National Roadmap for Responding to Climate Change

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Forest Service

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Climate change magnifies those complexities and introduces additional uncertainties.

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National Roadmap for Responding to Climate Change

The mission of the Forest Service, U.S. Department of Agriculture (USDA), is to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations. Americans rely on their forests and grasslands for a wide range of benefits—for provisioning services such as water, wood, and wild foods; for regulating services such as erosion, flood, and climate control; and for cultural services such as outdoor recreation, spiritual renewal, and aesthetic enjoyment. These services are connected and sustained through the integrity of the ecosystems on these lands.

Climate change places those ecosystems at risk. Most of the urgent forest and grassland management challenges of the past 20 years, such as wildfires, changing water regimes, and expanding forest insect infestations, have been driven, in part, by a changing climate. Future impacts are projected to be even more severe. Managing America's forests and grasslands to adapt to changing climates will help ensure that they continue to produce the benefits that Americans need, while helping to mitigate the effects of a changing climate and to compensate for fossil fuel emissions through carbon storage in healthy forests.

The Forest Service has a long history of managing the national forests and grasslands to enhance ecosystem health, sustainability, and resilience. Working with the States, the Forest Service assists private landowners who wish to sustainably manage their woodlands and, increasingly, participate in markets and programs to gain credit for climate change mitigation activities. To these ends, the agency's management strategies and actions have evolved to address a changing climate. Agency scientists are participants in national and international assessments of climate change effects on forests and grasslands, and they have summarized a range of management strategies to respond to climate change. Many of the agency's actions to sustain and restore healthy, flourishing ecosystems are responses to changing climatic conditions.

The sustainability of the Nation's forests and grasslands, however, requires these programs and field units to work together even more closely in an integrated national response.

In June 2010, USDA released the *2010-2015 Strategic Plan* that guides its agencies towards achieving several goals including Strategic Goal 2—Ensure our national forests and private working lands are conserved, restored, and made more resilient to climate change, while enhancing our water resources. This goal has several objectives. Objective 2.2 is to lead efforts to mitigate and adapt to climate change. The performance measures under this objective seek to reduce greenhouse gas emissions by the U.S. agricultural sector, increase the amount of carbon sequestered on U.S. lands, and bring all national forests into compliance with a climate change adaptation and mitigation strategy. The Forest Service response to this goal includes this National Roadmap for Responding to Climate Change and a Performance Scorecard.

In October 2008, the Forest Service introduced a "Strategic Framework for Responding to Climate Change." As field units began to implement the framework, the need emerged for a national roadmap to help the agency move from what it is already doing in response to climate change, through a range of additional short-term initiatives, to longer term investments in the future of America's forests and grasslands. The roadmap set forth here builds on the strategic framework. Based on regional guidance, individual units can put this roadmap to use, using a performance scorecard to track local implementation. The Forest Service will hold itself accountable for progress under this roadmap in four major dimensions: agency or organizational capacity; partnerships and conservation education; adaptation; and mitigation **(figure 1).**

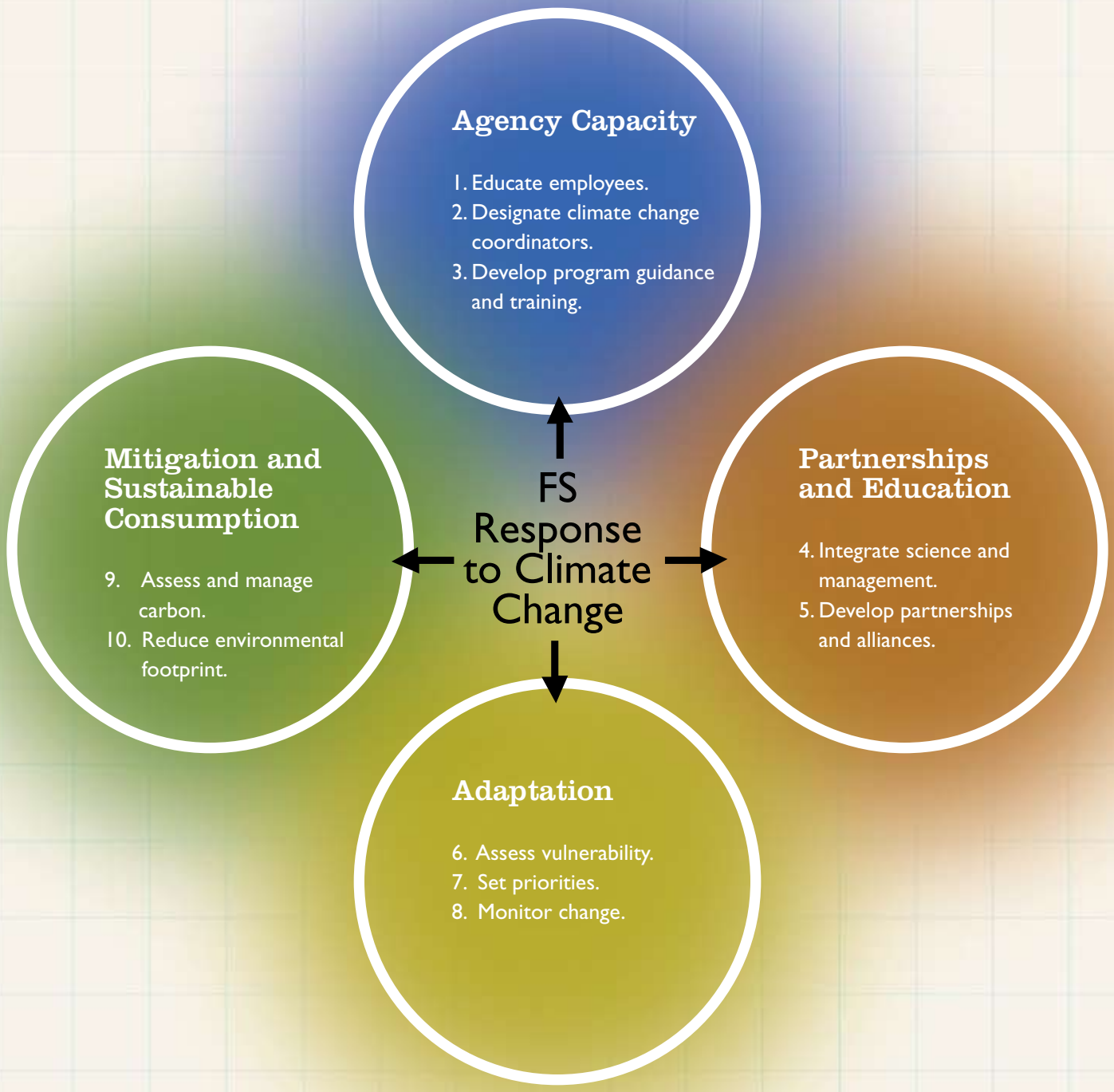


Figure 1. *The Forest Service Performance Scorecard for accountability in responding to climate change considers 10 elements in 4 dimensions.*

Modes of Action

The Forest Service will respond to climate change in three interconnected ways ***(figure 2)***:

- *Assess* current risks, vulnerabilities, policies, and gaps in knowledge.
- *Engage* employees and stakeholders to seek solutions.
- *Manage* for resilience, in ecosystems as well as in human communities, through adaptation, mitigation, and sustainable consumption strategies.

All three modes of action are dynamic and mutually reinforcing. They are interconnected through monitoring and evaluation, forming a continual feedback loop to allow opportunities for adjustment in direction or tactics.

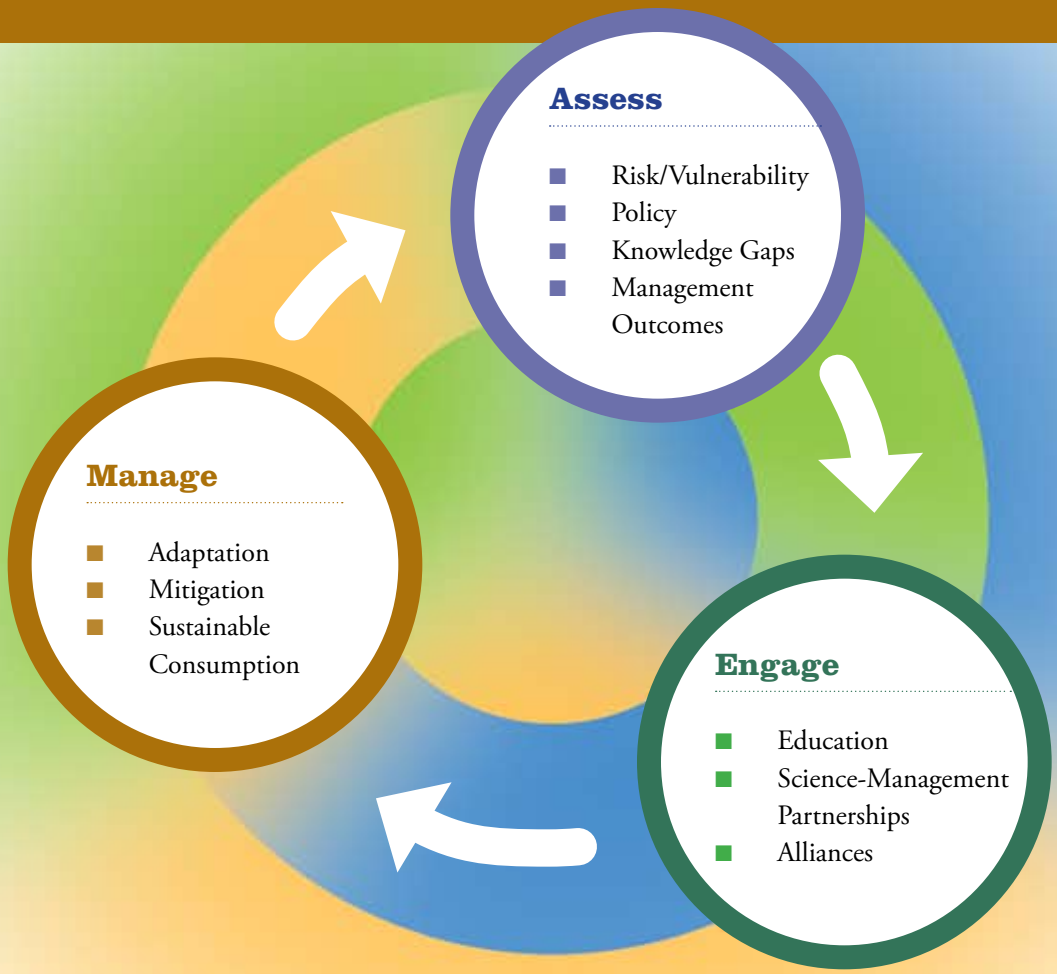


Figure 2. *The Forest Service will use three types of actions—assessing risks, vulnerabilities, policies, and knowledge gaps; engaging employees and external partners; and managing for adaptation and mitigation—in a continuous cycle of adaptive management informed by monitoring and evaluation.*

Assess

Nature is enormously complex. Climate change magnifies those complexities and introduces additional uncertainties. Not only is climate change having different impacts in different places; the likelihoods of those impacts will vary greatly. There will never be enough financial or other resources to address all of these risks. The first step in addressing climate change is to carefully assess the associated risks and vulnerabilities for natural and human communities alike. A primary role for scientists in addressing climate change will be to identify the associated knowledge gaps and fill them. As knowledge increases and uncertainty recedes, policies can be formulated and refined to better address climate change. Through careful monitoring, climate change and its impacts can be tracked, and the effectiveness of policies and the benefits of management actions can be evaluated.

Risks and Vulnerabilities

Climate change impacts will vary. Some ecosystems might experience only minor changes, whereas others might cease to exist, supplanted by new ecosystems. Impacts on water will also vary; desired ecosystem functions might diminish in some watersheds. Ecosystem vulnerability to climate change will depend on a suite of interacting factors, including the following:

- Climate change impacts on air and water quality.
- Plant community succession dynamics.
- The frequency and intensity of extreme events.
- Landscape patterns in relation to species dispersal.
- The magnitude of temperature and precipitation changes.
- Contextual features, such as topography and physical substrates.
- The ability of systems to adapt.
- Changes in disturbance regimes comprised of insects, pathogens, and wildland fire and their effects on key ecosystem processes.

Species vulnerability is also dependent on these factors, as well as on the sensitivity of individual species to change and the effectiveness of management actions in facilitating adaptation.

Infrastructure and human communities might also be vulnerable. Bridges, culverts, and campgrounds will be increasingly vulnerable to floods caused by rain-on-snow

The Forest Service Response to Climate Change: Why It Matters

Americans depend on forests and grasslands in many ways. Climate change will affect the ability of these lands to continue delivering a broad range of benefits, including clean air and water, habitat for wildlife, opportunities for outdoor recreation, and more.

- Climate change could exacerbate global conflicts over natural resources, inducing mass migrations in coming decades. Stewardship of America's forests and grasslands will become more critical than ever.
- Carbon dioxide uptake by forests in the contiguous United States offsets 11 percent of total carbon dioxide emissions. Forests and other ecosystems are carbon sinks, as they absorb CO2, thereby removing it from the atmosphere. Forest management activities will play a critical role in ensuring that forests remain a net carbon sink.
- Forests are an important source of employment and rural development. More than 2.5 million Americans have forest-related jobs, including in forest management, outdoor recreation, and the forest products industry.
- The Forest Service manages more than 35 million acres of designated wilderness areas, providing critical habitat and ecological connectivity.
- Nearly one-fifth of the Nation's water originates on the National Forest System.
- Virtually all lands that the Forest Service manages are open for public recreation. Americans spend up to 7.5 billion activity days per year enjoying their national forests and grasslands. With 80 percent of the U.S. population residing in urban areas, public opportunities to connect with the land are more important than ever.

Forests and Watershed Stewardship

A primary purpose for reserving Federal forest land at the turn of the 20th century was to protect watersheds. Today, roughly one out of five Americans depends on a national forest for drinking water. The quantity and quality of America's water, however, are affected by a changing climate. Rising air temperatures mean less snow, along with faster and earlier snowmelts. Greater variability in the volume and timing of precipitation means more floods and droughts. Warmer water in lakes and streams alters critical fish habitat, while increased evapotranspiration leads to drier vegetation and more fire, insects, and pathogens.

In an era of climate change, forests will play an increasingly vital role in protecting the Nation's watersheds. Forests reduce erosion, recharge aquifers, regulate stream flows, moderate water temperatures, and protect water quality. Wild and scenic rivers on the national forests, with relatively little direct human impact, provide ecosystem connectivity along elevational gradients and serve as baseline watersheds for scientific study. As the climate changes, the importance of America's forests is bound to grow as a source of clean and abundant water. A successful response to climate change will entail sound stewardship of America's watersheds.

events in warmer winters. Some groups of communities, such as American Indians, might be especially vulnerable because of location or cultural and economic circumstances. Some 70,000 communities in the wildland-urban interface might be at additional risk from wildland fires.

To address the risks and vulnerabilities associated with climate change, land managers will need science-based assessments of the relative vulnerability of key ecosystem components and their ability to adapt to increased stress. These assessments will help managers set priorities in maintaining healthy, resilient ecosystems and protecting communities and infrastructure. Basing their decisions on such assessments, land managers can avoid fragmented, piecemeal approaches and make cost-effective investments.

Vulnerability assessments will need to span the range of ecosystem elements and values at risk. Designated wilderness areas and wild and scenic rivers will need to be studied to help determine the potential impacts of climate change on these unique resources and determine their important role in adaptation and mitigation. Vulnerability assessments are needed for communities, their institutions, and their capacity to adapt to disturbances associated with climate change. Vulnerability assessments are the basis for defining the social, economic, and ecological costs of inaction as a reference point against which to compare proactive adaptation measures.

Understanding climate change effects and the systems involved requires integration across agencies, disciplines, and programs. Numerous efforts to assess the vulnerability of species, ecosystems, and communities are already underway, and additional efforts are planned. Various methods have been applied and new methods are in development to provide a reliable suite of tools for assessing various aspects of vulnerability. Existing vulnerability assessments will need to be synthesized and interpreted, using the results to guide more targeted appraisals for forest and grassland ecosystems. Useful assessments will require strong partnerships among science, management, and communities.

Knowledge Gaps

Scientists know a great deal about climate change, but not yet enough to help land managers fully facilitate successful adaptation. Climate change models predict temperature increases reasonably well; with the magnitude varying by model and emissions scenario, but uncertainty still surrounds future precipitation patterns for different parts of the United States. The frequency of extreme weather events, such as floods and droughts, will likely increase, but the local and regional impacts remain far from clear.

Advances in climate change knowledge, both scientific and experiential, can temper the risks and vulnerabilities associated with climate change and its impacts. Fortunately, the Forest Service is well positioned to make those advances The agency has a century of experience in conducting, synthesizing, and applying forest and grassland research and in examining the social and environmental processes that maintain healthy, resilient ecosystems. Since the 1980s, the agency has studied the actual and potential impacts of climate change and ecosystem response.

Efforts are under way to improve projections at spatial and temporal scales relevant to land managers and policymakers. In its ongoing research, the Forest Service is trying to better understand the effects of changing temperature and precipitation regimes on the major forest and grassland stress agents such as fire, insects and disease, and invasive species, and the resultant vulnerability of plants and animals. More research is needed on the capacity of individual species to adapt or migrate, their likelihoods of extinction, and their possible roles in emerging ecosystems.

The Forest Service's *Global Change Research Strategy for 2009–19 (http://www.fs.fed.us/climatechange/documents/global-change-strategy.pdf)* will build a progressively stronger foundation for assessing climate change and its impacts. The research will continue to improve the scientific basis for a unified approach to managing ecosystems based on a better under-

standing of the uncertainties created by climate change. The strategy calls for research to help accomplish the following:

- Enhance ecosystem sustainability (adaptation).
- Increase carbon sequestration and reduce emissions (mitigation).
- Provide better decision support.
- Address shared research needs (infrastructure, scientific collaboration, and science delivery).

To these ends, Forest Service Research and Development is building on existing expertise in areas such as landscape ecology, watershed hydrology, vegetation modeling, nutrient cycling, wildlife ecology, and ecosystem management. Long-term data from Forest Inventory and Analysis (FIA) plots across the Nation and from the Forest Service's network of experimental forests and ranges and its research natural areas will provide both a baseline on ecosystem composition and structure and a valuable network of sites for monitoring the future effects of climate change.

Policy

Forest Service policies, developed over many years, were mostly devised before the agency took climate change into account in its programs for public land management and private landowner assistance. Such policies might not provide the most effective means for guiding actions to address climate change across broad landscapes, jurisdictions, and resource areas. The Forest Service will identify shortcomings in its policies, procedures, and program guidance, reformulating them where necessary to align resources with an effective climate change response and to more effectively collaborate with other Federal agencies, States, tribes, and other stakeholders for landscape-scale conservation.

Monitoring

Monitoring will be key to the program's success. Monitoring paves the way for assessments to be updated and validated, revealing critical new issues. A unified, multiscale monitoring system capable of detecting and evaluating national, regional, and local trends will enable land managers to develop and adjust adaptation and mitigation strategies to improve their effectiveness across landscapes and landownerships. Improved information delivery systems will provide reliable, timely, and transparent information to inform planning, decisionmaking, and project implementation at all levels.

The Forest Service and other organizations have monitoring programs, but they are not well integrated. Climate-informed planning and monitoring of forests and grasslands will focus on shared landscapes and broad spatial contexts across ecological regions. A comprehensive interagency approach is needed to connect various monitoring efforts and to fill information gaps. Other organizations have monitoring systems, data, and expertise that the Forest Service needs; other organizations can benefit from Forest Service data, including periodic updates on the overall condition of America's forests.

Mechanisms and methods for effectively monitoring climate change impacts and program effectiveness are developing. In the short term, the Forest Service will undertake three interrelated forms of monitoring: systematic monitoring, targeted monitoring, and effectiveness monitoring (see the sidebar Monitoring Strategies). The Forest Service will also monitor changing trends in human behavior, using U.S. census data, the USDA Natural Resources Conservation Service's Natural Resource Inventory, and other large-scale land use surveys. The agency will constantly reevaluate its monitoring mechanisms, integrating tools such as the FIA landowner survey and the Resources Planning Act (RPA) assessments, adjusting them to the pace and nature of climate-induced changes.

Monitoring Strategies

Systematic monitoring establishes monitoring locations across large areas, with monitoring stations often located in an established grid of various resolutions. An example of systematic monitoring is the Forest Inventory and Analysis (FIA) program, which uses a systematic plot-based system that has extensive coverage and uses standard measures within U.S. forest lands. FIA uses a broad suite of indicators to assess status and trends in forest resource conditions and health over time. The U.S. Geological Survey (USGS) National Stream Gauging Network, the USGS National Atmospheric Deposition Program's National Trends Network, the Natural Resources Conservation Service's Natural Resource Inventory, and the Environmental Protection Agency's Ambient Air Quality Monitoring Program are additional examples of systematic monitoring programs.

Targeted monitoring assesses particular areas based on specific objectives, using measurements or indicators related to those objectives. It obtains quantitative or qualitative population density and trend estimates in areas where a given species or community has been identified as potentially vulnerable. Targeted monitoring enables early detection of adverse climate change effects and facilitates rapid responses for adaptation or restoration needs. Examples include monitoring of weather-related changes in watershed hydrology and outbreaks of insects and diseases or invasive species in areas that have been identified as vulnerable to infestation due to climate change.

Effectiveness monitoring is focused on evaluating resilience and adaptation outcomes that result from on-the-ground activities. The aim is to determine the effectiveness of management actions taken to reduce stressors, enhance resilience, or conserve species.

Assessment Actions

The Forest Service is already studying climate change, assessing risks and vulnerabilities, identifying knowledge gaps and monitoring needs, and formulating new policy designed to facilitate an effective response. The agency will continue such activities while undertaking a series of additional immediate and longer term assessment initiatives to help meet the challenge of climate change.

Ongoing Activities

- **Providing basic and applied science** to help managers respond to climate change. The Forest Service's Climate Change Resource Center (CCRC) Web site (*http://www.fs.fed.us/ccrc/*) is continuously updated with new tools and information for managers. Efforts include the following:
  - Upgrading carbon inventory and accounting tools, such as the Carbon OnLine Estimator (COLE) and I-Tree (for urban forest assessments) (*http://nrs.fs.fed.us/carbon/tools/*).
  - Evaluating potential future climate change impacts on ecosystems, thereby identifying vulnerabilities and helping to prioritize management actions.
  - Using RPA assessments (*http://www.fs.fed.us/research/rpa/*) to evaluate the effects of climate change, both current and projected, on America's natural resources.
- **Conducting workshops** that bring scientists and managers together at local, regional, and national levels to facilitate learning and develop adaptation strategies.
- **Utilizing national monitoring networks**, such as the FIA program (for forest cover and conditions); Integrated Monitoring of Protected Visual Environments, the Clean Air Status and Trends Network, and the U.S. Environmental Protection Agency's National Atmospheric Deposition Network (for air quality); and the U.S. Geological Survey's (USGS) National Water-Quality Assessment Program (for water quality). Other networks are associated with disturbances, such as insects and pathogens (Forest Health Monitoring), fires (Monitoring Trends in Burn Severity), and weather (remote automated weather stations).

Climate Change Resource Center

The Climate Change Resource Center (CCRC) is a Forest Service reference Web site for resource managers and decisionmakers who need information and tools to address climate change in planning and project implementation. The CCRC addresses the manager's question, "What can I do about climate change?" by providing information about basic climate sciences and compiling knowledge resources and support for adaptation and mitigation strategies. The site offers educational information, including basic science modules that explain climate and climate impacts, decision-support models, maps, simulations, case studies, and toolkits. Visit *http://www.fs.fed.us/ccrc/*.

Immediate Initiatives

- **Furnish more predictive information on climate change and variability**, both immediate and longer term, building on current research capacity and partnerships with the National Oceanic and Atmospheric Administration, National Aeronautics and Space Administration, USGS, and other scientific agencies.
  - Develop, interpret, and deliver spatially explicit scientific information on recent shifts in temperature and moisture regimes, including incidence and frequency of extreme events.
  - Provide readily interpretable forecasts at regional and subregional scales.
- **Develop vulnerability assessments**, working through research and management partnerships and collaboratively with partners.
  - Assess the vulnerability of species, ecosystems, communities, and infrastructure and identify potential adaptation strategies.
  - Assess the impacts of climate change and associated policies on tribes, rural communities, and other resource-dependent communities.
  - Collaborate with the U.S. Fish and Wildlife Service and National Marine Fisheries Service to assess the vulnerability of threatened and endangered species and to develop potential adaptation measures.
- **Tailor monitoring** to facilitate adaptive responses.
  - Expand observation networks, intensify sampling in some cases, and integrate monitoring systems across jurisdictions (see, for example, the national climate tower network on the experimental forests and ranges).
  - Monitor the status and trends of key ecosystem characteristics, focusing on threats and stressors that may affect the diversity of plant and animal communities and ecological sustainability. Link the results to adaptation and genetic conservation efforts.
- **Align Forest Service policy and direction** with the Forest Service's strategic response to climate change.
  - Review manuals and other policy documents to assess their support for the agency's strategic climate change direction. Evaluate current policy direction for its ability to provide the flexibility and integration needed to deal with climate change.
  - Develop proposals for addressing critical policy gaps.

Longer Term Initiatives

- **Expand capacity for assessing the social impacts and drivers** of climate change.
  - Increase support for research on how society will be affected by the impacts of climate change on natural resources.
  - Initiate partnerships to interpret and forecast changes in human behavior and land use patterns at multiple scales over time.
- **Implement a genetic resources conservation strategy**. Improve the Forest Service's genetic resources program to conserve at-risk species and facilitate transitions to more resilient ecosystems (see the sidebar Gene Resource Management).
- **Fortify internal climate change partnerships**. Building on existing research and management partnerships, formalize joint positions across Forest Service deputy areas focusing on improving climate change science delivery.

Forest Carbon Stocks

Since the early 1990s, the Forest Inventory and Analysis (FIA) program has provided official estimates of forest carbon stocks and flows for the United States. The estimates are used in international negotiations and domestic assessments. A three-phase approach is used to estimate changes in forest resources, including forest carbon stocks (see *http://www.fia.fs.fed.us* for more details):

- Phase 1: Remote sensing.
- Phase 2: Ground measurements of tree and plot attributes.
- Phase 3: Additional measurements for bioindicators of forest health and diversity.

Statistical estimates of forest area, species, and stand density are converted to ecosystem carbon estimates with known precision. This information has been incorporated into tools for estimating carbon stocks.

The Forest Carbon Calculator Tool estimates carbon sequestration in forests at the State level. State values are summed and used as the official U.S. forest carbon stocks reported to the United Nations Framework Convention on Climate Change.

The Carbon OnLine Estimator (COLE) is a Web-based tool that generates carbon estimates based on FIA data for any part of the Continental United States, down to the county level. In 2004, COLE was named the official 1605b Web-tool by the U.S. Departments of Agriculture and Energy. A new version (COLE-EZ), designed for reporting estimates in the format for reporting to the Department of Energy for its national carbon registry, has been released.

The Forest Service has also developed additional tools to estimate carbon in forests and urban settings at various scales. These tools can be found at *http://nrs.fs.fed.us/carbon/tools/*.

Gene Resource Management

Successful restoration activities use species and populations that are adapted to current and likely future conditions to successfully reestablish resilient ecosystems after disturbances. Genetically appropriate material is called for in the Forest Service's native plant materials policy (FSM 2070), but most species used in restoration lack suitable seed and propagation sources. In responding to climate change, the Forest Service will develop strategies and seed sources adapted to both current and likely future conditions. The agency will use more genetically diverse populations and breed for appropriate abiotic and biotic resistances.

Gene conservation practices will be critical in preserving populations and species at risk of extinction. Strategies will use both *in situ* (onsite) and *ex situ* (offsite) conservation practices. Maintaining species and their ecotypes *in situ* provides the Forest Service with a continuing source of restoration plant material that is adapted to a known set of conditions. *Ex situ* practices are becoming more important as factors such as climate change, increased insect and disease pressure, and invasive species reduce areas of suitable habitat.

Basic strategies for using seed as a gene conservation method have been developed (see *Forest Service General Framework for Genetic Conservation of U.S. Forest Tree Species*), and agreements are in place to use the USDA Agricultural Research Service's National Genetic Resources Program. Efforts are under way to preserve the seed of a handful of tree species, including high-elevation pines in the West and hemlocks and ashes in the East. Other efforts involve establishing conservation plantings (e.g., arboreta, botanic gardens, and specific conservation plantings in the field) in environments that do not experience the pathogen pressure threatening a species. Present efforts involve establishing oaks (at risk from sudden oak death) and hemlock (at risk from hemlock woolly adelgid) in other countries. These efforts are especially important for species whose seed cannot be stored long term (such as acorns).

Engage

A successful response to climate change will require working across organizational boundaries to discover common goals, avoid duplication, and build on complementary assets. The Forest Service will maintain its strong current partnerships; develop additional partnerships; and enhance awareness and understanding through effective education and outreach, engaging a wider range of stakeholders in learning about forests, grasslands, and climate change.

Forest Service Climate Change Education Resources

The Forest Service's Conservation Education Program coordinates the development and delivery of high-quality, science-based conservation education programs and materials nationwide. These efforts promote the connection of youth to nature, the development of environmental literacy, and the understanding of climate change and ways each of us can help to mitigate its effects. Conservation Education's goal is to help prepare students for real-world 21st century challenges.

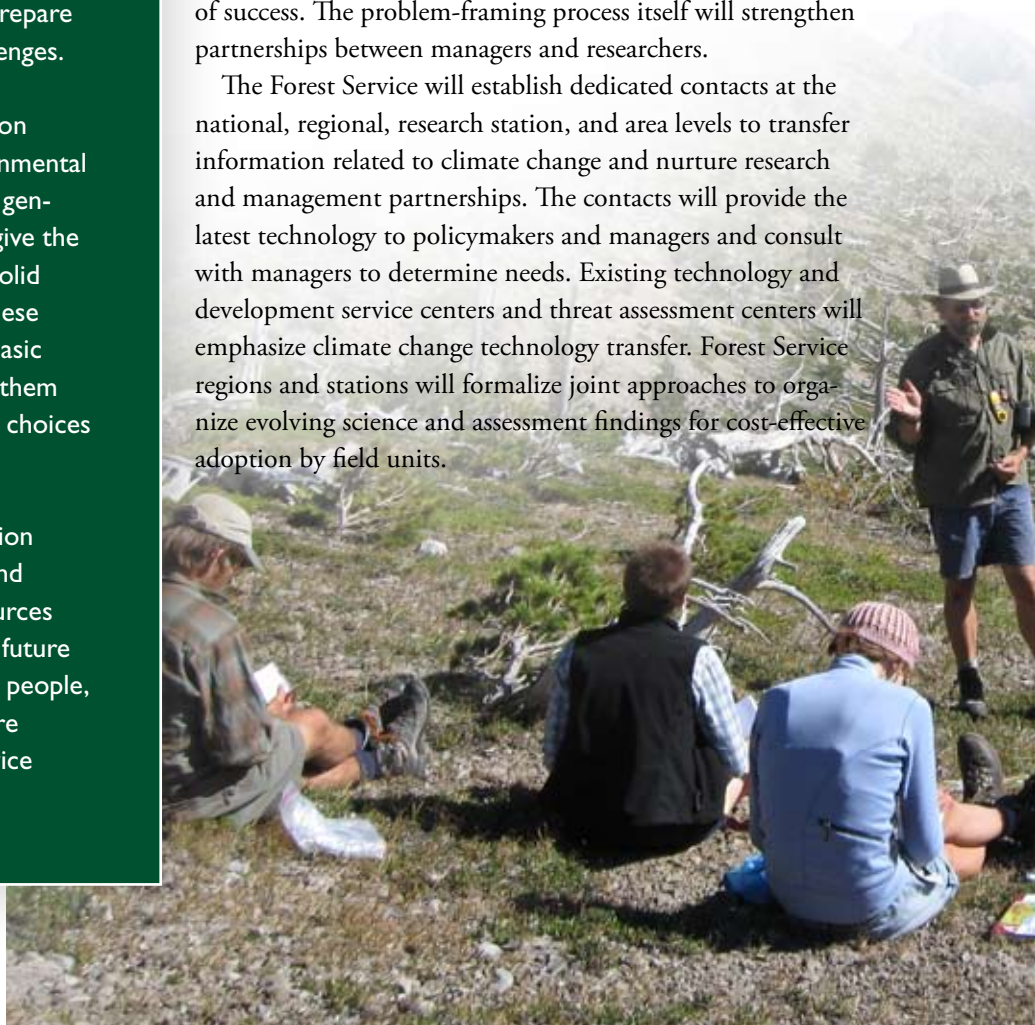
We will be passing on complicated environmental problems to future generations. We must give the next generation a solid understanding of these problems and the basic tools to overcome them and make informed choices in their own lives.

The Forest Service's Conservation Education Program helps people of all ages understand and appreciate our country's natural resources and how to conserve those resources for future generations. Last year, more than 4 million people, including children and their educators, were reached through a diversity of Forest Service educational and experiential programs.

Research and Management Partnerships

The Forest Service will improve its processes for defining and addressing important management problems and knowledge needs. An effective response to climate change starts with well-framed management questions that science can accurately address. Well-developed partnerships between managers and researchers will identify information needs and specify how information is to be delivered; managers will describe information needs, both current and possible future needs, and the modes of delivery with the highest probability of success. The problem-framing process itself will strengthen partnerships between managers and researchers.

The Forest Service will establish dedicated contacts at the national, regional, research station, and area levels to transfer information related to climate change and nurture research and management partnerships. The contacts will provide the latest technology to policymakers and managers and consult with managers to determine needs. Existing technology and development service centers and threat assessment centers will emphasize climate change technology transfer. Forest Service regions and stations will formalize joint approaches to organize evolving science and assessment findings for cost-effective adoption by field units.



All-Lands Approach

Landscapes are composed of mosaics of plant and animal communities and of landownership and human communities. In the Eastern and Western United States alike, critical issues such as forest health, invasive species, fire and fuels, water quantity and quality, and wildlife habitat connectivity are exacerbated by climate change. Such issues neither begin nor end at national forest boundaries. The Forest Service will work with its neighbors to devise and implement solutions that operate across jurisdictions at a landscape scale.

Accordingly, the Forest Service has embraced an all-lands approach to conservation through cross-boundary partnerships (see the sidebar A Shared Vision for America's Forests). Landscape-scale conservation is a logical extension of the collaborative approaches that have evolved over the past 100 years in wildland fire management and cooperative pest management, with State and Federal partners jointly setting policy and sharing resources to address cross-jurisdictional challenges. The Forest Service will use its full range of authorities to provide climate change adaptation services to citizens. All parts of the Forest Service are working to integrate research, management, and landowner assistance programs to address issues in high-priority landscapes across the country.

To this end, the Forest Service will expand collaboration beyond traditional partnerships, increasing cooperation and coordination with industry, environmental, outdoor recreation, and fish and wildlife stakeholders. The Collaborative Forest Landscape Restoration Program (*http://www.fs.fed.us/restoration/CFLR/index.shtml*) provides additional impetus to work across ownerships to build resilient forested landscapes.

Education

The Forest Service has a long tradition of fostering environmental awareness and understanding through multiple programs and disciplines. The agency will incorporate climate change science into programs to create awareness, build knowledge, and develop skills that lead to action. Three audiences will be targeted:

- *Youth:* Through a variety of programs, the Forest Service will engage youth in responding to climate change. Youth will be most affected by climate change and can do the most about it. In the decades to come, whole careers will be built around climate change and its effects.
- *The general public:* The Forest Service will provide all Americans with information that prepares them to participate in climate-related decisionmaking and actions affecting the Nation's forests and grasslands.
- *Employees:* A successful climate change response requires employees who are aware of potential climate change impacts and options for adaptation and mitigation. The Forest Service will educate employees accordingly.

Providing education on climate change adaptation will require substantial investment and planning. The Forest Service will employ a full range of communication methods, including printed materials, seminars and workshops, and interactive, on-demand electronic resources. Workshops held by individual units will engage employees and partners in developing context-specific climate change adaptation and mitigation strategies. It will be particularly important to maintain technology transfer positions that are dedicated to climate change.

Engagement Actions

Actions are already under way to engage partners and build public support for a strong climate change response. The Forest Service will continue ongoing activities while undertaking a series of additional immediate and longer term initiatives.

Ongoing Activities

- **Building public awareness** of climate change by doing the following:
  - Tailoring training and education to audience needs.
  - Providing professional development training for Kindergarten–12 educators through symposia, workshops, and webinars.
  - Presenting climate change as a global issue, emphasizing what the Forest Service does locally in research and management.

- **Building management capacity** for addressing climate change by doing the following:
  - Working with partners to develop education and information resources for land managers and natural resource practitioners.
  - Establishing climate change technology transfer contacts at the regional, station, and area levels.

Immediate Initiatives

- **Use collaborative approaches** to support multiparty climate change responses.
  - Establish a collaborative agreement on landscape-scale conservation between the U.S. Departments of Agriculture and the Interior.
  - Agree on a consistent Federal framework for responding to climate change.
  - Work with leaders from other Federal agencies, States, tribal, and local governments to develop national policies on climate change.
  - Develop landscape-scale assessments, adaptation plans, and management strategies.

- **Build public support** for a strong, well-coordinated climate change response.
  - Translate climate change science into messages tailored to youth, the public, and employees, partly through existing educational tools (such as *Natural Inquirer (http://www.naturalinquirer.org/)*, the CCRC *(http://www.fs.fed.us/ccrc/)*, and employee seminars or workshops).
  - Develop consistent climate change communication strategies to: (1) increase awareness of fundamental principles regarding climate change, (2) clarify the role of forests and grasslands and of the Forest Service in responding to climate change, and (3) use place-based messages to motivate action.

Longer Term Initiatives

- **Build interagency coordination** by developing the following:
  - A climate change infrastructure (such as councils and boards) for interagency coordination on climate change and land management issues.
  - A complementary interagency research and decision-support consortium and network to coordinate science delivery.
- **Engage youth in climate change response.** Work with partners to sponsor high school students as "climate ambassadors" who will educate other students and organize community learning projects.
- **Support community and regional collaboration.** Convene forums for dialogue among business and other nongovernmental stakeholders in the Nation's forests and grasslands, building support for actions at local, State, and Federal levels.

Climate Change Impacts: Rare Red Oaks in the Southeast

Some plant species, such as oaks, do not have seed that can be stored in long-term seed storage facilities. The Forest Service is in a partnership with Botanic Gardens Conservation International to conserve three rare southeastern trees in the red oak group: maple-leaf oak *(Quercus acerifolia),* Arkansas oak *(Q. arkansana)*, and Georgia oak *(Q. georgiana).* If sudden oak death, caused by the pathogen *Phytophthora ramorum,* becomes established in the Southeast, these three oaks will be at great risk of extinction. Tissue culture will be used and living collection will be established at an Australian arboretum; Australia has been chosen because *P. ramorum* is not known to occur there.

Environmental Justice

Many Federal agencies are engaged in activities to assess the potential and actual impacts of climate change on human and natural communities; develop strategies to mitigate these impacts where possible; and develop adaptation strategies that will reduce the vulnerability of human and natural communities to expected climate change effects. The Forest Service is working with partners to ensure consideration of the effects of climate change on low-income, minority, and indigenous populations. The Forest Service offers guidance and direction on priorities and gaps that leverage limited resources, prevent unnecessary duplication, and encourage the development and consistent implementation of policies and programs that appropriately engage diverse populations in climate change. In partnership with the Joint Center for Political and Economic Studies, Forest Service Research and Development is creating a benchmark report and compendium of information and resources for policymakers, researchers, and others that documents current and historic challenges, consequences, and actions that address the concerns of communities of color with regard to climate change issues.

Manage

Ultimately, the Forest Service's management response on the ground will be threefold: adaptation, mitigation, and sustainable consumption. The agency is responding to climate change through adaptive restoration—by restoring the functions and processes characteristic of healthy, resilient ecosystems, whether or not those systems are within the historical range of variation. Through restoration, the Forest Service is conditioning and repairing the key functions of ecosystems across landscapes so that they can withstand the stresses and uncertainties associated with climate change. In land management activities, adaptation and mitigation goals are inextricably linked. Forested landscapes capable of adapting to changing conditions will be more likely to sequester and store carbon sustainably, while furnishing woody materials to help offset fossil fuel use.

Climate Change Adaptation

The Intergovernmental Panel on Climate Change (IPCC) defines *adaptation* as an initiative to reduce the vulnerability of natural or human systems expected climate change effects. Adaptation strategies include the following:

1. Building *resistance* to climate-related stressors such as drought, wildfire, insects, and disease.
2. Increasing ecosystem *resilience* by minimizing the severity of climate change impacts, reducing the vulnerability and/or increasing the adaptive capacity of ecosystem elements.
3. Facilitating large-scale ecological *transitions* in response to changing environmental conditions.

Resistance strategies are appropriate for short-term protection of high-value resources, such as a human community or an endangered species; they tend to be costly and site specific. Resilience strategies are longer term and broader in scale, designed to help ecosystems attain a healthy condition, often within the historic pattern of stressors. Transitions are the longest term approach, responding to changes in environmental conditions and a concomitant need for ecosystems to adapt by moving or changing, often taking a trajectory beyond the historical conditions. Resistance, resilience, and transitions are tiered to increasing levels of environmental change; one task for science is to find ways of assessing change and choosing the most appropriate blend of management tools based on the relative risks, vulnerabilities, and likelihood of success.

Climate Change Mitigation

The IPCC (*http://www.ipcc.ch/*) defines *mitigation* as an intervention to reduce the emissions or enhance the storage of greenhouse gases. Mitigation is predicated on adaptation: the long-term capacity of ecosystems to capture and store carbon depends in large part on their ability to adapt to a rapidly changing climate. Mitigation strategies include the following:

1. Promoting the uptake of atmospheric carbon by forests and the storage of carbon in soils, vegetation, long-lived wood products, and recycled wood materials.
2. Indirectly reducing greenhouse gas emissions (for example, through the use of carbon-neutral bioenergy to offset fossil fuel emissions and substituting wood for more fossil fuel-intensive building products).
3. Diminishing greenhouse gas emissions (for example, through the cooling effects of urban forests, which reduce the need for fossil fuels to run air conditioners) or through more prudent consumption in facilities, fleet, and other operations.

The United States has historically addressed climate change simply by conserving forests. The national forests and Forest Service were established, in part, to help stem the Nation's dramatic forest losses in the 19th century. Within a single generation, net forest loss almost entirely ceased. America's forest estate stabilized at about 750 million acres, one-third of the Nation's land area. A century of forest conservation and restoration has turned America's forests from a net carbon

A Shared Vision for America's Forests

Secretary of Agriculture Tom Vilsack, in a speech in August 2009, articulated a vision for the future of America's forests. America's forests and grasslands are under severe stress. Climate change, wildfire, insects, pathogens, and urban development are among the cross-boundary challenges.

The threats facing our forests don't recognize property boundaries. So, in developing a shared vision around forests, we must also be willing to look across property boundaries. In other words, we must operate at a landscape-scale by taking an all-lands approach.

The Forest Service will work with other Federal agencies, States, tribes, conservation groups, industry, communities, and private landowners to meet shared goals for healthy, resilient ecosystems across landownerships. Through an all-lands approach, America will sustain and restore flourishing forest and grassland ecosystems capable of delivering clean and abundant water, carbon sequestration and storage, sources of renewable energy, habitat for fish and wildlife, opportunities for outdoor recreation, and all the other benefits that Americans want and need.

Climate Change Impacts: Whitebark Pine Decline

Whitebark pine *(Pinus albicaulis)* is a keystone species throughout the high mountain ranges of Western North America. Often the only tree capable of surviving in harsh subalpine areas, whitebark pine is crucial in stabilizing soil and moisture and creating habitats that support a wide variety of plants and animals. Its nuts are a critical food source for grizzly bears as they prepare for winter hibernation. Throughout its range, whitebark pine and other five-needle pines are declining due to a complex of stresses. White pine blister rust, caused by an invasive pathogen *(Cronartium ribicola)*, has caused extensive dieback of older trees and mortality of seedlings. Recently, large outbreaks of the native mountain pine beetle *(Dendroctonus ponderosae)* have affected extensive areas, including sites previously thought too cold for serious beetle outbreaks. Changes in beetle activity have been linked to warmer winter temperatures that have led to quicker development and higher survival rates for overwintering insects. Warmer and moister weather might also favor white pine blister rust by producing frequent "wave years" of conditions that promote massive numbers of infections. Rangewide restoration strategies for whitebark pine are needed to reverse current trends. The Forest Service is collaborating with partners, including the National Park Service, University of Colorado, and University of Montana, to develop and implement restoration and gene conservation strategies for whitebark pine and other threatened tree species. *http://www.fs.fed.us/r1-r4/spf/fhp/whitebark_pine/WBPCover_4.htm.*

source into a net carbon sink. In 2006, America's forests, including the carbon stored in wood products and landfills, offset about 12.5 percent of the carbon dioxide that Americans emitted.

Forest regrowth in the United States and the attendant high rates of carbon sequestration, however, have limits, linked as they are to recovery from past deforestation and logging practices. Greenhouse gas accumulations in the atmosphere will have uncertain effects on carbon sequestration. On the one hand, increasing carbon dioxide might accelerate forest growth and carbon uptake; on the other, climate change will exacerbate drought, wildfire, insects, disease, and other disturbances. Opportunities for effective, sustained climate change mitigation through forestry are therefore limited; many might entail unacceptable risks and tradeoffs. For example, storing carbon in overly dense forests increases the risk of losing the carbon through smoke and decomposition of fire-killed trees following large wildfires.

Taking any tradeoffs into account, the Forest Service will work with partners to sustain or increase carbon sequestration and storage in forest and grassland ecosystems and to generate forest products that reduce and replace fossil fuel use. The Forest Service will balance its mitigation efforts with all other benefits that Americans get from healthy, resilient forests and grasslands, such as wildlife habitat, wood fiber, water quantity and quality, and opportunities for outdoor recreation.

The Western Collective: Implementing Sustainable Consumption Practices in a Place-Based Way

In 2009, five Forest Service western regions (Northern, Rocky Mountain, Southwest, Pacific Northwest, and Intermountain Regions) and the Rocky Mountain Research Station formally chartered the Sustainable Operations Western Collective (WC). Recognizing that sustainable consumption practices require a leadership climate supporting cross boundary and interdisciplinary work, these units are pooling resources, staffing, and strategy to reduce energy, water usage, waste production, fleet emissions, and the overall environmental footprint of operations. Through pooling experimentation and case study effort, learning can be more quickly applied across the West, and propagated across the Nation and with other partners and sister agencies. In 2010, the Western Collective was able to leverage $635,000 of hard cash contributions into about $1.2 million of work that directly supported reductions in consumptions, as well as creating a leadership climate that supports those changes becoming a long-term part of our culture. http://www.fs.fed.us/sustainableoperations/western-collective.shtml

Sustainable Consumption

As it faces the enormous challenge of sustaining forests and grasslands under a changing climate, the Forest Service recognizes that it must also become more transparent with the implications of the agency's own use of natural resources. The IPCC and the United Nations Commission on Sustainable Development both suggest that making development more sustainable can enhance synergies between adaptation and mitigation approaches. Our long-term commitment to sustainability involves strategically connecting our land stewardship with practices that reduce the agency's consumption and environmental footprint. The direct relationship between our healthy forests, faucets, heating systems, clean air, modes of transportation, and many other goods and services has never been more apparent. Water and energy conservation, fleet and transportation management, and waste prevention/recycling and purchasing habits are activities that we must now include in our approach of "caring for the land." The work of developing habits that create more sustainable consumption patterns includes working across disciplines and staff groups within the Forest Service as well as with other agencies, partners, and communities. Strategies the Forest Service will use to move towards more sustainable consumption patterns include:

- Incorporate and maintain long-term programs, practices, tools, and policies that integrate sustainable consumption principles throughout the organization by removing barriers and promoting the use of efficient appropriate technologies and behavior changes.
- Institute a culture that emphasizes education, rewards positive actions, and recognizes achievements that reduce our environmental footprint in long lasting ways.
- Integrate sustainable consumption activities into daily decisions, habits, planning, and operations.
- Increase leadership capacity and day-to-day capabilities to implement sustainable consumption patterns at and between all levels of the organization.

The Forest Service's 2007 environmental footprint can be found at: http://www.fs.fed.us/sustainableoperations/documents/fy2007-environmental-footprint.pdf.

As the Forest Service responds to a changing climate, it strives to:

Maintain biodiversity

Maintaining diverse, functioning forest and grasslands into the future is critical in dealing with the variable and uncertain impacts of climate change. When possible, the Forest Service should work to conserve existing forests and grasslands, restoring diversity, structure, and functions that may have been lost. While systems are certain to change, having a greater array of ecosystems and species reduces our vulnerability to the impacts of a changing climate.

Sustain multiple benefits

Forests and grasslands provide multiple goods and services—clean and abundant water, clean air, carbon storage, biodiversity, wildlife habitat, timber, food, fiber, fuel, recreation, aesthetic enjoyment, and other public services. Policies should sustain the full range of diverse products and services that forests and grasslands provide to meet society's current and future needs.

Consider scale

Our national forests and grasslands are part of a larger human and ecological landscape comprised of public and private lands. Problems must be addressed at scales that make sense and make a difference. Local objectives need to be balanced with broader goals on a landscape scale. The Forest Service should strategize for ecosystem conservation at the landscape scale, but maintain flexibility to manage locally. One-size-fits-all strategies are unlikely to be efficient or effective.

Consider human communities

Maintaining the social health and economic prosperity of human communities is a vital part of landscape-scale conservation. Humans shape and depend on forests and grasslands for a variety of benefits and are an intrinsic component of the landscape. Adaptation and mitigation strategies need to explicitly recognize the vulnerabilities of human communities to a changing climate. Strategies should address how changing ecological and climate conditions, and associated policies, affect the array of ecosystem services and products and economic opportunities generated by forests and grasslands.

Manage risk

Continuous environmental monitoring and incorporation of new science into planning, policies, and decisionmaking processes are critical to adaptation and mitigation in an uncertain climate future. The Forest Service's decision processes require institutional flexibility to manage for risk while acknowledging the uncertainty of the magnitude and nature of climate change impacts on local and regional scales.

Embrace partnerships

Achieving a landscape-scale approach to adaptation and mitigation hinges on partnerships with other Federal, State, and local government agencies; tribes; nongovernmental organizations; and the private sector. Through diverse partnerships, the Forest Service can build capacity to promote learning, facilitate the exchange of ideas, and create sustainable solutions based on traditional and scientific knowledge. Institutional and public support for implementing innovative approaches is essential.

Build from established programs

Many of the actions needed to address climate change build upon established practices for advancing sustainable forest and grassland management. The Forest Service should build on its knowledge, integrating and refining practices as it learns about the implications of a changing climate. Where knowledge gaps are identified, the agency should continue to emphasize fundamental scientific inquiry into the causes, consequences, and strategies for responding to climate change in forests and grasslands.

Provide incentives and examples

The Forest Service is changing agency behavior to encourage sustainable consumption and, as a result, reduce its environmental footprint. Policies should encourage best practices of employees and the public for reducing carbon emissions through conservation and renewable energy use.

Management Actions

The Forest Service has a long history of managing the national forests and grasslands for sustainability and of working with the States toward sustainable forest management on private lands. Many management actions already address climate change. The Forest Service will continue its ongoing activities while undertaking additional initiatives, both immediate and longer term, to facilitate adaptation and mitigation.

Ongoing Actions

- **Restoring healthy, resilient forest and grassland ecosystems** by doing the following:
  - Treating overgrown forests to make them less vulnerable to wildfire, pathogens, and insect attack.
  - Controlling insects, pathogens, and invasive species that threaten the health and resilience of ecosystems.
  - After major disturbances, quickly restoring ecosystems with species and populations adapted to current and future climates.
- **Protecting infrastructure** by modifying or relocating roads, culverts, trails, campgrounds, and other facilities to resist floods and other major disturbances.
- **Actively managing carbon stocks** in forests, grasslands, and urban areas over time by doing the following:
  - Rapidly reforesting land damaged by fires, hurricanes, and other disturbances, consistent with land management objectives.
  - Conserving working forests and grasslands.
  - Providing technical assistance for programs designed to enhance carbon sequestration potential through afforestation, reforestation, and practices that increase and maintain productivity and ecosystem health.
  - Encouraging communities to retain green space and to plant and maintain trees.
  - Using available tools to understand the impacts of management actions on carbon stocks and fluxes.
- **Facilitating demonstration projects** leading to the development of markets for ecosystem services, including carbon markets.
- **Promoting woody biomass utilization** by doing the following:

Climate Change Impacts: Alaska Yellow-Cedar Decline

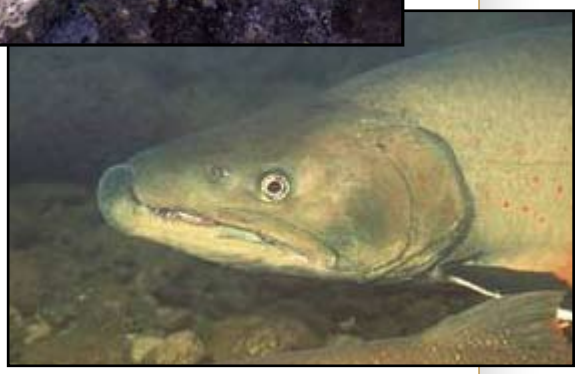
More than one-half million acres of Alaska yellow-cedar *(Chamaecyparis nootkatensis)* mortality have been mapped during aerial surveys in southeast Alaska. The affected areas contain mixtures of long-dead, recently died, and dying yellow-cedar trees. Yellow-cedar has extremely valuable wood; thus, the problem has considerable economic consequences. This tree also has ecological and cultural importance: its wood and bark have long been used by indigenous people. Analysis of aerial survey data reveals that tree mortality is concentrated at lower elevations and on wet soil types. Research indicates that the problem began about 100 years ago at the end of the Little Ice Age. Tree death appears to result from root freezing, predisposed by low snow accumulations in the 1900s. Shallow roots in anaerobic soils and a unique vulnerability to cold injury in early spring are associated with the decline. Knowledge of the cause of yellow-cedar decline and associated site risk factors is leading to a conservation strategy for this valuable tree species in the context of a warming climate with reduced snow. For more information, go to *http://www.fs.fed.us/pnw/research/climate-change/yellow-cedar/*.

Climate Change Impacts: Rare Plants

Christ's Indian paintbrush *(Castilleja christii)* is a showy, yellow-flowered perennial endemic to subalpine meadow and sagebrush habitats in the upper elevations of the Albion Mountains in Idaho. This species is known from only a single population on the summit of Mount Harrison. The conservation and protection of this rare population are managed by the Sawtooth National Forest, Minidoka Ranger District. It is currently ranked as one of Idaho's rarest plants.

The plant is now threatened by another Indian paintbrush that has climbed in elevation due to the effects of climate change. Christ's Indian paintbrush is hybridizing with this other native plant. In addition, invasive plants are gaining in elevation and have begun to occupy the habitat of this very rare species. The species will not be able to survive *in situ* for these reasons. Long-term survival will require extraordinary measures, including seed collection and preparation for long-term storage. Living collections in botanical gardens will also be part of this overall *ex situ* conservation plan.

Climate Change Impacts: Animals Adapted to Cold



Many animal species occupy a geographic range within certain thermal limits. Because the Forest Service manages many cold, higher elevation landscapes, it plays an important role in sustaining populations of cold-adapted species. As annual temperatures rise, animals will shift northward or move to higher elevations. For example, many species in the Great Basin, in particular butterflies and pika, will be forced into smaller, more isolated patches of high-elevation habitats. Similarly, many trout and char populations will be forced into smaller, more isolated headwaters; some might disappear. Woodland caribou in northern Idaho occupy the southern extent of their range. Northward migration would eliminate them from the Continental United States. To protect all these species and more, the Forest Service will need to make habitats more resilient to climate change and increase connectivity among them. Failure will mean the disappearance of these species from the National Forest System.

- Encouraging the use of woody materials for thermal heat and power production and as a substitute for more energy-intensive building materials.
- Increasing the reliability of an accessible and sustainable supply of woody biomass from national forests and private lands, where feasible.
- Providing research, technical assistance, and grants to foster (1) the substitution of wood-based building products for more energy-intensive materials (such as steel and concrete); (2) more use of excess wood from forests and urban areas as renewable sources of heat, power, and transportation fuels; and (3) development of cost-competitive, wood-based liquid transportation fuels and chemicals to reduce fossil fuel use.

- **Reducing the Forest Service's environmental footprint**, including reduced carbon emissions and more efficient use of energy and water resources.
  - Require all new design and construction at owned buildings and leased buildings over 10,000 gross square feet meet the criteria of the U.S. Green Building Council's Leadership in Energy and Environmental Design Silver Certification, where practicable.
  - Install advanced electric meters in agency buildings by 2012 and natural gas/steam meters by 2016.
  - Promote Energy Saving Performance Contracts and Utility Energy Service Contracts, when life-cycle cost effective, to help finance energy and water efficiency projects.
  - Optimize use of vehicles and right-size fleet.

- **Addressing climate change in planning and analysis** by doing the following:
  - Incorporating climate-related vulnerabilities and uncertainties into land management and project-level environmental analyses.
  - Discussing how a range of uncertain future climate conditions might affect the expected consequences of proposed activities.
- **Playing a leadership role** in carbon assessments and climate change monitoring by coordinating with other Federal agencies in assessing and reporting carbon stocks and in monitoring for climate-driven impacts and changing conditions on the ground.
- **Protecting rare and sensitive species** by restoring and reconnecting their habitats.

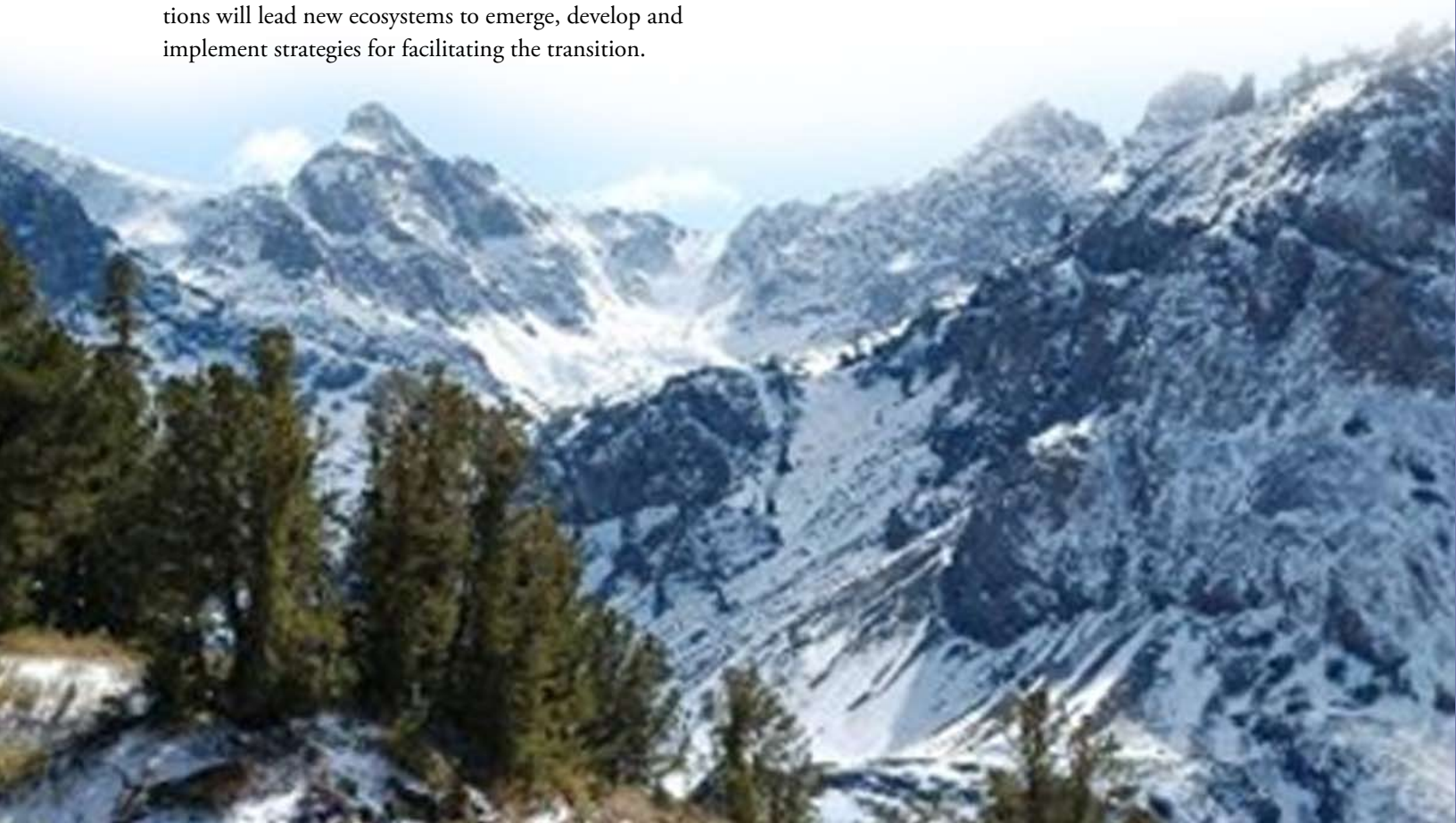
Immediate Initiatives

- **Develop decision support tools** for adaptation and mitigation.
  - Update data systems for identifying current resource conditions, feedback from past management practices, and future high-priority activities and the feasibility of their implementation.
  - Develop comprehensive tools for priority setting and budgeting that are applicable at all geographic scales using existing data and compatible with data and tools being used by partners.
- **Set priorities** for management actions.
  - Develop a risk-based management system to identify adaptation and mitigation priorities across landscapes and watersheds within bioregions. The system would use risk management concepts to evaluate resource conditions and trends, values at risk, relative vulnerabilities, and other local factors, encouraging balancing risk reduction across multiple risks and costs.
  - Develop new management strategies for reconnecting habitats, maximizing the habitat accessible to native species while minimizing the spread of unwanted species.
- **Refine management practices** for addressing projected climate change impacts and ecosystem dynamics, using the principles of risk management and adaptive management.
- **Develop a web-based sustainable operations information system** that integrates with existing databases to report and monitor energy and water use, green purchasing, fleet and transportations, waste prevention, and recycling activities and provide guidance in achieving goals in reducing the agency's environmental footprint.
- **Connect habitats** to improve adaptive capacity.
  - Collaborate with partners to develop strategies that identify priority locations for maintaining and

restoring habitat connectivity. Seek partnerships with private landowners to provide migration corridors across private lands.
  - Remove or modify physical impediments to the movement of species most likely to be affected by climate change.
  - Manage forest and grassland ecosystems to decrease fragmentation.
  - Continue to develop and restore important corridors for fish and wildlife.

Longer Term Initiatives

- **Increase long-term restoration capacity.**
  - Restore disturbed areas, where appropriate, with planting stock from seed sources and species that will be adapted to changing conditions.
  - Develop seed and plant stocks that will be appropriate for revegetation in light of climate change.
  - Implement genetic conservation strategies for at-risk species or populations, including saving and storing seed stocks for trial and study.
- **Develop transition strategies.** Where changing conditions will lead new ecosystems to emerge, develop and implement strategies for facilitating the transition.
- **Develop comprehensive strategies for maintaining and restoring habitat connectivity.**
- **Implement effectiveness monitoring systems** to evaluate the results of management actions designed to facilitate adaptation and mitigation.
- **Take sustainable consumption to the next level.**
  - Beginning in fiscal year (FY) 2020, design all new buildings and those buildings undergoing major renovation to achieve zero-net energy by FY 2030.
  - Facilitate and coordinate the implementation of the Power Track system by 2012. Power Track has the potential to greatly enhance the ability of field units to track their own energy use. This system is designed to capture more consumption data than current National Finance Center systems.



The Way Forward

Climate change is one of the greatest challenges the Nation has ever faced. The implications for both society and natural resources are profound and complex, as are the challenges of integrating adaptation and mitigation responses. A successful approach will be based on thorough assessments and well-tailored policies, engaging a full range of stakeholders across the landscape in activities for adaptation, mitigation, and education.

The Forest Service's *"Strategic Framework for Responding to Climate Change"* has set the stage for the roadmap presented here. The roadmap can help Forest Service units chart a course to the future tailored to local needs, based on three interrelated modes of action (assessing, engaging, and managing) and three sets of activities for each (ongoing, immediate, and longer term). The roadmap points the way to a comprehensive, science-based approach to managing forests and grasslands in an era of climate change.

Land and resource management are inherently fraught with risk and uncertainty. Climate change exacerbates both. In response, the Forest Service must be nimble, willing to learn from mistakes, and must incorporate lessons learned into future agency direction. The agency is ready to work with and learn from others, sharing its knowledge, skills, and experience to make America's forests and grasslands sustainable for present and future generations, even in an era of climate change.

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