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Briefing Paper

"Climate change makes droughts worse, causing worse insect outbreaks and worse fires, which in turn means more smoke and carbon in the atmosphere—and more climate change. This cycle threatens the capacity of our forests to provide all kinds of environmental services that people have come to expect, including clean air and water, habitat for fish and wildlife, and opportunities for hunting, fishing, skiing, and other kinds of outdoor recreation."

—Forest Service Chief Gail Kimbell

We are already seeing the effects of climate change on our forests:

- Fires are a natural part of forested landscapes, but each year the fire season is coming earlier and ending later. In addition, the fires themselves are burning hotter. Fires have become more damaging and dangerous.
- Insects are also a natural part of forested landscapes, but now the insects—both the native ones and the invaders—are spreading more rapidly. The winter cold isn't knocking some populations back. Epidemics are larger and last longer, killing more trees and increasing fire risk.
- The warmer winters are also affecting our water supplies. The snowpacks are thinner and they melt earlier in spring, so the water runs out from the forest earlier in summer. Extended droughts make trees more vulnerable to fire and insects.

If warming continues as anticipated over the next 30 years:

- The number and severity of large wildfires are likely to increase.
- The range and frequency of large insect outbreaks are likely to increase.
- Hurricanes and ice storms are likely to increase. Storm damage can reduce forest productivity and carbon storage.

What is the Forest Service doing about climate change?

- The Forest Service has developed the ***Strategic Framework for Responding to Climate Change*** to help us set priorities and to make informed decisions for sustaining forest and grassland resources in a changing environment.
- The framework envisions a future where ecosystem services are sustained; forests and grasslands are adapting successfully to changing climate; and management actions contribute to mitigating impacts of climate change.

America's researchers and land managers are working to help America's ecosystems adapt to climate change by:

- Actively managing the national forests and grasslands to improve ecosystem health; sequester more carbon; and be more resilient to stresses such as drought, air pollution, and invasive insects and diseases.
- Improving our ability to detect and model the impacts of climate change on plants and animals and on water quality and availability.
- Better understanding ecosystem vulnerability and finding ways to increase ecosystem resilience.
- Preventing and reducing such barriers to species migration as forest fragmentation.
- Restoring ecosystems where necessary after large-scale disturbances.
- Considering realignments of seed zones and planting methods.

America's forests could potentially offset a portion of America's annual carbon emissions through partnerships and management measures, including:

- Encouraging and assisting private landowners to preserve forests and other ecosystems that store carbon.
- Encouraging private landowners to actively manage their forest lands to improve ecosystem health, creating forests more resilient to stresses such as drought and more efficient at storing carbon.
- Supporting the development of markets for carbon offsets created by sound forest management.
- Finding new ways to use small-diameter woody biomass in wood products that can store carbon.
- Finding ways to use woody biomass to heat homes, generate electricity, and power cars through cellulosic ethanol.
- Promoting tree growth in urban areas to take up carbon and to provide shade and greenery.

For specific facts and references, see *Climate Change Quick Facts.*

Forest Service Mission
Sustain the health, diversity, and productivity
of the Nation's forests and grasslands
to met the needs of present and future generations.

Today's Challenges and Opportunities
Climate Change

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Quick Facts

Atmospheric Carbon
In the 1990s, greenhouse gases in the atmosphere grew at an average rate of 3.2 billion tons per year because emission sources more than offset carbon sinks (Houghton 2003):

Burning fossil fuels	+ 6.3 billion tons per year
Land use conversion	+ 2.2 billion tons per year
Ocean uptake	– 2.4 billion tons per year
Other carbon sinks (forests, rangelands, croplands, etc.)	– 2.9 billion tons per year

Atmospheric carbon dioxide concentration is now higher than at any time in the past 10 million years (Kennedy and Hanson 2006).

Temperature
Eleven of the last 12 years rank among the 12 warmest years since 1850 (IPCC 2007a).

Over the next hundred years, the average temperature in the United States is expected to rise by 4 to 9 °F (Field and others 2007).

Precipitation
Annual mean precipitation is projected to decrease in the Southwest but increase over the rest of North America (Christensen and others 2007; Field and others 2007; IPCC 2007a).

The fraction of annual precipitation falling as rain (rather than snow) increased at 74 percent of the weather stations in the western mountains of the United States from 1949 to 2004 (Field and others 2006).

Warming in western mountains is projected to decrease snowpacks, cause more winter flooding, and reduce summer streamflows (Field and others 2007).

Snow and ice will melt earlier, resulting in drier summer conditions, particularly in the arid West (IPCC 2007b).

Disturbances
Many ecosystems are likely to be threatened in this century by an unprecedented combination of climate change, associated disturbances (e.g., flooding, drought, wildfire, insects), and other global change drivers (e.g., land use change, pollution, over-exploitation of resources) (IPCC 2007b).

Major disturbances such as floods and droughts are likely to increase in number and intensity (IPCC 2007b).

The ecological impacts of wildfires as well as forest pests and diseases are expected to rise, with extended periods of high fire risk and large increases in area burned (IPCC 2007b).

Projected increases in area burned annually in the United States range from 4 to 31 percent (Bachelet and others 2003).

Selected Ecological and Other Impacts
Plant and animal communities will tend to migrate northward and upslope (IPCC 2007a).

Typical spring events, such as the leafing out of trees and the migration and nesting of birds, will come earlier in the year (IPCC 2007b).

About 20 to 30 percent of the plant and animal species assessed are likely to be at increased risk of extinction if increases in global average temperatures exceed 2.7 to 4.5 °F (IPCC 2007b).

Rising levels of atmospheric carbon dioxide could help the spread of invasive weeds such as Canada thistle, yellow starthistle, leafy spurge, spotted knapweed, field bindweed, and perennial sowthistle (Ziska 2003).

If warming continues as anticipated in the arid West (Ryan and others 2007):
• Higher temperatures and decreased soil moisture will likely reduce the stability of surface soil, leading to increased erosion.
• Increases in high-intensity storms will likely increase water erosion in uplands.
• Increases in windspeed and gustiness will likely increase wind erosion, dust emission, and transport of nutrient-rich dust to downwind ecosystems, causing more rapid spring melt and shorter availability of snowmelt for human use.

Projected changes in temperature and precipitation will likely (Ryan and others 2007):
• lower forest productivity in Alaska, the Southwest, the Interior West, and eastern parts of the Southeast; and
• increase forest productivity in the Lake States, the Northeast, and western parts of the Southeast.

Projected increases in hurricanes and ice storms will likely lower forest productivity in the Southeast and Northeast, exacerbating or offsetting changes caused by temperature and precipitation (Ryan and others 2007).

Without snowmaking, the ski season in the Sierra Nevada will likely shorten by 3 to 6 weeks by the 2050s and by 7 to 15 weeks by the 2080s (Field and others 2007).

By the 2050s, there will likely be no reliable snowmobile season in most of the East (Field and others 2007).

Carbon Sequestration
From 1990 to 2004, forest growth in the United States sequestered about 627 million metric tons of atmospheric carbon dioxide on average each year, offsetting about 10 percent of the carbon dioxide emitted by Americans burning fossil fuels (EPA 2006).

If current trends continue, then net carbon uptake by terrestrial ecosystems worldwide is likely to peak before midcentury and then weaken or reverse, amplifying climate change (IPCC 2007a).

Biofuels

Forests in the contiguous United States could produce up to 368 million tons of biomass for conversion to energy, enough to meet about 9 percent of current national demand for transportation fuels (Perlack and others 2005).

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