests can be expected to accumulate carbon for many decades.

Carbon sequestration vs thinning to reduce fire potential

Variation in climate, and surface fuel supply and continuity are factors that contribute to increased fire potential. Recent studies (Campbell et al. 2007&2009, Hudiburg et al. 2009, Donato et al. 2009, Mitchell et al. 2009) suggest that efforts to reduce fuels in many types of forests will be counterproductive to sequestering carbon to help offset climate change. Fuel reductions may be necessary in dry regions where uncharacteristic amounts of fuel have accumulated. In moist forests, however, fires were historically infrequent. Findings:

- Most of the forest biomass (live and dead wood) is not consumed by wildfires, even in high severity fires
- Some fuel reduction techniques, especially those that remove half or more of the larger trees, could lead to an increase in fire severity because of additions of logging debris
- Fuel reduction can be effective in reducing fire severity, however, fuel reduction results in decreased long-term carbon storage

Balancing a public interest in maximizing landscape carbon storage with a desire to reduce wildfire severity will likely require thinning treatments to be applied strategically rather than indiscriminately treating all forest stands across the landscape.

One suggested method of compensating for losses in carbon storage due to thinning to reduce fire hazard is to use carbon harvested in fuel reduction treatments as biofuels. Timing is an important factor to consider, for example, how long it took to grow the trees, how quickly the biomass will be used, and how long it will take to replace the removed carbon. Other considerations are fuel efficiency and carbon cost of removal, so there needs to be full carbon accounting. A recent study indicated that using the thinned trees for biofuels will not be an effective strategy over the next 100 years (Mitchell et al. 2009), and 50-100 years is probably the relevant timeframe of forest carbon policy. The analysis on forests with high biomass production and storage capacity showed it would take ~170 years for biomass production to offset carbon emitted from fossil fuels, and over 300 years for ethanol production. This assumed all of the possible energy in these fuels would be utilized, which isn't likely to be the case.

Climate change projections and adaptation

The IPCC (Field et al. 2007) climate projection for North America is characterized by a variety of different patterns of precipitation, with increasing precipitation at high latitudes and a sharp decrease in precipitation across the Southwest. Drought-affected areas will likely increase in extent. Warming in western mountains of the U.S. is projected to cause decreased snowpack, more winter flooding and reduced summer flows.

The IPCC (2007b) also states that (1) about 20-30% of known plant and animal species are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5°C; (2) types of changes seen in plants include range shifts (latitude, elevation) and changes in growing season length, and threatened systems include those with physical barriers to migration (e.g. montane ecosystems); (3) non-climate stresses can increase vulnerability to climate change by reducing resilience and adaptive capacity; and (4) unmitigated climate change would, in the long term, be likely to exceed the capacity of natural and managed systems to adapt (IPCC 2007c).

To facilitate forest response to climate change, measures can be taken to conserve plant and animal species and genetic diversity, and ensure forest landscape connectivity for migration of species to climate in which they can survive and thrive (e.g. corridors, roadless areas). Genetic diversity allows selection for traits that may be more suited to a new climate. There will be winners and losers in a new climate, and species diversity improves the odds of formation of sustainable ecosystems. Federal lands have many of the mature and old forests that can serve as sources of genetic and species diversity needed for dispersal.

In semi-arid to arid regions like the Southwest U.S., prolonged drought pushes species to the limits of survival, and this is often followed by mortality from insects and diseases. If climate becomes more severe in these regions, the idea of sustaining a particular plant association in a particular location could be futile because a tipping point may be reached where climate is outside the historical range for survival of some species within a forest type. If prolonged drought impacts dry forests, thinning may be effective to alleviate drought stress in the remaining trees, but if there is no water available within the rooting depth, mortality will occur even if the forests are thinned (independent of density). Thinning could be counterproductive to adaptation goals if removed trees or seedlings damaged from harvest activities are those best suited to survive and thrive in a new climate.

New policies

New policies are needed for federal forests to focus on sustaining ecological function. Policies should accommodate the variation that exists in forest ecosystems in terms of their diversity and disturbance histories. For example, in the Pacific Northwest, there are distinct differences between moist forests and dry forests that require different policies and adaptation approaches (Johnson & Franklin 2009). The moist forests have evolved with very infrequent high severity disturbance regimes (e.g. wind, fire) where mosaics of stand replacement have occurred. Old-growth moist forests have had little human impact and management treatments are generally not needed to maintain them in the foreseeable future. Younger forests that exist in this moist region could be manipulated to increase ecological diversity. The dry forests have evolved with more frequent low and mixed severity wildfire as the primary disturbance regime, and the structure and function of old forests has been altered by ingrowth of less drought- and fire tolerant species.

Historically, these forests had relatively low densities and with scattered older trees of highly drought- and fire-resistant species. In dry forests, focus should be on sustaining the old trees, modifying fuel loads, and reducing trees that crowd the older trees and make them susceptible to mortality from fire, insects and disease. Such careful applications are needed to maintain ecological function of forests.

Long-term observation networks and a decision support framework will be required to assess the vulnerability of forests to climate change, and to refine management of forests for carbon sequestration. Critical elements of decision support for regional to local actions include integrated long-term observations, an accessible data and information system populated in a timely manner, forest process studies to improve regional prediction, and regional climate modeling appropriate for societal decisions. This would allow management for goals of carbon sequestration and ensuring species and genetic diversity for a future climate. The existing Forest Service Forest Inventory & Analysis program (FIA) has observation sites where measurements could be modified for producing carbon budgets of soil and vegetation and for detecting shifts in productivity and species. The AmeriFlux network that examines responses to climate and disturbance has ~30 sites on federal lands and can be used to detect vulnerabilities and improve model predictions of forest response. For example, over 10-15 years, sites in the network have seen increases in growing season length and the effects on the carbon balance of the ecosystems. The two observation systems can be combined with a decision support system that is needed to produce assessments for aiding policy and management decisions.

Concerns about carbon policy

It is important for carbon credits to prove a concept called additionality, whereby additional carbon is stored due to new actions, going beyond business-as-usual. The concept of 'additionality' addresses the question of whether the project would have happened anyway, even in the absence of revenue from carbon credits. In the case of federal lands, it seems it would be difficult to be considered for additionality because they are mandated to be managed for the public interest of carbon sequestration (the project would have happened anyway). Federal lands should be managed for the public interest of carbon sequestration, not revenue from carbon credits. If federal lands are managed for revenue from carbon credits, it will likely impact ecosystem functioning and other ecosystem services.

A potential unintended consequence of carbon policy would be a reduction in carbon sequestration prior to implementation of the policy so that revenue could be obtained for new actions to increase carbon storage.

If credit is given for choosing not to cut existing forests, monitoring and audits of carbon sequestration will be necessary to determine status of carbon uptake, insurance will be necessary to protect past carbon sequestration from destruction by fire or windstorms, and penalty payments will be necessary if the forest is eventually cut. Such efforts will be costly to administer, diminishing the value of the rather modest carbon credits expected from forestry (Schlesinger 2006).

The IPCC (2007) suggests net carbon uptake by the land is going to decrease in the future. The risk with ecosystem impacts and feedbacks to climate is that once climate reaches a certain point, the problem will become more difficult to address because of less capacity of forests to store carbon. Forests have an important but limited potential to offset climate change.

The critical issue is that we need to slow GHG emissions growth rapidly to quickly enter into a period of decreased emissions.

Summary

As climate change accelerates, the capacity of forests to store carbon will decline, and unmitigated climate change could exceed the capacity of natural and managed systems to adapt. Forests can play an important but limited role in carbon sequestration for mitigating climate change. In evaluating carbon sequestration policy and management options, it is important to fully account for the carbon involved. To manage federal forests in response to climate change for carbon sequestration and adaptation, we can (1) increase or maintain carbon sequestration by avoiding forest removal, replanting forests, and restoring ecosystem function; and (2) facilitate response to climate change by sustaining genetic and species diversity through forest preservation (e.g. for seed sources), enhancing landscape connectivity for migration/dispersal of plant and animal species, and by aiding dispersal to favorable climates. To avoid carbon losses due to drought or fire, it may be necessary to thin some dry forests that have accumulated uncharacteristic amounts of fuels. Thinning could be counterproductive to adaptation goals if removed trees are those best suited to survive and thrive in a new climate. Federal lands have an important role to play in both carbon sequestration and ecosystem adaptation to climate change. The overarching goal should be to sustain forest ecosystem function.

To inform policy decisions, ecosystem function should be assessed at long-term observation sites to quantify baseline conditions in ecosystem function and carbon sequestration, and to track changes in response to climate. The existing FIA and AmeriFlux observation sites on federal lands could serve this need. Critical elements of decision support for regional to local actions include integrated long-term observations, an accessible data and information system, process studies to improve regional prediction, regional climate modeling, and integration of research to produce assessments for aiding policy and management decisions.

Citations

Campbell, J.C., D.C. Donato, D.A. Azuma, B.E. Law. 2007. Pyrogenic carbon emission from a large wildfire in Oregon, USA. *Journal of Geophysical Research* 112(G4), G04014, doi:10.1029/2007JG000451.

Campbell, J., G. Alberti, J. Martin, B.E. Law. 2009. Carbon dynamics of a ponderosa pine plantation following fuel reduction treatment in the northern Sierra Nevada. Forest Ecology & Management 257:453-463.

CCSP. 2007. *The First State of the Carbon Cycle Report (SOCCR): The North American Carbon Budget and Implications for the Global Carbon Cycle.* Anthony W. King, Lisa Dilling, Gregory P. Zimmerman, David M. Fairman, Richard A. Houghton, Gregg Marland, Adam Z. Rose, and Thomas J. Wilbanks, editors, 2007. A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research, Washington, DC.

Donato, D., J.L. Campbell, J.B. Fontaine, B.E. Law. 2009. Quantifying char in post-fire woody detritus inventories. Fire Ecology 5:104-115.

Field, C. B., L. D. Mortsch, M. Brklacich, D. L. Forbes, P. Kovacs, J. A. Patz, S. W. Running, and M. J. Scott. 2007. North America. Pages 617-652 *in* M. L. Parry, O. F. Canziani, J. P.

Palutikof, P. J. v. d. Linden, and C. E. Hanson, editors. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

Harmon, M. E., Harmon, J. M., Ferrell, W. K., and Brooks, D. 1996. Modeling carbon stores in Oregon and Washington forest products:1900–1992. Climatic Change 33: 521–550.

Hudiburg, T., B.E. Law, D.P. Turner, J. Campbell, D. Donato, M. Duane. 2009. Carbon dynamics of Oregon and Northern California forests and potential land-based carbon storage. Ecological Applications 19:163-180.

IPCC. 2007b. Summary for Policymakers.*in* M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, and C. E. Hanson, editors. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.

IPCC. 2007c. Summary for policymakers. Pages 1-23 *in* B. Metz, O. R. Davidson, P. R. Bosch, R. Dave, and L. A. Meyer, editors. Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge and New York.

Johnson, N., and J. Franklin. 2009. Restoration of Forests in the Pacific Northwest: Strategies and Management Implications. 10 pp.

Law, B.E., D. Turner, J. Campbell, O.J. Sun, S. Van Tuyl, W.D. Ritts, W.B. Cohen. 2004. Disturbance and climate effects on carbon stocks and fluxes across western Oregon USA. Global Change Biology 10:1429-1444.

Luyssaert, E.-D. Schulze, A. Börner, A. Knohl, D. Hessenmöller, B.E. Law, P. Ciais. J. Grace. 2008. Old-growth forests as global carbon sinks. Nature 455: 213-215. doi:10.1038.

Mitchell, S.R., M.E. Harmon, K.B. O'Connell. 2009. Forest fuel reduction alters fire severity and long-term carbon storage in three Pacific Northwest ecosystems. Ecological Applications 19:643-655.

Schlesinger, W.H. 2006. Carbon Trading. Science 314:1217.

Schuur, E.A.G., J.G. Vogel, K.G. Crummer, H. Lee, J.O. Sickman, T.E. Osterkamp. 2009. The effect of permafrost thaw on old carbon release and net carbon exchange from tundra. Nature 459: 556-559.