U.S. Forest Service
Leadership Team Meeting
New Orleans, LA, April 24, 2007

The Case for Developing an Agency-Wide Integrated Response to Global Change and its Effects on Forest and Range Ecosystems

The warming of the last century is clearly different from the changes in the last millennium, and can only be mimicked by including human-caused GHG emissions. The Forest Service needs to anticipate and plan for significant changes in land management and operations. We need an integrated, agency-wide global change strategy to focus on change and managing for uncertainty.

1. **What can we do about global climate change? How can the Forest Service be part of the solution to the increasing concentration of atmospheric GHG?**
   - Forests are part of the solution to mitigating climate change. U.S. forests and wood products currently offset 10% of carbon dioxide emissions from fossil fuels.
   - This rate of sequestration may not be sustainable without additional actions to increase carbon storage capacity, and may switch to a source in the face of increasing threats from climate change, wildfire, and other disturbances.
   - Implementing carbon management on forest lands requires integration with other management objectives and a coordinated effort by all branches of the Forest Service.
   - The FS should aggressively reduce its environmental footprint especially regarding fossil fuel emissions from operations (buildings, fleet, and other transportation).
   - The nation needs a comprehensive analysis of the potential benefits and tradeoffs from carbon management strategies for the states, public lands, and private lands.
2. **How can the Forest Service respond to the positive and negative effects of climate change on ecosystems, and sustain the resources that we and our partners manage?**
   - Develop and adopt strategies that include both ***adaptation*** and ***mitigation***, or suffer the consequences of rapidly changing climate.
   - Expect surprises -- impacts will range from the subtle to the totally unexpected. The worldview of managers must change from managing for the *status quo* to managing for change *per se*.
   - Revise current interpretations of sustainability. Without understanding the past climate, both historic and natural ranges of variability are poor references for current and future management.
   - Increase resilience and resistance of ecosystems from other interacting risks such as increasing wildfire, insect infestations, and water shortages.
3. **How can we organize to respond and adapt to global change which will be characterized by a large degree of variability, uncertainty, and risk?**
   - Immediately convene a climate strike team from all Deputy areas to develop a comprehensive national strategy that includes collaboration between policy-makers, managers and scientists. Link this team with reducing the FS environmental footprint.
   - Work with USDA and the States to develop, promote, and practice good forest carbon management practices and with other land management agencies to develop, promote and adopt management practices that facilitate adaptation to a changing climate.
   - Provide line officers and managers with new decision support tools that account for climate as it influences resource management, and ecosystem services.
   - Develop guidance on how to incorporate climate change into the planning process, and engage the public to integrate climate change in natural resource management.

Research & Development

USDA Forest Service

Global Change and the US Forest Service: The Nature of the Climate Threats We Face

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ISSUE: We must consider how dependable the trends are that describe current and predicted future climate changes, what the nature of the changes will be that Forest Service needs to understand in its land planning activities, and what the character is of the current effort being devoted to study climate change and implement it in management planning.

1. How real is the threat of global climate change?

Three major lines of information tell us this is real and it works as theory suggests:

- The greenhouse effect is defined by the **laws of physics** (e.g., First Law of Thermodynamics).
- **Synchrony of temperature and CO_2** changes has a long history, supporting our application of the law.
- The **warming is clearly different** in the last century from changes of the last millennium (faster, greater), from changes due to solar variations (troposphere heats while stratosphere actually cools), and climate models can replicate it, but only by including historic greenhouse gas increases.

2. What predicted climate changes have already been measured?

- **Warming** has been clearly measured, including greater warming at the poles than at the equator, over continents than over oceans, in winter than in summer, and at night than in daytime. Warming of the past few years in the U.S. has been concentrated in the West and Alaska
- **Precipitation** has increased because warming increases the intensity of the hydrological cycle (more evaporation, then more rainfall and runoff; more large storms) except in arid areas and many summer-dry (Mediterranean) climates. Changes in soil moisture in the past few years have increased drought intensity and length in the West, and increased soil moisture in the East.

3. What climate changes are projected for the future?

- **Warming** should continue in the same geographic, daily and seasonal patterns. Local predictions are uncertain because warming estimates differ from place to place, depending on the model and the amount of mitigation the global community applies. However, there is no doubt about the continuing upward direction of warming.

- **Precipitation** variation should continue to increase, producing more droughts and downpours, while subtropical deserts spread poleward, and large storms including hurricanes increase in intensity. Local predictions are even more uncertain because climate models are weak at simulating the local processes determining precipitation.

4. How important are inter-annual and inter-decadal climate cycles?

- El Niño **(ENSO)** shows up every **3-7 years** for a year or two, causes dry winters in the PNW, wet ones in the southwest; La Niña does the opposite in PNW (wet) and southwest (dry); times without either condition occur and may be disappearing.
- The Pacific Decadal Oscillation **(PDO)** at intervals of ~**20 years** has a warm/dry phase that increases drought in the PNW, cool/wet in the south and southwest, and a cool/wet phase that does the opposite; we seem to be in a warm/dry phase now.
- The Atlantic Multidecadal Oscillation **(AMO)** at intervals of ~**60 years** appears to induce warm/dry, or cool/wet conditions to the entire West; we seem to be entering a warm/dry phase.
- Each cycle, separately and together, can ameliorate or amplify regional effects of warming, but none will overwhelm the continuing trend to warmer climates.

5. What is the current Forest Service global change research effort and strategy?

Our 2007 budget request is much smaller than the big players, NASA, NOAA, NSF, and DOE, and about the same as our sister research agencies, USGS and EPA. Our research falls into three related categories

- **Enhancing Mitigation Options** – carbon sequestration by reducing emissions and enhancing carbon sequestration through land management
- **Enhancing Ecosystem Resilience** –the intersection of adaptation and mitigation – through testing management options via field research, and quantifying options with decision support tools.
- **Assessing the Impact of Climate Change** – the basis for adaptation to future climate changes, it includes physical and ecological research to understand climate change effects, assessment and modeling to quantify the potential impacts, and studies of human dimensions to document the costs and benefits to people.

6. Take-away messages

- Global **climate change is real**, and is as permanently present as death and taxes; there is no going back to pre-Columbian or even pre-logging conditions.
- Equally certain is the **uncertainty** of future climate at any specific time and location.
    - Immediate effect is to increase climate variability, amplifying major disturbances, such as droughts, wildfires, insect infestations, and hurricanes.
    - Inter-annual and inter-decadal climate cycles like ENSO, PDO, and AMO, modify effects of climate change, but do not swamp those effects.
- The U.S. Forest Service has a basic **global change research program** now 15 years old, and a research infrastructure ready to support a focused effort.
- There is no **FS-wide global change strategy** to apply that research or create new information needed to manage with uncertainty.

Opportunities to Increase Carbon Sequestration and Reduce Emissions for U.S. Forest Lands

Issue: a variety of forestry activities can protect existing forest carbon stocks and increase the rate of carbon sequestration. But, increasing threats from climate change, wildfire, and other disturbances threaten the stability of the carbon currently stored in forests. Implementing good forest carbon management requires a concerted leadership effort by the Forest Service.

U.S. forests currently offset 10% of carbon dioxide emissions from fossil fuels, but this rate of carbon sequestration may not be sustainable without additional actions.

- 100 years ago, U.S. forests were so heavily cleared, utilized and damaged that they were emitting vast quantities of stored carbon – as much as 2,900 millions tons of CO_2 per year.
- Because of regrowth, good management practices, and fire suppression, today's forests and forest products sequester 700 million tons of CO_2 per year.
- The current rate of net sequestration is not sustainable without continued good management, and may not be sustainable at all under some climate change scenarios.
- There is potential to sequester an additional 1,200 millions tons of CO_2 per year. The potential for forest biofuel offsets may be 600 millions tons of CO_2 or more per year.
- Sustainable carbon management involves protecting existing forest carbon stocks, restoring forest health, and applying management practices to increase sequestration or offset emissions.

Sustainable carbon management involves a variety of forestry activities that must be integrated with other objectives of federal, state, local, and private entities.

- U.S. forests are highly diverse ecosystems with different patterns of land use history. Forest management has adapted locally to this diversity and to various state regulations.
- Categories of forestry activities that can contribute to sustainable carbon management include increasing carbon stocks, using forest biomass for energy, and substituting wood for other manufactured products. Avoiding deforestation and urban forestry are also important.
- These activities are consistent with many common landowner objectives such as timber production, restoration of wildlife habitat, and watershed protection. But there may also be tradeoffs. For example, higher tree density may reduce water availability.
- There is a variety of accounting systems and greenhouses gas registries that need to be harmonized to facilitate a national greenhouse gas action plan.
- Engaging the nation's landowners will require flexibility in implementation of programs, while promoting national consistency in accounting, reporting, and verification.

Natural disturbances, especially wildfire and insects, threaten resource sustainability and increasingly disrupt our nation's ability to implement management programs.

- Wildland fires release about 1,000 million tons of CO_2 each year, along with other greenhouse gases. As long as the incidence and severity of wildfires remains constant, regrowth of burned areas offsets this release.
- The incidence and impact of wildfire is increasing significantly and is clearly linked to fuel buildup and climate variability. Insect disturbances are also on the rise.
- Programs that are designed to restore healthy forests are critical to the long-term sustainability of carbon stocks.
- Restoring healthy forests that resist intense wildfire is good carbon management especially if fuel removed from the forest is utilized for wood products or energy.
- Land management programs that restore forests to healthy and productive conditions will help ensure the long-term maintenance of existing forest carbon stocks.

There is a need to invest in some specific research, development, planning, and management activities to implement sustainable forest carbon management.

- Good carbon management involves multiple objectives: increasing carbon sequestration, reducing and offsetting emissions, and responding to forest threats.
- Improved inventory and monitoring systems are needed to efficiently estimate changes in carbon stocks for forests and wood products, and for emissions inventories.
- We need to develop forest management and biofuel technologies that reduce global warming potential and fully account for co-benefits and tradeoffs.
- The long-term impacts of changing wildfire regimes and fuel reduction programs on greenhouse gas emissions and sequestration are poorly understood. We don't yet know how to manage aging and threatened forests to protect existing carbon stocks.
- We need a comprehensive analysis of the potential benefits and tradeoffs from different carbon management activities for states, the private sector, and public lands.
- We need to develop a long-term national strategy for good carbon management that includes adaptable forest planning to contend with the uncertainty of future climate.
- The Forest Service has a unique role to lead the nation in developing, promoting, and practicing good forest carbon management.

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Climate Panel Brief

Strategic Planning for Climate Change Research and Management

Forest Service National Leadership Team Meeting
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Issue: How can climate change be placed in the context of sustainability? How can a systems perspective assist the Forest Service in addressing climate change impacts on forests in its research, management, and policy?

Both a systems perspective and an engaged management approach provide ways to improve understanding and management of factors affecting climate change and its effects on forests.

- A systems perspective is needed to understand the inherent complexities on climate change. A systems approach increases understanding of the role of feedbacks, how changes to any of the interactions can affect the overall system, and how perturbations to systems may result in a new level or type of stability. This perspective also helps identify key pressure points for which management actions might be most effective or stake holder groups have common ground.

- A management approach engaged with research provides an appropriate way for decision makers to deal with the uncertainties inherent in climate change. Management actions can be treated as experiments that test hypotheses, answer questions, and thus provide future management guidance. This approach requires that both conceptual models be developed and used and relevant data be collected and analyzed to improve understanding as the system changes.

When the full context of the causes and effects of climate change are considered, the most effective management options can be identified to minimize the impacts of climate change and take advantage of the opportunities under the new climate.

- Climate change should be considered in view of other global changes. Land-use condition both affects climate change and influences its impacts. There are strong regional trends in population, resource scarcity and quality (e.g., water), and pollution. Other global changes include the rise in atmospheric CO_2 concentration, increased ultraviolet radiation,

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and the spread of invasive species. Climate changes can both cause and be affected by changing disturbance regimes (e.g., fire and Invasive species).

- Management actions both respond to and affect climate changes. These actions include the amount and means to harvest and manage resources as well as supply and demand for resources and access (e.g., transport routes). Carbon emissions can be reduced by forest management that focuses on sequestration.

- Forest Service actions that strategically align with other research and management activities can take advantage of models and experiments designed to enhance understanding of effects of changes in climate and atmospheric CO_2 concentration.

When scientific investigations and decision-making are integrated, enhanced understanding about underlying processes and management implication can be achieved.

- Recent trends in decision making include a more complex view of world, increasing environmental pressures, more awareness of environmental pressures, stakeholders being more educated and actively involved, and the world becoming more networked (e.g., globalization of economies).

- Future directions of developing and using research for resource management are that there is a recognized need to address the full scope of problem, to explore diverse approaches, to use long-term vision to direct research and management, to explore alternative futures in a gaming mode, and to maintain communication between scientists and decision makers.

- The communication between scientists and decision makers is critical. It is a two-way street. Both translating scientific results to particular conditions and extrapolating beyond a specific study are challenging. Regular discussions between scientists and decision makers can enhance communications and build mutual respect.

- Designing climate change research for decision making requires active collaboration amongst researchers and key decision makers, a focus on the appropriate scales of resolution, inclusion of all relevant disciplines and expertise, a “living” strategic plan of action, a commitment to transfer information and technology, and clear recognition of the uncertainties. Because trees are so long-lived and climate changes are occurring so rapidly, the research must combine modeling, experimental and management approaches to be able to address complexities and scales of the challenge. Recognizing and adapting to this need often requires a change in planning perspectives.

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U.S. Forest Service
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ISSUE: Climate Change, Uncertainty and Forecasts of Global to Landscape Ecosystem Dynamics

1. What are the scope and nature of the resource issues of concern?

- **Forest resource issues are Multi-Scale, requiring Global to Local Assessment**
  - Forest and range resources occur in a **global** marketplace and sustain all of humanity; yet, are managed at the **local** scale.
  - The **dynamics** of forest and range resources occur on **Near** to **Long** Term timescales with a full spectrum of temporal variability. **Oceanic oscillations** dominate interannual to interdecadal timeframes; whereas, variations in **Greenhouse Gas concentration**s will dominate the long-term trends.
  - Historical Management, e.g., Fire Suppression can leave long-term **Legacies**
- **Natural Resources and Issues of Concern are defined by *What* is at stake, how it *functions* and how these forms and functions might be interrupted via catastrophic *disturbance*.**
  - ***Biodiversity*** defines the ***What*** and incorporates the full hierarchy of Biotic Forms and their distributions from highly aggregated Biomes to individual Species.
  - Ecosystem ***Function*** includes Global Carbon Balance – Sources and Sinks, Forest Productivity, Nutrient Balance, Wildlife Habitat and Water Resources.
  - Catastrophic ***Disturbance*** includes large-scale Drought, Fire, Infestation and Disease.
- **Managers are challenged with the Management of *Change*, per se, rather than the *Status Quo*.**
  - ***Perpetual Uncertainty*** will prevail over our more traditional view of a relatively 'certain' or predictable future.
  - A ***Toolbox for Managers*** is needed to replace existing quantitative management tools that presume a stationary climate.

2. Global Impacts are in Progress Now

- **"Early greenup – later browndown"** – Two different Dynamic General Vegetation Models (DGVMs), LPJ and MC1, running under numerous future climate scenarios initially produce **carbon gains from mild warming**, but **Evapotranspiration and Decomposition increase exponentially with temperature** and carbon losses eventually overcome productivity increases with **potential for large-scale, catastrophic forest dieback** and ***Positive Feedback to Climate Change***.
  - Boreal and Temperate forests could show **increases in biomass consumed by fire of 20% to 60% or greater over large areas of the globe**.
  - There is **High Risk of *water shortages* in temperate and subtropical regions.**
  - Plant and many animal migrations will not be able to keep up with climate change.
    - Rapid dispersers (pests, weeds) will become ***Invasive Species*** in communities that house slowly dispersing T&E species.
    - There is ***Potential for mass extinctions*.**

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3. Regional Impacts are in Progress Now

- **Regional Legacies of management activities**, e.g. Fire Suppression and Exclusion, Grazing, Harvest, Agricultural Expansion and Abandonment are pervasive.
- **Interdecadal climate variability** is manifest as persistent regional droughts, floods, cold spells and hot spells and could be enhanced by GHG-induced climate change, creating ***significant uncertainty at the regional scale*** **in the near term**.
- Scenarios show **possibly wetter in the West, drier in the Eastern U.S.** (Temperature-induced drought stress).
  - There is a large potential **for *increased woody expansion* (carbon sequestration) in the West**, but accompanied by increased fire.
  - Initial growth increases possibly followed by ***widespread drought, infestation and fire*** **in the Eastern U.S. temperate and subtropical forests**. Possible conversion of forests to savannas, woodlands and grasslands.
- There is a **Widespread, catastrophic ecosystem *dieback potential*** in both eastern and western woody ecosystems.
- There is a **large *Invasive* potential** of subtropical (frost-intolerant) vegetation and wildlife into Temperate and Boreal ecosystems (Infestations, Weeds, increased competition for T&E species).

(Italicized below will not be presented, but is included here for information purposes)
4. Local Impacts – In Progress Now

- *Several* ***statewide assessments have been published for California***
  - *Considerable vegetation composition change*
  - *Increased fire risk in coastal and inland mountains*
- ***Very few process-based landscape-scale simulations of climate change*** *impacts have been done. Glacier National Park is a good example.*
- ***Landscapes will be significantly transformed*** *by:*
  - *Phenology shifts, Physiognomic change, Considerable migration, Potential dieback in specific landscape locations, Shifting elevational ecotones, both up (higher temperatures) and down (enhanced moisture)*
- ***Interdecadal climate variability significantly increases the uncertainty*** *at the landscape scale in the near term. This is the scale at which management puts 'boots on the ground'.*

5. Management Toolbox

- Almost all current, commonly used, quantitative tools for forest planning, such as FVS, TELSA and VDDT, do not explicitly take climate variability and change as inputs.
- These tools must be re-built to take climate variability and change directly as inputs, yet to retain the 'look and feel' of the commonly used tools
- Workshops between scientists and managers will help to design and refine these tools
- Socio-economic factors must be built into the models
- **Managers' 'worldview' must change from managing for the *status qo* to managing for *change*, per se.**
- **Use scenario and risk analysis, since the future will 'forever' remain uncertain, but within definable bounds**.

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Climate Panel Brief

Climate Change Impacts on US Water Resources

Forest Service National Leadership Team Meeting
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Issue: Providing clean and plentiful drinking water was one of the earliest missions of the Forest Service. Climate change could seriously impact water resources from National Forests. What role will the Forest Service have in maintaining the national water supply and how can Forest Service land managers, policy makers and science work together to minimize future water shortages?

Back ground on water resources

Precipitation is one of the major components of climate change. Historically records indicate that the intensity of individual rain events has increased since 1900. General Circulation models predict that precipitation patterns will change in the coming years and decades. Although the nation receives many times more precipitation than is used by people and the environment, the distribution of precipitation is not homogeneous. Much of the precipitation falls east of the Mississippi River, while much of the inter-continental region receives little precipitation. Even areas that on average receive sufficient precipitation experience inter-annual or inter-decal water shortages. Land managers are currently struggling with water resource limitations, and climate change (and other factors) could increase these problems.

Climate change will likely alter precipitation patterns

- Climate change impacts the timing (i.e., monthly, seasonal), distribution (i.e. changes in regional averages), form (i.e., rain, or snow), and intensity (i.e. gentle or severe) of precipitation.
  - The consensus of General Circulation Climate Models suggest that the western US will receive less precipitation while the eastern US will receive annual precipitation amounts equal or above current levels.
  - Even if annual precipitation amounts remain relatively constant, the distribution of precipitation with the year is equally important.

Impact of changing precipitation patterns on ecosystems

- Increased wild fire risk and occurrence. Recent studies suggest that early spring snow melts, and summer droughts are closely tied to wild fire occurrence. Climate change will likely alter patterns and timing of snow fall and precipitation could further increase wildfire risk.
- Increased soil erosion and stream sedimentation. The percentage of precipitation that occurs as an extreme event (2"/day) has increased by 25% since 1900. Soil erosion is highly related to increased rainfall intensity. Climate change will likely continue to increase rain fall intensity and soil erosion, and reduce water quality in affected streams.
- Increased insect outbreaks. Trees need water to produce secondary compounds such as oleoresin used to reduce insect colonization of trees. Reduced in growing season precipitation could experience a significant increase insect populations and increasing forest mortality.
- Altered forest productivity. Changes in precipitation patterns will likely be both beneficial and detrimental to forest productivity depending on precipitation timing and amount.
- Altered tree and animal ecosystem composition. As wildfire, insects and changing precipitation patterns impact the survival of plants and animals, changes in ecosystem composition is

inevitable. If the changes were to occur over thousands of years, natural ecosystem shifts might be predicted. However, it is difficult to accurately estimate how forest ecosystems will evolve if change occurs over decades and not millennia.

Management Options

. Manage for more resistant tree species. Some tree species (e.g., longleaf pine) are more drought and fire tolerant than other faster growing species (e.g., loblolly pine). It will become necessary to shift back toward the management of slower growing but more environmentally viable tree species to maintain forest cover.

Impact of changing precipitation patterns on people

. *Increased interannual and inter-decadal water shortages.*
  - Timing of snow melt. Both people and ecosystems living west or the Sierra Mountains are highly dependent on spring snow melt as source of growing season water. Reductions in snow pack and earlier season snow melt is increasing leaving the region with a water shortage during the summer months. Increased air temperatures associated with climate change will like melt snow progressively earlier in the year, and thus increase the likelihood of growing season water shortages.

. *Other Human factors could exacerbate or ameliorate climate change Impacts*
  - Changes in human population demographs. US population shifts to warmer states will place additional pressure on local water supplies.
  - ground water reserves. Much of the US is highly dependent on ground water reserves. The loss of ground water would likely have a much greater impact on local water stress than would decreases in precipitation.
  - Irrigated agriculture is the primary user anthropogenic water user in both the eastern and western US. The continue practice of agricultural irrigation may be come more difficult with climate change in areas with a heavy reliance on ground water reserves.

. *Management Options*
  - Develop more water reservoirs within the national forest system store water during periods of low water availability. An expensive but potentially viable contribution to reducing inter-annual water stress.

. *Unrealistic Management options*
- Cutting and maintaining areas of cut forest sufficiently large to increase local water supply. Cutttng forest vegetation has been shown to increase local water yield by 30% or more. However, the economic cost and logistical impracticality of maintaining a large enough area of cleared land would prohibit the use of this method for increasing forest water yield. Additionally, other factors (e.g., increase soil erosion and estatic implications will make this option environmentally and socially unfavorable.
- Encouraging the establishment of deciduous (aka hardwood) over coniferous (aka softwood) tree species. Studies show that deciduous species use less water that conifers species. However, outside of the northern and northeastern US, hardwoods have less commercial value compared to softwoods. Difficulties in excluding conifers and the loss of economic return from forest growth would likely preclude this option as a means for reducing water stress.

Take Home Points

- The loss of ground water reserves would have a greater impact on water stress than would climate change over much of the US.
- Climate change will impact water availability more in the western than eastern US
- Even in areas with little change in annual water supplies inter-annual water availability (e.g. changes in snow melt) could significantly impact water stress.
- Forest managers have limit practical options for increasing water supplies from forests.

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Climate Panel Brief

Re-Framing Management Strategies in the Face of Climate Change

Forest Service National Leadership Team Meeting
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ISSUE: What can Forest Service managers and decision-makers do about climate change? How can science best inform development of resource-management and policy strategies?

Work within the premise that major environmental changes are underway, that the future will be different from the present and past, and that there is significant uncertainty about details of direction and magnitude of these change.

• In addition to changes in climate, novel environmental stresses (invasive species, pollution, habitat fragmentation) are interacting to create conditions without precedence. This implies that we have fewer useful guidelines from the past, and that we must develop management approaches that incorporate change.

• Many of our existing management frameworks are based on assumptions that the future will be similar to the past, and thus don't adequately accommodate the nature of anticipated change. These include:

-- Historic range of variation: Past is a poor reference for current or future conditions.
-- Ecological sustainability: Current interpretations are overly static for dynamic reality.
-- Managing for disturbance directly: Climate changes exacerbate conditions, complicating strategies and creating a need for institutional capacity beyond expectation.

• Climate and vegetation models rarely can predict the future with the level of accuracy and precision needed by managers working at local (national forest and below) scales, although projections give qualitative insight on the nature of change and uncertainty.

Creating climate-smart management plans for specific conditions involves setting local goals and selecting from a toolbox of options. Flexibility, innovation, and capacity to course-correct are important for effectively incorporating change and uncertainty into planning.

• Strategic approaches can be adopted that include reversible or incremental steps; promote ongoing learning (broader than formal adaptive management); foster redundancy, innovation, risk-taking, and experimentation; and are capable of changing directions readily as new information unfolds.

• No single solution will fit all climate-change challenges. A toolbox approach will work best wherein different approaches may be selected and combined for different situations. This affords opportunities to modify and re-select different tools based on learning as changing conditions become understood.

Adaptation and mitigation are complementary strategic approaches to resource management in the context of climate change and uncertainty.

• *Adaptation strategies* include management actions that assist ecosystems to accommodate climate-imposed changes. They seek to minimize undesired and/or abrupt (catastrophic) responses that might occur without intervention and assistance.

• *Mitigation strategies* include management actions that assist ecosystems to reduce anthropogenic climatic change by sequestering CO_2 and reducing greenhouse-gas emissions.

• While adaptation and mitigation strategies may occasionally conflict (e.g., even-age, monotypic plantations at landscape scales, or low-diversity but fast-growing short-rotation species conflicting with habitat needs for age-, species, and structural diversity), and trade-offs must be evaluated, best management strategies may be found that incorporate both adaptive and mitigative goals.

Adaptation options comprise a range of choices, from forestalling undesired effects of climate and maintaining current structure & function, to assisting transitions to new ecosystem states.

• ***Resistance*** options are those that protect high-value resources (plantations, endangered species, habitat) by sheltering or defending them from impacts of climatic change. Practices (e.g., aggressive fuel breaks, extensive seed banking) seek to forestall the effects of climate on sensitive and valued conditions. They may be appropriate only in the short term, because as changes accumulate (e.g., temperatures continue to rise), it becomes increasingly difficult to maintain status quo, and undesired and rapid transitions may occur.

• ***Resilience*** options are those that improve the capacity of ecosystems to maintain or return to current conditions after disturbance. Relieving environmental stresses through stand thinning, mixed species plantations, or reducing fuels reduces the likelihood of extreme disturbance, and promotes ability to endure disturbance. As in resistance, resilience may be achievable only in the short term (“paddling upstream”).

• ***Response*** options are those that plan *for* change rather than resisting it, with the goal of enabling or facilitating ecosystems to respond adaptively as environmental changes accrue. Management opportunities include assisted migration (enabling species to migrate by moving seed outside current range limits); planning for redundancy and replication (multiple plantations across environmental gradients and outside traditional “best sites”); expand and relax genetic transfer and diversity guidelines; manage for landscape asynchrony; establish “neo-native” restoration plantations; re-align conditions that are out of natural variation; and promote landscape connectedness through large management units, corridors, and riparian continuity.

Setting priorities for action (including no action) is extremely important under situations of rapid change, especially where conditions are urgent, resources are highly valued and sensitive, and institutional capacity to respond is inadequate (limited funds, time, staff, resources, expertise).

• *Triage,* from the French, “to sort”, is a useful, systematic approach for prioritizing high-demand and rapidly changing situations. Triage is used in medical and civil emergencies and can be adapted to resource-management. Triage methodology not only sorts (identifies) situations that are of great urgency and demand high priority for treatment, but also identifies situations that are urgent but *un*treatable (no action) with current capacity. That the latter may represent a majority of total cases has important implications in public discourse. The few critical yet feasible projects are then most likely to receive effective treatment.

• Managers may opt to time their institutional investment to address climate change at three junctures (which we find pertain in current national forest contexts): No anticipatory plans or actions taken; incorporate climate-smart actions after disturbance; or proactively plan in advance for anticipated changes. Priority-setting exercises may dictate that different situations are addressed in one or the other of these times (e.g., some may be chosen for pro-active planning while others are best addressed by no action at present).

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Planning, Management, and Research for Adaptation to Climate Change
FS National Leadership Team Meeting
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ISSUE: Natural resource managers are facing significant challenges in addressing climate change in management and planning activities. Options exist to incorporate adaptation into planning and management. Information, tools and research are needed to respond to climate change.

USDA FS is currently mandated to address climate change in the Resources Planning Act (RPA).

Climate change has been a component of the RPA Assessment since 1990s, with conclusions similar to those from other national climate assessments:

- Markets facilitate adaptation in the forest sector nationally.
- Opportunities exist for carbon sequestration in rural and urban forestry operations.
- Surprises are expected.

Natural resource managers from federal, state, local, tribal, non-governmental organizations and the private sector have begun to address climate change.

- Managers have engaged in informal discussions, assessments, monitoring, research, education and outreach, policy and planning, management, and mitigation activities. For the most part, on-the-ground management activities are taken to deal with the 'symptoms' of climate change – drought, insects, or fire.
- Managers often focus on enhancing resilience as a strategy to manage ecosystems under climate change, other stressors and their interactions.
- Climate change has been mentioned or considered in 12 out of the 120 National Forest plans available on the web as of December 2006, either as a threat or a trend potentially restricting programs. Opportunities for carbon sequestration, monitoring, and research were identified in discussions about climate change.

Options exist to incorporate adaptation into planning and management.

- Planning and management approaches to climate change could include no anticipatory plans or management actions, responses focused on adaptation activities post disturbance, and planned responses anticipating opportunities and effects of climate change.
- Adaptation options for resource management under climate change involve creating climate-smart management plans for specific landscapes, identifying local adaptation and/or mitigation goals, selecting from a toolbox of practices, and planning for flexibility.

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Information, tools, and research are needed to respond to climate change.

Adaptation options for planning under climate change will be aided by better information.

- Broaden national analyses of climate change in the RPA assessment beyond forest dynamics to include water, wildlife, and rangeland dynamics, and develop links to national forest and regional planning analyses.
- Continue national analyses of carbon accounting.
- Develop a how-to guide customized for planners who want to incorporate climate-change science and adaptation and mitigation options in forest plans and other documents. Develop fact sheets on climate change, climate change impacts and adaptation and mitigation options for internal and external use.

Identification of appropriate management responses will be aided by ecological and socio-economic research that continues to add to the knowledge base on climate change effects (positive and negative) on ecosystems.

- Increase our understanding of climate change effects on ecosystems and people.
- Enhance ecosystem resilience under climate change.
- Determine how social and economic systems are changing and likely to change further as climate change influences the ecosystems, services and resources within and surrounding National Forests.
- Develop information and tools for tradeoff analyses.
- Test management alternatives for adapting to and mitigating the effects of a changing climate and other stressors on resources and ecosystem services.

Create science-based tools to support forest planning and management under climate change.

- Develop techniques, methods and information to assess the consequences of climate change and variability on physical, biological, and socio-economic systems at varying spatial scales.
- Develop a tool box for resource managers that can be used to assess current assumptions about climate and quantify effects of climate change on natural resources.

Overall Recommendations

- Convene a team from all Deputy areas to develop a comprehensive national strategy to respond to climate change.
- Nurture and cultivate human capital through information, training, and a learning environment.
- Provide line officers and managers with new decision support tools that account for climate as it influences resource management and ecosystem services.
- Develop guidance on how to incorporate climate change into the planning process and engage the public to integrate climate change in natural resource management.
- Work with other land management agencies to develop, promote, and adopt management practices that facilitate adaptation to a changing climate.

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