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Informe sobre Estados Unidos de América - Cambio climático y bosques del país: retos y oportunidades

Resumen

Los científicos han vinculado al cambio climático la creciente gravedad de las temporadas de incendios en los Estados Unidos desde los años 80. Actualmente la principal fuente de carbono en la atmósfera es la quema de combustibles fósiles. Los bosques en proceso de crecimiento captan el dióxido de carbono de la atmósfera y lo almacenan como biomasa; las masas forestales que han sufrido perturbaciones liberan biomasa en forma de dióxido de carbono.

Durante el siglo pasado, las temperaturas superficiales han aumentado en el mundo entero como promedio en alrededor de 1º F, y en algunas partes de los Estados Unidos este aumento ha sido de hasta 5º F. Varios factores han contribuido a esta tendencia mundial al calentamiento, en particular la deforestación, la variabilidad del clima natural y el aumento de las emisiones de gases con efecto invernadero. Se prevé que la temperatura media en los Estados Unidos aumente entre 4 y 10º F en los próximos 100 años.

Se estima que este cambio será demasiado rápido para que las actuales masas forestales se adapten a él, lo que entraña un alto riesgo de pérdida generalizada de arbolado y una amenaza para los bosques debido al aumento de insectos, enfermedades y contaminación del aire. Es muy probable que estas amenazas, que están interrelacionadas, afecten a las industrias y comunidades que dependen de bosques saludables y productivos.

Los responsables de la ordenación de los bosques deben estar preparados para ayudar a las superficies forestales a adaptarse a los cambios previstos. Las actividades que pueden contribuir a equilibrar la economía mundial de carbono reduciendo las emisiones de gases con efecto invernadero o aumentando la retención de carbono incluyen la forestación, en particular la reconversión de tierras de cultivo en áreas forestales, la restauración de la vegetación natural y el hábitat de la fauna y flora, la regeneración activa de áreas forestales explotadas, en especial para establecer especies de rápido crecimiento, la agroforestería, la modificación de las prácticas de ordenación forestal para aumentar el nivel de retención de carbono o reducir las emisiones procedentes de la descomposición, las plantaciones de biomasa forestal de rotación corta, la protección de los bosques contra la explotación forestal y su reconversión en áreas no forestales, la explotación maderera de impacto reducido, en la mejora de los procesos de transformación de

la madera para reducir las emisiones procedentes de la utilización de desechos de la madera y de dendroenergía así como la silvicultura urbana.

El sector privado desempeñará un papel fundamental a la hora de decidir si la ordenación de los bosques de América permite o no a estos hacer frente al cambio climático y sus efectos. En los Estados Unidos, la Unión Europea y en otros lugares se están elaborando enfoques y programas de incentivos voluntarios para gestionar los gases de efecto invernadero.

Para que los mercados del carbono puedan prosperar, es necesario que los Estados contribuyan a establecerlos y apoyarlos. El Estado también debe impulsar la investigación fundamental. En concreto podrían llevarse a cabo, entre otras, las siguientes actividades: evaluar las posibilidades de retener más carbono en los bosques y productos madereros, facilitar la eliminación y utilización de biomasa forestal en exceso como biocombustible y conceder incentivos para aumentar la superficie de las plantaciones para generación de energía a partir de la biomasa, determinar cómo afectaría una mayor retención de carbono a otros valores forestales, cuantificar los incentivos financieros necesarios para aumentar el nivel de retención de carbono, facilitar información a los propietarios de bosques sobre lo que puedan hacer para aumentar el nivel de retención de carbono en sus tierras, ayudarles a adoptar las medidas necesarias para aumentar el nivel de retención de carbono, registrar dichos aumentos y obtener créditos por dicho concepto, acelerar el desarrollo de métodos de inventario, acceso a datos y herramientas de análisis en relación con el carbono, elaborar proyectos de demostración y realizar sesiones de capacitación así como aplicar sistemas de "alerta temprana" para detectar los efectos del cambio climático.

Las futuras perspectivas son preocupantes pero hay esperanza. Como responsables de la ordenación de los bosques, el reto al que nos enfrentamos es el siguiente: cómo ayudar a los bosques a adaptarse al cambio climático y cómo reforzar su capacidad para almacenar más carbón y contrarrestar las fuentes de emisión de carbono. A pesar de la incertidumbre existente respecto de la evolución del clima, tenemos oportunidades para actuar. Podemos vigilar los bosques que gestionamos para obtener datos sobre el cambio climático y prepararnos para adaptar nuestros planes de ordenación en consecuencia. Los beneficios de dicha adaptación van más allá del cambio climático; podemos adoptarlos ya sin temor.

Asimismo, podemos modificar una amplia gama de actividades forestales para reducir las emisiones de gases con efecto invernadero o aumentar la retención de carbono. Sin embargo, la introducción de estas modificaciones a gran escala continuando a producir bienes y servicios forestales al mismo tiempo constituirá un enorme desafío.

Introduction

1. The fires of 2000 shocked the nation. Through televised broadcasts, millions of Americans witnessed some of the most severe fire behavior in living memory. Yet the fires were no anomaly; they capped a period of steadily worsening fire seasons since the great Yellowstone Fires of 1988, and they were followed within a few years by the largest individual fires ever recorded in six states. Large fire seasons have continued, particularly in Alaska, with the number of acres burned repeatedly exceeding the ten-year average.

2. Scientists have now linked growing fire season severity since the 1980s to rising temperatures and earlier snowmelts (Westerling and others 2006). Higher temperatures are also blamed for unprecedented bark beetle outbreaks across the West (Nijhuis 2004; Schulte 2006). From Arizona and California to Alaska and British Columbia, tens of millions of acres of beetle-killed trees threaten to fuel even worse fire seasons to come.

3. A common thread is climate change. What is behind it? And what can we do about it as forest managers?

Rising Carbon Emissions

4. Carbon is the basis of life. It provides food, fiber, and energy, and it contributes to the greenhouse gases—mainly carbon dioxide and methane—that keep the planet habitable by trapping heat in the atmosphere. The world's oceans and forests play a role in regulating greenhouse gases. Growing forests take up carbon dioxide from the atmosphere and store it as biomass; disturbed forests release biomass as carbon dioxide.

5. The amount of carbon in the atmosphere has varied widely over geological time, but it has been fairly constant since the arrival of Homo sapiens on the planet—that is, until about 200 years ago. From air samples trapped in deep ice cores, we know that the concentration of carbon dioxide is now higher than at any time in the past 400,000 years (Petit and others 1999).

6. In modern times, the main source of atmospheric carbon has come from burning fossil fuels. In the 1990s, global carbon emissions from fossil fuels were about 6.3 billion tons per year and from land use conversion about 2.2 billion tons per year. Total emissions were offset by an ocean uptake of about 2.4 billion tons of carbon per year and by an "unidentified sink" of about 2.9 billion tons per year—probably a terrestrial uptake in the temperate and boreal zones of the Northern Hemisphere. For the 1990s, the global carbon budget yielded a net greenhouse gas gain of 3.2 billion tons of carbon per year (Houghton 2003).

7. Greenhouse gas buildups tend to warm the earth's surface by trapping increasing amounts of heat in the atmosphere. Over the last century, surface temperatures worldwide have risen on average by about 1 °F, with some parts of the United States warming by as much as 5 °F (IPCC 2001; Joyce and Birdsey 2000). Several factors have contributed to the warming trend worldwide, including deforestation, natural climate variability, and rising emissions of greenhouse gases.

8. Researchers have teased out biological responses to climate change by focusing on climate-sensitive behaviors of plants and animals, such as breeding, emergence from hibernation, seasonal migration, productivity, and changes in species ranges (Parmesan and Galbraith 2004; Parmesan and Yohe 2003). Examples in the western United States include earlier egg laying by Mexican jays; earlier emergence from hibernation by marmots (by nearly three weeks); northward expansion of the range of the sachem skipper butterfly; and the rising dominance of warmwater species in the intertidal community at Monterrey, CA.

9. Researchers have also documented changes in disturbance regimes. About 4 million acres of forest in southeastern Alaska have had 10 to 20 percent mortality from spruce beetle since 1969—one of the largest outbreaks on record. Moreover, the average area of boreal forest that has burned each year has doubled since 1970. A detailed analysis of fire records has revealed a strong

correlation between the length and severity of recent fire seasons and rising spring and summer temperatures coupled with earlier snowmelts (Westerling and others 2006).

Future Impacts of Climate Change

10. If such ecological shifts continue, what does the future hold? Forecasting climate change is fraught with peril, but researchers hedge their bets by modeling a variety of possible climate scenarios based on a range of reasonable assumptions.

11. All climate models project continued warming in the United States in response to projected increases in greenhouse gases (NAST 2001). The average temperature in the United States is projected to rise from 4 to 10 °F over the next hundred years, with the greatest increases in the continental interior and in winter. Growing seasons will likely continue to lengthen in both spring and fall. Precipitation changes will vary, but rainfall events will probably increase in intensity nationwide. The hotter and dryer conditions predicted under some scenarios will likely continue to intensify wildfire activity in many parts of the United States; projected increases in area burned annually range from 4 to 31 percent (Bachelet and others 2003).

12. Under these scenarios, how will ecosystems respond? The answer is far from clear. Researchers must take faraway trends into account, such as changes in Arctic ice. The Arctic climate is now rapidly warming, with much larger changes projected for the future (ACIA 2004). Changes in the Arctic can have a global impact: Increased glacial and river runoff can lower ocean salinity and alter ocean currents that bring warm water to northern latitudes. Changes in the Arctic can also affect migratory species that depend on seasonal habitat in the northern latitudes for breeding and feeding.

13. Researchers must also model the impact of increased atmospheric carbon on plant growth and ecosystem dynamics. Other factors that affect forests are also changing, such as the chemical composition of the atmosphere: Ground-level ozone is rising, and acid deposition continues to be a problem. These factors interact in complex ways that are only partly understood (Aber and others 2001). HHHowever, there is a general consensus among scientists that (1) forest productivity will likely increase in the short term due to warming temperatures and higher levels of carbon dioxide in the atmosphere; and (2) factors that decrease forest productivity, such as tropospheric ozone, could prevail over time, resulting in regional changes in forest cover and the loss of some sensitive species.

14. Climate change and concomitant changes in forest cover are nothing new (Shugart and others 2003). Since the Pleistocene ended about 10,000 years ago, the average global temperature has increased by about 3°F. As the glaciers retreated and temperatures warmed, trees migrated northward, gradually yielding today's forest patterns. For example, relict northern hardwoods can still be found in some of the cooler drainages in Virginia's Piedmont, now dominated by oak/hickory forest, attesting to a colder climate in the past.

However, similarly gradual shifts in forest cover are unlikely today for two reasons:

The anticipated rate of climate change over the next century is at least a hundred times greater than it was following the Pleistocene.

Developed landscapes form barriers to northward migration for both plants and animals.

15. In fact, the anticipated rate of change is expected to be too rapid for existing forests to adapt, creating a high risk of widespread tree mortality and increased threat from forest stresses such as insects, diseases, and air pollution. The interacting threats will very likely affect industries and communities that depend on healthy, productive forests (Shugart and others 2003).

16. Projected changes in live vegetation carbon under two climate scenarios illustrate both the uncertainty of climate projections and the regional differences in expected response (fig. 1). One simulation shows continued growth in eastern forests through the end of the 21st century, with forests declining in parts of the West and the Great Lakes region. Another model suggests nearly

the opposite, with significant forest declines in the East and Midwest—especially in the South, where forests in some areas are projected to give way to savanna or even grassland. Large areas of forest in Canada and Alaska are expected to be particularly sensitive to climate change due to higher latitude and projected greater warming (Hogg and Bernier 2005).

17. Invasive plants could benefit from climate change. Ziska (2003) explored the response of six invasive weeds (Canada thistle, yellow starthistle, leafy spurge, spotted knapweed, field bindweed, and perennial sowthistle) to concentrations of carbon dioxide from the beginning of the 20th century to the end of the 21st century. Increases in atmospheric carbon dioxide from the early 20th century to the present stimulated invasive plant biomass by an average of 110 percent, raising the possibility that increased atmospheric carbon might be partly responsible for the spread of invasive weeds in the 20th century. The trend is expected to continue: Likely future concentrations of carbon dioxide in the atmosphere will stimulate invasive plant biomass by an average of 46 percent, with the largest response for Canada thistle.

Adapting Forests to Climate Change

18. Although countries around the world are taking steps to reduce greenhouse gas emissions, future reductions are unlikely to be enough to stop climate change. Forest managers must prepare to help forested landscapes adapt to anticipated changes. The nature of the changes is still unclear, but researchers are making progress in predicting them. Using new technology, they are conducting experiments on intact forest communities under the effects of elevated greenhouse gases, and they are using more sophisticated climate and vegetation models to increase confidence in their projections. Forest managers can already use their results to monitor forests for the impacts of climate change and to adapt their management plans accordingly.

19. The goal of adaptation is to reduce the vulnerability of ecosystems to climate change and to increase their resilience following climate-induced changes in disturbance regimes. Specific adaptation responses might include:

- reducing the impacts of stresses that can exacerbate the effects of climate change, particularly wildland fire, air pollution, and insects and diseases;
- preventing or reducing barriers to species migration, such as forest fragmentation;
- improving forest health monitoring for early detection of climate change impacts;
- stepping up measures to prevent and control the spread of invasive species;
- helping forests regenerate following large-scale disturbances, for example through reforestation;
- increasing stand-scale resilience following drought and the spread of invasive species;
- taking historical and projected climate changes into account in planning forest management;
- considering the impacts of climate change in selecting planting stock and choosing planting methods;
- supporting research to better understand forest vulnerability to multiple stresses and to find ways to enhance forest resilience; and
- perhaps most importantly, raising awareness among natural resource managers about climate change and other threats to forest health.

20. Each of these management strategies maximizes the flexibility needed to respond to the certainty of climate change—and to uncertainty about its effects. An overarching management goal should be ecological diversity, with a variety of species, nursery stock, and stocking levels across the landscape. Diversity can enhance forest resilience in the face of future challenges,

increasing the options available to forest managers to learn from climate change and respond accordingly.

Countering Climate Change Through Forestry

21. Adaptive management is only part of what forest managers can do to respond to climate change. Forests in the United States currently sequester about 200 million tons of atmospheric carbon per year (Heath and Smith 2004), offsetting about 10 percent of the carbon dioxide emitted by Americans burning fossil fuels. A century ago, forests in the United States were a net source of carbon rather than a sink: They emitted as much as 750 million tons of carbon per year (Birdsey and others 2006), mainly due to agricultural clearing, heavy logging, and losses to fire and pests. The switch from source to sink was due to forest regrowth, land use reversion from cropland to forestland, and successful fire and pest control. As forest managers, we can build on that success by analyzing our management practices, identifying the ones that increase carbon sequestration, and taking them into account in making future land management decisions.

22. A forest has three main carbon pools—live biomass, woody debris, and soil organic matter. Each is affected by disturbance in different ways and over a different timescale (Pregitzer and Euskirchen 2004). In forests managed primarily for natural processes, the carbon balance is mainly driven by soil productivity and natural disturbance regimes; in intensively managed plantations, the main drivers tend to be site preparation, planting stock selection, and thinning treatments. For both types of forest, the disturbance return interval drives carbon dynamics, with both the timing and the intensity of the disturbance playing a role: The longer the average time between disturbances, the more carbon is stored; and the less severe the disturbance (for example, the less biomass is consumed by a fire), the more carbon is retained.

23. For most forests, total carbon stored increases with time since the last disturbance, although carbon pools such as down woody debris might decline for awhile after a timber harvest. The pattern of carbon sequestration depends on climate, site productivity, type of disturbance, and other factors. Figure 2 shows a typical pattern following a timber harvest—increasing carbon storage, with the rate of increase declining over time. In very old forests, carbon stocks can actually begin to decline (Ryan and others 1997).

24. Additional accounting is required for carbon sequestered in wood products. When wood is removed from a forest, all of the carbon does not immediately return to the atmosphere. Carbon pools in wood products include wood in use (such as lumber, furniture, and paper) and wood discarded in landfills. Wood used in construction can also reduce fossil fuel burning to produce substitute building materials such as steel or concrete (Lippke 2006; MacCleery 2005).

25. Taking all this into account, a range of forestry activities can help balance the global carbon budget by reducing greenhouse gas emissions or increasing carbon sequestration. They include:

- afforestation, particularly the conversion of cropland to forestland;
- restoration of native vegetation and wildlife habitat;
- active regeneration of harvested forestland, particularly to establish fast-growing species (Moore 2006);
- agroforestry—that is, cultivating trees with crops or pasture—by sequestering carbon and by decreasing the need for fossil fuels and energy-intensive chemicals in producing food and fuel;
- modification of forest management practices to increase the rate of carbon sequestration or reduce emissions from decay;
- short-rotation woody biomass plantations, by sequestering carbon and providing energy feedstocks that displace fossil fuels in energy production;

- forest protection from timber harvest and from conversion to nonforest land uses (Wayburn and others 2000);
- reduced-impact logging, by decreasing the soil disturbance and biomass decay that often result from traditional timber harvest methods;
- improvements in processing wood to reduce emissions from wood waste and energy use; and
- urban forestry, by increasing carbon sequestration in trees and reducing energy used in heating or cooling homes and businesses.

26. One of the nation's most difficult forestry challenges is increasing wildfire activity in western forests. Fuels reduction and forest health treatments reduce rather than increase carbon stocks in forests; however, less biomass is consumed in the resulting low-severity fires than would be in a crown fire conflagration. If the biomass removed is used to produce energy, then it will also offset carbon emissions from fossil fuel burning.

27. Studies suggest that forestry activities in the United States could increase carbon sequestration by 100 to 200 million tons per year (Birdsey and others 2000; Environmental Protection Agency 2005; Lewandrowski and others 2004; Stavins and Richards 2005), possibly doubling the amount of carbon currently sequestered by America's forests. However, the rate of increased carbon storage would likely decline over time as low-cost forestry opportunities run out, forestry sinks become saturated, and timber harvesting takes place.

Opportunities in the Private Sector

28. About 430 million acres of the nation's 749 million acres of forest land are in private ownership. With more than half of the nation's forests, the private sector will play a central role in deciding whether or not America's forests are managed for climate change and its effects. Both market approaches and voluntary incentive programs to manage greenhouse gases are under development in the United States, the European Union, and elsewhere (Totten 1999). Some carbon sequestration projects are already underway, even though sequestered carbon has little current market value (Winrock International 2005).

29. However, widespread private participation in carbon sequestration activities will likely require financial incentives. One way would be through the sale of carbon credits accumulated by landowners to developers, industries, and others whose activities add more carbon to the atmosphere. Studies suggest that improved forest management would become attractive to landowners at carbon prices below $10 per ton of carbon; afforestation at $15 per ton or more; and management for biofuels at $30 to $50 per ton (Environmental Protection Agency 2005; Lewandrowski and others 2004; Stavins and Richards 2005).

30. The success of a carbon market depends on various factors (Collins 2006). The trading price of carbon is key, as are transaction costs; forest carbon credits must also be exchangeable with credits for reduced emissions, and carbon sequestration must be accurately estimated and reported. In addition, a technical support system is needed to provide land managers with the knowledge and tools necessary to make competent decisions about how to manage particular forests to reduce greenhouse gases.

31. Side effects might not all be beneficial. Water quantity might decline due to increased transpiration by trees, and taking land out of crop production might affect food prices—at higher carbon prices, nearly 100 million acres might revert from cropland to forestland (Environmental Protection Agency 2005). A sound forest carbon management policy for the private sector will need to take all effects into account, both positive and negative.

Opportunities in the Public Sector

32. For carbon markets to flourish, government must furnish a "driver," such as an impetus for voluntary participation or a regulatory cap on carbon emissions (Collins 2006). The Bush administration has promoted a voluntary scheme for reducing greenhouse gas emissions, whereas states such as Maine and California are implementing regulatory action plans for both emissions reductions and carbon sequestration, and a regional greenhouse gas initiative in the Northeast involves eleven states. Voluntary markets such as the Chicago Carbon Exchange are driven in part by expectations of a future national cap on carbon emissions (Bayon and Hawn 2006).

33. Government must also play a role in setting up and supporting carbon markets. The Forest Service is the lead agency for revising the national accounting rules and guidelines for reporting and registering emissions reductions and increases in carbon stocks. This national greenhouse gas registry is a key part of the Administration's voluntary approach to reducing atmospheric carbon. Forest Service Research is developing the monitoring, accounting, and reporting protocols for the carbon registry; the Forest Service's State and Private Forestry staff can help implement the guidelines through state and landowner assistance.

34. Government must also drive basic research, and for almost two decades the Forest Service has taken the lead. The Forest Service has conducted research on how forest management, storage of carbon in wood products, and natural factors affect the exchange of carbon with the atmosphere. Forest Service Research provides the fundamental knowledge needed to identify and develop forestry practices and management systems to increase carbon sequestration, accurately account for changes in carbon storage, and prepare scientifically credible reports.

35. With some 319 million acres of forestland in public management, government can play a key role in managing the nation's forests for climate change and its effects. The role of state and federal programs in capturing the benefits of forest carbon management, particularly through state/federal partnerships, can be a model for the nation. Specific activities might include:

- assessing the potential for sequestering more carbon in forests and wood products through afforestation, improved forest management, and substitution of wood for other materials that require more energy to produce;
- facilitating the removal and use of excess forest biomass for biofuel and providing incentives to increase the area of biomass energy plantations;
- identifying how increased carbon sequestration would affect other forest values, such as wood production and wildlife habitat;
- determining the level of financial incentives needed to increase carbon sequestration;
- providing landowners with information on what they can do to increase carbon sequestration on their lands;
- helping landowners take the necessary steps to increase carbon sequestration, record the gains, and earn the corresponding carbon credits;
- accelerating the development of carbon inventory methods, data access, and analysis tools;
- developing regional demonstration projects and training sessions; and
- implementing an "early warning" system to detect adverse effects from climate change.

Managing Forest Carbon for the Future

36. The climate is changing. More carbon in the atmosphere is driving a wider range of temperature extremes, producing warmer summers and earlier snowmelts. The combined effects appear to be at least partly responsible for growing fire season severity, unprecedented activity by forest pests, and even the accelerated spread of invasive weeds.

37. The future outlook is troubling, but there is hope. Climate variability and change can alter the structure and function of ecosystems, in turn reducing ecological resources and benefits, shifting feedbacks between ecosystems and climate, and disrupting lives and livelihoods that depend on healthy forest ecosystems. Western forests are currently estimated to be a carbon sink (Heath and Smith 2004), but they could become a source due to increasing wildfire activity.

38. As forest managers, the challenge we face is this: how to help forests adapt to climate change and how to build their capacity to store more carbon and offset sources of carbon emissions. Despite uncertainty about the changing climate, we do have opportunities to act. We can monitor the forests we manage for evidence of climate change, and we can prepare to adapt our management plans accordingly. The benefits of adaptive management go beyond climate change; we can already adopt them without regret.

39. We can also modify a broad range of forestry activities to reduce greenhouse gas emissions or increase carbon sequestration. However, implementing these modifications on a broad scale while continuing to produce forest goods and services will be a formidable challenge. Federal and state governments can play a key role in helping forest landowners ensure that forest carbon management and adaptation practices are sensitive to, and fully integrated with, management plans and practices that protect and enhance the entire suite of the nation's forest values.

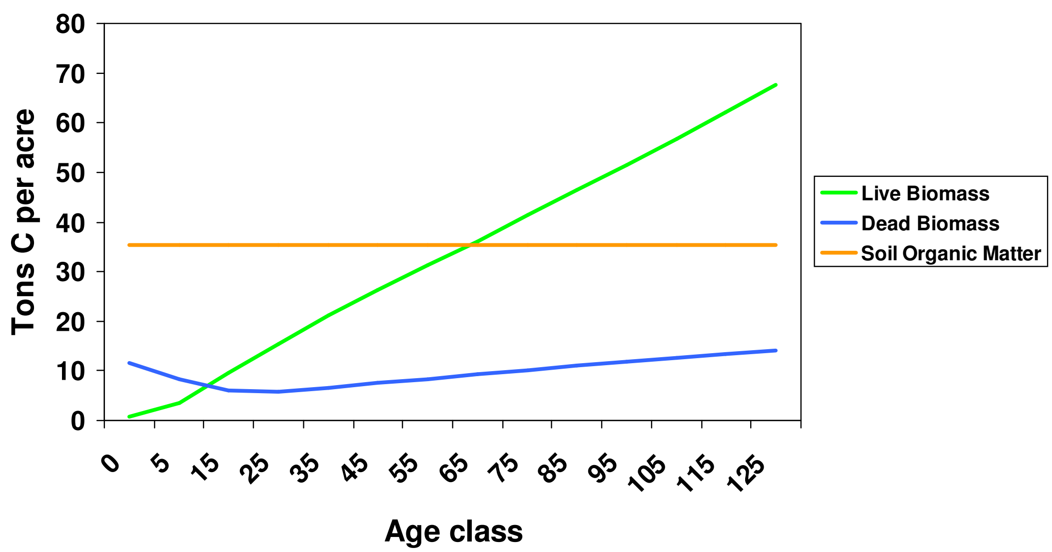

Figure 1. How carbon stocks in different pools change after a clearcut. Dead biomass includes standing dead trees, down woody debris, and forest floor. This example is for aspen-birch forests of the Lake States (Smith et al. 2006).

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