National Fish, Wildlife and Plants Climate Adaptation Strategy

Shrubland Ecosystems

Photo: NPS

Disclaimer

The information in this Shrubland Ecosystems Background Paper was developed by the Grassland, Shrubland, Desert, and Tundra Technical Team of the National Fish, Wildlife and Plants Climate Adaptation Strategy (hereafter *Strategy*), and was used as source material for the full *Strategy* document. It was informally reviewed by a group of experts selected by the Team. While not an official report, this Shrubland Ecosystems Background Paper is available as an additional resource that provides more detailed information regarding climate change impacts, adaptation strategies, and actions for U.S. shrubland ecosystems and the species they support. These papers have been edited by the Management Team for length, style, and content, and the Management Team accepts responsibility for any omissions or errors.

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Introduction

Over the past decade, there have been increasing calls for action by government and non-governmental entities to better understand and address the impacts of climate change on natural resources and the communities that depend on them. These calls helped lay the foundation for development of the National Fish, Wildlife and Plants Climate Adaptation Strategy (hereafter *Strategy*).

In 2009, Congress asked the Council on Environmental Quality (CEQ) and the Department of the Interior (DOI) to develop a national, government-wide climate adaptation strategy for fish, wildlife, plants, and related ecological processes. This request was included in the Fiscal Year 2010 Department of the Interior, Environment and Related Agencies Appropriations Act Conference Report. The U.S. Fish and Wildlife Service (FWS) and CEQ then invited the National Oceanic and Atmospheric Administration (NOAA) and state wildlife agencies, with the New York State Division of Fish, Wildlife, and Marine Resources as their lead representative, to co-lead the development of the *Strategy*.

A Steering Committee was established to lead this effort and it includes representatives from 16 federal agencies with management authorities for fish, wildlife, plants, or habitat as well as representatives from five state fish and wildlife agencies and two tribal commissions. The Steering Committee charged a small Management Team including representatives of the FWS, NOAA, Association of Fish and Wildlife Agencies (representing the states) and Great Lakes Indian Fish and Wildlife Commission to oversee the day-to-day development of the *Strategy*.

In March of 2011, the Management Team invited more than 90 natural resource professionals (both researchers and managers) from federal, state, and tribal agencies to form five Technical Teams centered around a major ecosystem type. These teams, which were co-chaired by federal, state, and I most instances, tribal representatives, worked over the next eight months to provide technical information on climate change impacts and to collectively develop the strategies and actions for adapting to climate change. The five ecosystem technical teams are: Inland Waters, Coastal, Marine, Forests, and a fifth team comprising four ecosystems: Grasslands, Shrublands, Deserts, and Arctic Tundra.

This Background Paper focuses on shrubland systems, including information about these systems, existing stressors, impacts from climate change, and several case studies highlighting particular impacts or adaptation efforts. Information from this Background Paper informed discussion of shrubland impacts and adaptation measures in the full *Strategy*, and was used to develop the Goals, Strategies, and Actions presented in that document and repeated here. This Background Paper is intended to provide additional background information and technical details relevant to shrubland systems, and to summarize those approaches most relevant to managers of these areas and the species they support. Some of the material presented herein overlaps with that for other ecosystem types, particularly regarding cross-cutting issues.

The ultimate goal of the *Strategy* is to inspire and enable natural resource professionals, legislators, and other decision makers to take action to adapt to a changing climate. Those actions are vital to preserving the nation's ecosystems and natural resources—as well as the human uses and values that the natural world provides. The *Strategy* explains the challenges ahead and offers a guide to sensible actions that can be taken now, in spite of uncertainties over the precise impacts of climate change on living resources. It further provides guidance on longer-term actions most likely to promote natural resource adaptation to climate change. The *Strategy* also describes mechanisms to foster collaboration among all levels of government, conservation organizations, and private landowners.

Federal, state, and tribal governments and conservation partners are encouraged to look for areas of overlap between this Background Paper, the *Strategy* itself, and other planning and implementation efforts. These groups are also encouraged to identify new efforts that are being planned by their respective agencies or organizations and to work collaboratively to reduce the impacts of climate change on shrubland fish, wildlife, and plants.

Shrubland Ecosystem Description

Shrublands are landscapes dominated by woody shrub species, often mixed with grasses and forbs. Shrubland ecosystems are associated with relatively arid climates, and are strongly influenced by disturbance regimes, particularly fire. Shrublands of various types and sizes occur throughout the United States, totaling approximately 410 million acres in the lower 48 states (Heinz Center 2008). They are found predominantly in the Intermountain Semi-desert and Desert Provinces and in the Southwest Plateau and Plains Dry Steppe and Shrub Provinces, as described by Bailey (1998). In addition to serving as "primary range" for livestock grazing on millions of acres of public lands in the west, shrublands provide habitat for numerous native plant and animal species. These lands also provide the public with recreation opportunities from hunting and fishing to wildlife viewing, hiking, camping, and other activities. Recreational activities such as these serve as an important source of jobs and income in the United States (U.S. DOI and U.S. DOC 2006), and particularly benefit rural communities economically, since most of the nation's outdoor recreation areas are in rural counties (Lal et al. 2011).

Shrubland ecosystems also provide critical regulating and supporting services tied to water quality and quantity, including watershed protection, erosion control, flood protection, and ground water recharge. They contain large quantities of soil organic carbon, and when left intact (no-till), these systems can help offset emission of carbon dioxide (CO_2) to the atmosphere (Paustian et al. 2000).

The intermountain sagebrush steppe (and associated mountain grasslands) includes two major geographic areas, the Basin and Range and the Columbia Plateau, and is bounded by the major mountain ranges of the Cascades and Sierra Nevada to the west and the Rockies to the east. Another shrubland type, the California chaparral, covers almost 47,000 square miles from the coast of California in the United States and Baja California in Mexico inland to the foothills. The only Mediterranean climate shrubland in North America, the chaparral is extremely diverse, and is characterized by short and scrubby drought tolerant shrub vegetation, with trees no taller than about eight feet. Shrublands also occur across the state of Texas, the result of geology/soils, climatic extremes (frequent droughts, flashfloods, tornadoes, hurricanes, ice and hail storms, heat waves, and frigid cold snaps), and/or land management practices such as fire suppression or overgrazing.

Sagebrush steppe habitats include a variety of shrubs such as big sagebrush, bitterbrush, mountain mahogany, and several species of saltbush. Texas shrublands include the Tamaulipan Thornscrub, dominated by mesquite (*Prosopis glandulosa*), acacias (*Acacia berlanderi*, *A rigidula*, *A. farnesiana*, *A gregii*) and Texas paloverde (*Parkinsonia texana var. macra*), and the Edwards Plateau Limestone Shrubland, dominated by shin oak (*Quercus sinuata var. breviloba*), Texas persimmon (*Diospyros texana*) and shrubby trees.

Sagebrush habitats are estimated to provide habitat for more than 400 plant species and 250 wildlife species (Idaho National Laboratory 2011), including 100 bird and 70 mammal species (Baker et al. 1976, McAdoo et al. 2003). However, approximately 20 percent of the sagebrush ecosystem's native flora and fauna are imperiled, and many sagebrush-associated species are declining (Wisdom et al. 2005).

Relatively moist areas within shrublands, such as wet meadows, valley bottoms, and riparian (streamside) corridors, tend to have a much higher diversity of wildlife and plant species. Characteristic sagebrush wildlife includes pronghorn antelope (*Antilocapra americana*), sage grouse (*Centrocercus urophasianus*), pygmy rabbit (*Brachylagus idahoensis*), golden eagle (*Aquila chrysaetos*), and a variety of reptiles such as the sagebrush lizard (*Sceloporus graciosus*) and striped whipsnake (*Masticophis taeniatus*). A number of species are locally endemic to the system, including basalt daisy (*Erigeron baslaticus*) and White's milkvetch (*Astragalus sinuatus*), Washington ground squirrel (*Urocitellus washingtoni*), the sage thrasher (*Oreoscoptes montanus*), and sage sparrow (*Amphispiza belli*).

Existing Stressors:

The number of acres of sagebrush cover type has decreased from approximately one-third to over 90 percent in the most impacted regions (Leu and Hanser 2011). As in grasslands, one of the main historic losses of shrublands occurred through development and conversion to agricultural use. Infrastructure associated with agriculture including roads, fences, and canals has also contributed to habitat loss, fragmentation, and degradation. In addition to agricultural conversion, livestock grazing during the late 1800s drastically altered the remaining shrubland communities, decreasing abundance of associated herbaceous species, increasing sagebrush density and cover as well as bare ground, and shifting community composition and structure to favor exotic herbaceous species such as cheatgrass (*Bromus tectorum*), yellow star thistle (*Centaurea solstitialis*), and knapweed (Chambers et al. 2007).

Another serious risk to the drought-tolerant, non-sprouting species that typically dominate shrublands is disruption of the historic fire regime (Chambers et al. 2007). A higher abundance of non-native annual grasses, which mature and dry out in early spring, create a continuous fine fuel layer that can lead to increased fire frequency. Since frequent (less than every 5-10 years) fire kills sagebrush seedlings, more fire allows invasive grasses like cheatgrass to further dominate, outcompeting native herbaceous species for soil moisture and nutrients (Chambers et al. 2007). Impacts to native species richness associated with increased severe fires may be exacerbated where habitat has already been degraded by livestock grazing (Shinneman and Baker 2009). In highly disturbed areas, invasive exotics such as cheatgrass or knapweed dominate the understory and are maintained by frequent fire, resulting in habitat conditions that are no longer suitable for many native species of wildlife and plants.

The wide open spaces associated with shrublands also attract recreational uses such as hunting, fishing, camping, and off-road vehicle activities, which have the potential to disturb the soil and vegetation, altering wildlife habitat. In addition, mineral extraction and energy development (oil and gas and alternative energy) are economically important land uses in shrubland ecosystems that threaten to further fragment wildlife habitat and degrade ecosystem services.

Impacts of Climate Change on Shrubland Systems

Since 1980, western U.S. winter temperatures have been consistently higher than long-term values, and average winter snow packs have declined. For example, the onset of snow runoff in the Great Basin is currently 10-15 days earlier than 50 years ago, with significant impacts on the downstream use of the water (Ryan et al. 2008), though periods of higher than average precipitation has helped to offset the declining snow packs (McCabe and Wolock 2009). Similarly, California has seen an increase in temperature accompanied by an increase in annual precipitation and a decrease in the climatic water deficit (less difference between plant water use and precipitation) from the 1930's to 2005. The Great Basin region is also predicted to become both warmer and possibly wetter over the next few decades (Larrucea and Brussard 2008).

The likely impacts of climate change on shrubland ecosystems are summarized in Table 1. These include extreme weather events driven by more energy in the system, increasing temperatures, and altered timing of precipitation. Changes can be complex: in areas where both a reduction in total annual rainfall and increased intensity of individual precipitation events are predicted, wet areas are likely to become wetter while dry areas may become drier. More intense rainfall events without increased total precipitation can lead to lower and more variable soil water content, and thus, reduce above-ground net primary production (and livestock carrying capacity). Higher temperatures associated with climate change are likely to intensify water stress through increased potential evapotranspiration (Tietjen and Jeltsch 2007).

Table 1: Expected Climate Change Impacts on Shrubland Ecosystems (USGCRP 2009 and IPCC AR4 2007)

Major Changes Associated With Increasing Levels of GHGs	Major Impact on Shrublands
Increased atmospheric CO_2:	Increased spread of exotic species such as cheatgrass
Increased temperatures:	Intensified water stress through increased evapotranspiration
Melting ice/snow	Reduced snowpack changes water flows
Changing precipitation patterns:	Dry areas getting drier
Drying conditions/drought:	Decline in prairie pothole wetlands, loss of nesting habitat
More extreme rain/weather events:	More variable soil water content

Slight changes in temperature or precipitation can significantly alter the distribution, abundance and composition of species (Archer and Predick 2008). Climate change is increasingly recognized as adding to the sensitivity of shrubland species, many of which already live near their physiological limits for water and temperature stress. Thus, sensitive and vulnerable species will likely be further stressed by climate change, which may alter the strategies for their recovery and protection. Increased CO_2 can also lead to changes in species distribution: it has been suggested that the spread of cheatgrass has been favored by rising CO_2 concentrations (D'Antonio and Vitosuek 1992, Larrucea and Brussard 2008).

The encroachment of shrubs and trees into grasslands and shrublands and the "thicketization" of savannas have occurred worldwide. While CO_2 enrichment associated with climate change may play a role, other factors such as heavy grazing in the late 1800's and fire suppression likely have a stronger influence. The shift from grass to shrubs and trees is most pronounced in areas that have experienced these stressors (Archer et al. 1995). For example, livestock grazing is believed to have interacted with climate change and fire suppression to cause increased density and expansion of pinyon-juniper trees into some shrublands and grasslands, though the exact mechanism is less understood (Romme et al. 2007).

The indirect or secondary impacts of climate change could lead to changes in landscape pattern, wildlife habitat connectivity, and other ecosystem services in shrubland systems. Shifting centers of agricultural production due to climate change as well as increased energy development and domestic energy production (including oil and gas and alternative energy development) may also lead to increased loss of habitat. Hydrologic changes may exacerbate water shortages, and engineered solutions such as increased water storage and delivery facility development could also lead to further habitat loss and fragmentation.

GREAT BASIN SAGEBRUSH COMMUNITIES IN A CHANGING CLIMATE

The future of our resilient sagebrush ecosystems, including 350 associated species of conservation concern, are at risk due to the direct impacts of wildfire, invasive species, climate change, and habitat fragmentation. Sagebrush communities cover more than 100 million acres of land in the western United States, providing essential habitat for sage grouse, mule deer (*Odocoileus hemionus*), pronghorn antelope and other native plant and animal species. It is estimated that each 1.8 °F temperature increase would cause the loss of 12 percent of the West's current sagebrush habitat (IPCC AR4 2007) . The increase in temperature benefits non-native species such as invasive cheatgrass, which thrives in hot, open, fire-prone environments and crowds out the native sagebrush species. Increasing temperatures and changes in wildfire patterns (shorter fire intervals and longer fire season) have combined to accelerate the further spread of exotic species and deplete native seed reserves in the soil – thus simplifying structure and species associations.

Within the Great Basin there is an immediate need for increased supplies of genetically diverse, regionally adapted native seed for restoration of critical areas to prevent further losses. The Great Basin Native Plant Selection and Increase Project is addressing this need as part of the Interagency Native Plant Materials Development Program, which was mandated by Congress in 2001 to foster the development of native plants for restoration and rehabilitation of public lands after wildfires. More than 30 partners (13 Federal laboratories, nine universities, two non-profit organizations, and many private sector partners within the seed industry) make up the Great Basin Native Plant Selection and Increase Project and together they are conducting research on over 65 native plant species of the Great Basin. Through their efforts, over 15 native plant species are commercially available now from the seed industry, and over 25 native plant species are undergoing seed increase by private seed growers and will be available commercially in the near future.

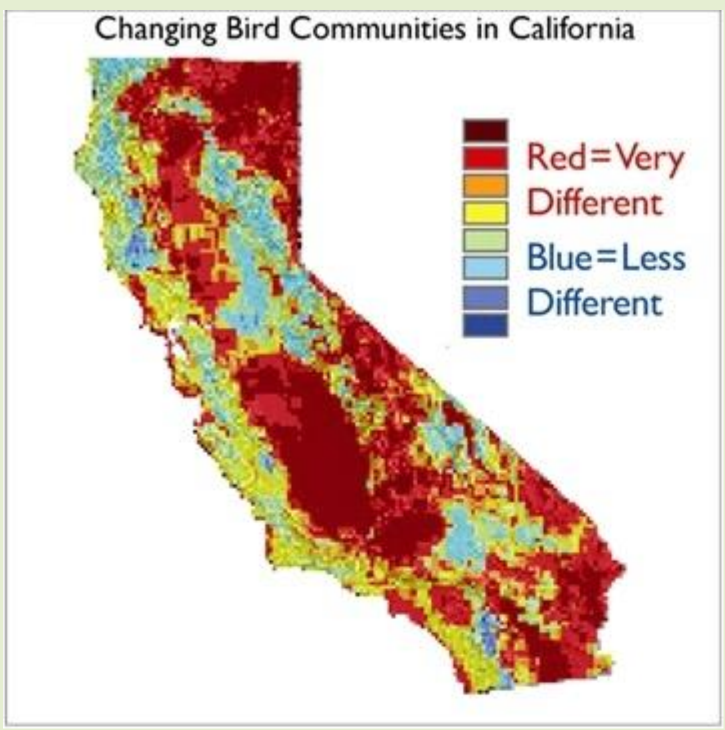
The Great Basin Native Plant Selection and Increase Project is working to ensure that native seed is collected from across the Great Basin, conserved in long-term storage, and commercially developed for restoration use. Additionally the project is researching the equipment and technology required for reestablishing diverse native plant communities throughout the Great Basin. It is through eco-regional efforts such as the Great Basin Native Plant Selection and Increase Project that we will have some of the most important tools to protect native plant habitats in a changing climate.

Habitat restoration in shrublands may require decades or centuries, and in some areas is not considered feasible. Many areas previously dominated by sagebrush are unlikely to be restored because alteration of vegetation, nutrient cycles, topsoil, and living soil crusts often exceeds recovery thresholds. In addition, processes to restore sagebrush ecosystems are relatively unknown, and activities are often limited by financial and logistic resources and lack of political motivation (Knick et al. 2003).

Conservation of shrublands is very challenging in part because the arid climate, geography, temperature extremes, and relative scarcity of water resources have created a unique endemic biota easily subject to threats and stressors. Almost one-fifth of native grassland and shrubland animal species are already considered to be at risk (Heinz Center 2008), making them even more vulnerable to the impacts of climate change. Unique shrubland areas such as the Tamaulipan Thornscrub, Edwards Plateau, and California chaparral each support an amazing diversity of rare and endemic species, some of which occur nowhere else. A number of these species are listed under the Endangered Species Act, including the pygmy rabbit, the endangered shrubby reed-mustard (*Schoenocrambe suffrutescens*), the threatened northern Idaho ground squirrel (*Spermophilus brunneus brunneus*), the threatened Utah prairie dog (*Cynomys parvidens*), and the endangered southwest willow flycatcher (*Empidonax traillii extimus*). Many of these species are further threatened by the increased frequency and severity of wildfires and spread of annual exotic grasses, which degrade habitat quality.

CLIMATE ALTERED BIRD DISTRIBUTION

As global climate temperatures continue to climb, many birds are finding the ecosystems they've coevolved with are not as hospitable as they once were (see map). Habitats they have occupied for centuries are changing, sometimes rapidly, forcing them to search for more suitable environments elsewhere. Researchers at Point Reyes Bird Observatory Conservation Science have combined climate change forecast data with survey data from 60 bird species in California. What they found was that movements of many bird species have not followed predictable patterns. For example, it might readily be hypothesized that bird movements would primarily be influenced by climatic factors, sending birds species towards higher altitudes and latitudes or towards the coast. Instead, researchers are finding that suitable breeding habitat is the most influential factor leading to the movement response seen in many bird populations.



Stralberg et al. 2009

There is ample scientific evidence available describing how vegetation communities are shifting in response to climate change. For example, as oak woodlands move north, they are being replaced by chamise (*Adenostoma fasciculatum*), while redwoods (*Sequoiadendron giganteu*), and other conifers are being replaced by scrubs and hardwoods (Stralberg et al. 2009). As these vegetation communities shift, so too do the species living there. Not all species will find new homes, and some will find neighbors they have never previously encountered, creating new, unprecedented community assemblages. Other species may not be able to move at all, especially those severely affected by landscape changes or urban development. To begin to address this limitation, habitat corridors are being designed that could provide pathways through otherwise highly disturbed or developed areas.

Urban planners are beginning to embrace smart growth whereby some of the negative effects of urbanization can be reduced. Efforts to conserve and manage biodiversity of individual species could be substantially improved by considering not just the future changes in the distribution of individual species, but also building into the urban footprint connected natural open space areas to assist species adaptation in a changing climate.

Climate Adaptation Strategies and Actions for Shrubland Systems

The National Fish, Wildlife and Plants Climate Adaptation Strategy identified seven primary Goals to help fish, wildlife, plants and ecosystems cope with the impacts of climate change. As discussed in the Introduction, these Goals were developed collectively by diverse teams of federal, state, and tribal technical experts, based on existing research and understanding regarding the needs of fish, wildlife and plants in the face of climate change. Each Goal identifies a set of initial Strategies and Actions that should be taken or initiated over the next five to ten years.

Actions listed here were derived from those Technical Team submissions determined to be most applicable to shrublands. Numbers correspond to the full Strategy document, though some wording has been adapted to make Actions more relevant to this system.

GOAL 1: Conserve habitat to support healthy fish, wildlife and plant populations and ecosystem functions in a changing climate.

Strategy 1.1: Identify areas for an ecologically-connected network of terrestrial, freshwater, coastal, and marine conservation areas that are likely to be resilient to climate change and to support a broad range of fish, wildlife, and plants under changed conditions.

Actions:

— A: Identify and map high priority areas for conservation using information on species distributions (current and projected), habitat classification, land cover, and geophysical settings (including areas of rapid change and slow change). (**S 1.1.1**)

Strategy 1.2: Secure appropriate conservation status on areas identified in Action 1.1.1 to complete an ecologically-connected network of public and private conservation areas that will be resilient to climate change and support a broad range of species under changed conditions.

Actions:

— A: Work with partners at landscape scales to maximize use of existing conservation programs (e.g., easement, management, mitigation), particularly the conservation titles of the Farm Bill, the private lands programs focused on endangered species, and other federal and state private lands incentive programs to conserve private lands of high conservation value, to enhance habitat values and maintain working landscapes under climate change. (**S 1.2.4**)

— B: Identify and pursue opportunities to increase conservation of priority lands and waters by working with managers of existing public lands such as military installations or state lands managed for purposes other than conservation. (**S 1.2.5**)

Strategy 1.3: Restore habitat features where necessary and practicable to maintain ecosystem function and processes and resiliency to climate change.

Actions:

— A: Restore degraded habitats as appropriate to support diversity of species assemblages and ecosystem structure and function. (**S 1.3.2**)

— B: Restore natural disturbance regimes as appropriate, including instituting human-assisted disturbance (e.g., prescribed fire) to augment natural processes and mimic natural patterns and recurrence for specific ecological systems. (**S 1.3.4**)

Strategy 1.4: Conserve, restore, and as appropriate and practicable, establish new ecological connections among conservation areas to facilitate fish, wildlife, and plant migration, range shifts, and other transitions caused by climate change.

Actions:

— A: Assess and prioritize critical connectivity gaps and needs across current shrubland conservation areas, including areas likely to serve as refugia in a changing climate. (**S 1.4.2**)

— B: Conserve corridors and transitional habitats between ecosystem types through both traditional and non-traditional (e.g., land exchanges, rolling easements) approaches. (**S 1.4.3**)

— C: Assess existing barriers or structures that impede movement and dispersal within and among habitats to increase natural ecosystem resilience to climate change, and where necessary, consider the redesign or mitigation of these structures. (**S 1.4.4**)

— D: Provide landowners and stakeholder groups with incentives to maximize use of existing conservation programs, such as the conservation titles of the Farm Bill and landowner tools under the ESA, to protect private lands of high connectivity value under climate change. (**S 1.4.6**)

GOAL 2: Manage species and habitats to protect ecosystem functions and provide sustainable cultural, subsistence, recreational, and commercial use in a changing climate.

Strategy 2.1: Update current or develop new species, habitat, and land and water management plans, programs and practices to consider climate change and support adaptation.

Actions:

— A: Incorporate climate change considerations into existing and new management plans and practices using the best available science regarding projected climate changes and trends, vulnerability and risk assessments, and scenario planning. (**S 2.1.1**)

— B: Review and revise as necessary techniques to maintain or mimic natural disturbance regimes and to protect vulnerable habitats. (**S 2.1.5**)

— C: Develop cattle grazing practices that function in ecosystems with reduced rainfall and increasing temperature.

— D: Participate in USDA/NRCS state technical committees to encourage incorporation of climate change into species status assessments and within future federal Farm Bill programs.

Strategy 2.2: Develop and apply species-specific management approaches to address critical climate change impacts where necessary.

Actions:

— A: Use vulnerability and risk assessments to design and implement management actions at species to ecosystem scales. (**S 2.2.1**)

— B: Develop criteria and guidelines for the use of translocation, assisted migration, and captive breeding as climate adaptation strategies. (**S 2.2.2**)

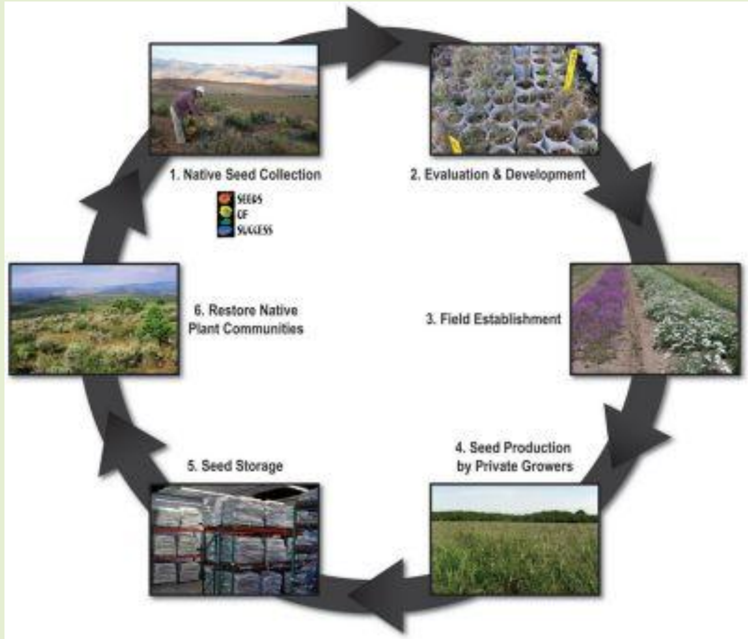
— C: Where appropriate, actively manage populations (e.g., using harvest limits, seasons, translocation, captive breeding, and supplementation) of vulnerable species to ensure sustainability and maintain biodiversity, human use, and other ecological functions. (**S 2.2.3**)

SEED BANKING IN A CHANGING CLIMATE

Climate change may bring the loss of major populations of plants—or even entire species. One of the key approaches for boosting a species' chances of surviving on a changed planet is maintaining the species' genetic diversity.

Both of these issues can be addressed by collecting and banking seeds and other plant materials. An extensive seed bank can save species that go extinct in the wild, preserve the genetic diversity needed for other species to cope with a changed environment, and provide the seed needed for restoration projects.

Such a preservation effort is now underway. In 2001, Congress directed the Interagency Plant Conservation Alliance to develop a long-term program to manage and supply native plant materials for various Federal land management restoration and rehabilitation needs. Working with hundreds of partners in federal, tribal, and state agencies, universities, conservation groups, native seed producers, and others, the program has now collected seeds from more than 3,000 native plant species in the United Sates.



Bureau of Land Management 2009. Native Plant Materials Development Program: Progress Report for FY2001-2007.

Global networks also exist to protect plant diversity such as the Global Strategy for Plant Conservation and the Gran Canaria Declaration on Climate Change and Plant Conservation. These are both important documents that can be used in the development of criteria and guidelines for plants.

Strategy 2.3: Conserve genetic diversity by protecting diverse populations and genetic material across the full range of species occurrences.

Actions:

— A: Protect and maintain high quality native seed sources including identifying areas for seed collection across elevational and latitudinal ranges of target species. (**S 2.3.2**)

— B: Develop protocols for use of propagation techniques to rebuild abundance and genetic diversity for particularly at-risk species. (**S 2.3.3**)

— C: Seed bank, develop, and deploy as appropriate plant materials for restoration that will be resilient in response to climate change. (**S 2.3.4**)

GOAL 3: Enhance capacity for effective management in a changing climate.

Strategy 3.1: Increase the climate change awareness and capacity of natural resource managers and enhance their professional capacity to design, implement, and evaluate fish, wildlife, and plant adaptation programs.

Actions:

— A: Build on existing training courses and work with professional societies, academicians, technical experts, and natural resource agency training professionals to address key needs, augment adaptation training opportunities, and develop curricula and delivery systems for natural resource professionals and decision makers. (**S 3.1.2**)

— B: Develop training on the use of existing and emerging tools for managing under uncertainty (e.g., vulnerability and risk assessments, scenario planning, decision support tools, and adaptive management). (**S 3.1.3**)

— C: Encourage use of interagency personnel agreements and interagency (state, federal, and tribal) joint training programs as a way to disperse knowledge, share experience and develop interagency communities of practice about climate change adaptation. (**S 3.1.5**)

— D: Increase scientific and management capacity (e.g., botanical expertise) to develop management strategies to address impacts and changes to species. (**S 3.1.7**)

Strategy 3.2: Facilitate a coordinated response to climate change at landscape, regional, national, and international scales across state, federal, and tribal natural resource agencies and private conservation organizations.

Actions:

— A: Identify and address conflicting management objectives within and among federal, state, and tribal conservation agencies and private landowners, and seek to align policies and approaches wherever possible. (**S 3.2.2**)

— B: Collaborate with tribal governments and native peoples to integrate traditional ecological knowledge and principles into climate adaptation plans and decision-making. (**S 3.2.4**)

Strategy 3.3: Review existing federal, state and tribal legal, regulatory and policy frameworks that provide the jurisdictional framework for conservation of fish, wildlife, and plants to identify opportunities to improve, where appropriate, their utility to address climate change impacts.

Actions:

— A: Review existing legal, regulatory and policy frameworks that govern protection and restoration of habitats and ecosystem services and identify opportunities to improve, where appropriate, their utility to address climate change impacts. (**S 3.3.1**)

Strategy 3.4: Optimize use of existing fish, wildlife, and plant conservation funding sources to design, deliver, and evaluate climate adaptation programs.

Actions:

— A: Prioritize funding for land and water protection programs that incorporate climate change considerations. (**S 3.4.1**)

— B: Review existing federal, state, and tribal grant programs and revise as necessary to support funding of climate change adaptation and include climate change considerations in the evaluation and ranking process of grant selection and awards. (**S 3.4.2**)

— C: Collaborate with agricultural interests and businesses to identify potential impacts of climate change on crop production and identify conservation strategies that will maintain or improve ecosystem services through programs within the Conservation Title of the Farm Bill and other vehicles. (**S 3.4.4**)

GOAL 4: Support adaptive management in a changing climate through integrated observation and monitoring and use of decision support tools.

Strategy 4.1: Support, coordinate, and where necessary develop distributed but integrated inventory, monitoring, observation, and information systems to detect and describe climate impacts on fish, wildlife, plants, and ecosystems.

Actions:

— A: Develop consensus standards and protocols that enable multi-partner use and data discovery, as well as interoperability of databases and analysis tools related to fish, wildlife, and plant observation, inventory, and monitoring. (**S 4.1.2**)

— B: Work through existing distributed efforts (e.g., National Climate Assessment (NCA), National Estuarine Research Reserve System -wide monitoring program, State Natural Heritage Programs, National Wildlife Refuge System, National Park Service) to support integrated national observation and information systems that inform climate adaptation. (**S 4.1.4**)

— C: Develop, refine, and implement monitoring protocols that provide key information needed for managing and conserving species and ecosystems in a changing climate. (**S 4.1.7**)

Strategy 4.2: Identify, develop, and employ decision support tools for managing under uncertainty (e.g., vulnerability and risk assessments, scenario planning, strategic habitat conservation approaches, and adaptive management evaluation systems) via dialogue with scientists, managers (of natural resources and other sectors), and stakeholders.

Actions:

— A: Conduct risk assessments to identify key climate change hazards and assess potential consequences for shrubland fish, wildlife and plants.

— B: Engage scientists, resource managers, and stakeholders in climate change scenario planning processes, including identification of a set of plausible future scenarios associated with climate phenomena likely to significantly impact fish, wildlife, and plants. (**S 4.2.2**)

— C: Conduct vulnerability and risk assessments for priority species (threatened and endangered species, species of greatest conservation need, species of socioeconomic and cultural significance). (**S 4.2.4**)

— D: Ensure the availability of and provide guidance for decision support tools (e.g., NOAA's Digital Coast, etc.) that assist federal, state, local, and tribal resource managers and planners in effectively managing fish, wildlife, and plants in a changing climate. (**S 4.2.7**)

GOAL 5: Increase knowledge and information on impacts and responses of fish, wildlife and plants to a changing climate.

Strategy 5.1: Identify knowledge gaps and define research priorities via a collaborative process among federal, state, and tribal resource managers and research scientists working with the National Science Foundation (NSF), USGCRP, NCA, USDA Extension, Cooperative Ecosystem Study Units (CESUs), Climate Science Centers (CSCs), LCCs, Migratory Bird Joint Ventures (JVs), and Regional Integrated Sciences and Assessments (RISAs).

Actions:

— A: Increase coordination and communication between resource managers and researchers through existing forums (e.g., NSF, USGCRP, NCA, USDA, CESUs, CSCs, LCCs, JVs, RISAs, and others) to ensure research is connected to management needs. (**S 5.1.1**)

— B: Bring managers and scientists together to prioritize research needs that address resource management objectives under climate change. (**S 5.1.2**)

— C: Prioritize research on questions relevant to managers of near-term risk environments (e.g., low-lying islands and glaciated areas) or highly vulnerable species. (**S 5.1.6**)

Strategy 5.2: Conduct research into ecological aspects of climate change, including likely impacts and the adaptive capacity of species, communities and ecosystems, working through existing partnerships or new collaborations as needed (e.g., USGCRP, NCA, CSCs, RISAs, and others).

Actions:

— A: Support basic research on life histories and food web dynamics of fish, wildlife, and plants to increase understanding of how species are likely to respond to changing climate conditions and identify survival thresholds. (**S 5.2.2**)

— B: Identify and address priority climate change knowledge gaps and needs (e.g., species adaptive capacity; risk/rewards of assisted migration; climate change synergy with existing stressors; etc.). (**S 5.2.3**)

— C: Accelerate research on establishing the value of ecosystem services and potential impacts from climate change such as loss of pollution abatement or flood attenuation, etc. (**S 5.2.4**)

— D: Conduct research on the propagation and production of native plant materials to identify species or genotypes that may be resilient to climate change. (**S 5.2.5**)

— E: Increase understanding of the adaptive capacity of shrubland communities and species under climate change.

Strategy 5.3: Advance understanding of climate change impacts and species and ecosystem responses through modeling.

Actions:

— A: Develop and use models of climate-impacted physical and biological variables and ecological processes at temporal and spatial scales relevant to conservation.

— B: Improve modeling of climate change impacts on vulnerable species, including projected future distributions and the probability of persistence. (**S 5.3.2**)

GOAL 6: Increase awareness and motivate action to safeguard fish, wildlife and plants in a changing climate.

Strategy 6.1: Increase public awareness and understanding of climate impacts to natural resources and ecosystem services and the principles of climate adaptation at regionally- and culturally-appropriate scales.

Strategy 6.2: Engage the public through targeted education and outreach efforts and stewardship opportunities.

Strategy 6.3: Coordinate climate change communication efforts across jurisdictions.

GOAL 7: Reduce non-climate stressors to help fish, wildlife, plants, and ecosystems adapt to a changing climate.

Strategy 7.1: Slow and reverse habitat loss and fragmentation.

Actions:

— A: Work with farmers and ranchers to apply the incentive programs in the Conservation Title of the Farm Bill as well as the landowner tools under the ESA and other programs to minimize conversion of habitats, restore marginal agricultural lands to habitat, and increase riparian buffer zones. (**S 7.1.2**)

— B: Work with farmers and ranchers to apply the incentive programs in the Conservation Title of the Farm Bill as well as the landowner tools under the ESA and other programs to minimize conversion of habitats, restore marginal agricultural lands to habitat, and increase riparian buffer zones. (**S 7.1.5**)

— C: Minimize impacts from alternative energy development by focusing siting options on already disturbed or degraded areas. (**S 7.1.7**)

— D: Support land trusts and farmland and ranchland preservation programs as a way to sustain habitat values on working landscapes.

Strategy 7.2: Slow, mitigate, and reverse where feasible ecosystem degradation from anthropogenic sources through land/ocean-use planning, water resource planning, pollution abatement, and the implementation of best management practices.

Actions:

— A: Work with local and regional land-use, water resource, and coastal and marine spatial planners to identify potentially conflicting needs and opportunities to minimize ecosystem degradation resulting from development and land and water use. (**S 7.2.1**)

— B: Work with farmers and ranchers to develop and implement livestock management practices to reduce and reverse habitat degradation and to protect regeneration of vegetation. (**S 7.2.2**)

Strategy 7.3: Use, evaluate, and as necessary, improve existing programs to prevent, control, and eradicate invasive species and manage pathogens.

Actions:

— A: Employ a multiple barriers approach to detect and contain incoming and established invasive species, including monitoring at points of origin and points of entry for shipments of goods and materials into the United States and for trans-shipment within the country. Utilize education, regulation, and risk management tools (e.g., the Hazard Analysis and Critical Control Point process) to address. (**S 7.3.1**)

— B: Apply risk assessment and scenario planning to identify actions and prioritize responses to invasive species that pose the greatest threats to natural ecosystems. (**S 7.3.3**)

— C: Monitor pathogens associated with fish, wildlife, and plant species for increased understanding of distributions and to minimize introduction into new areas. (**S 7.3.6**)

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