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POLICY AND STRATEGY CONSIDERATIONS FOR ASSISTED MIGRATION ON USDA FOREST SERVICE LANDS

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INTRODUCTION

Due to increased temperatures and shifts in precipitation patterns associated with climate change, bioclimatic zones that provide habitat for many species are expected to expand, contract, disappear, shift poleward, or move towards higher elevations (WGA 2008). Species will respond to changing climate and disturbance regimes individually, with some species moving quickly, others taking longer to move, and finally those incapable of keeping pace, which can lead to extinction (IPCC 2002; Chen et al. 2011).

Across the globe, species are already shifting their ranges in response to climate change (Parmesan and Yohe 2003; Gonzalez et al. 2010; Chen et al. 2011). Recent studies show that economically-important tree species in the eastern U.S. have already shifted their distributions in response to changes in climate, with some moving northward and others contracting (Woodall et al. 2009; Zhu et al. 2011). Some non-migratory butterflies in Europe have shifted north by 35-240 km over the 20th century (IPCC 2002). The Wildlife Corridors Initiative established by the Western Governors' Association found several bird species and hundreds of other plant and animal species in the western United States are also shifting their ranges several kilometers poleward or several meters upward in elevation per decade (WGA 2008).

Unfortunately, not all species have the ability to keep pace with a rapidly changing climate and disperse to newly suitable areas. Models of projected change in suitable habitat for tree species suggest that trees would need to migrate hundreds of feet to several miles per year to keep up with changes in climate (Iverson and Prasad 2002). However, for widespread plant species the "unit" that needs to migrate is not the species per se, but populations within a species. Plant species with wide geographic ranges tend to have adaptive genetic variation patterned over the landscape that has resulted from natural selection of different traits for different environments where the species exist. The probability of survival for an individual of a specific population in a new location depends on whether it's genetic makeup 'pre-adapts' it to the new environment. The more 'fine-tuned' they are to their existing environment, the less able they are to exist elsewhere. In order to account for this variation in adaptive traits, it has been necessary to develop seed movement guidelines and breeding zones to ensure that reforestation and restoration activities result in adapted populations.

One option for overcoming a species', or population's, inability to migrate at the pace necessary to sustain itself under current and projected change in climate is the use of assisted migration. Assisted migration has been defined as the movement of species, populations, or genotypes to places outside the areas of their historical distributions to maintain biological diversity or ecosystem functioning with changing climate (Richardson et al. 2009; Schwartz et al. 2012). Assisted migration has been used synonymously with other terms such as managed relocation, assisted colonization, and managed translocation (Hunter 2007; McLachlan et al. 2007; Hoegh-Guldberg et al. 2008; Olden et al. 2011). Assisted migration may be motivated by a desire to (a) maintain genetic diversity, (b) protect species from extinction, (c) mimic dispersal interrupted by human habitat barriers, (d) maintain ecosystem functionality, or (e) maintain a population used in natural resource extraction (Schwartz et al. 2012). It has also been used to introduce desirable species (e.g., biological controls) where they have not existed previously. Regardless of the purpose, assisted migration is controversial.

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Actions associated with assisted migration cover a wide variety of movements for a number of different purposes, ranging from moving a seed source[1] to another location within the species range in order to maintain ecosystem productivity, to moving a suite of species, or a community, outside of its historical range to prevent extinction. This paper examines two major categories of assisted migration that primarily impact management decisions on National Forest System (NFS) lands, **assisted migration to maintain ecosystem services** (*Ecosystem AM*) and **species rescue assisted migration** (*Species Rescue AM*); these definitions closely follow what is presented by Pedlar et al. (2012) for forest trees. These two categories differ in the types of species managed, management objectives, relative feasibility, and associated risks (summarized in Table 1; from Pedlar et al. 2012). Most discussions in the literature focus on species rescue and little on Ecosystem AM.

Moving a seed source outside its current population "range", but within the range of the species, falls under the broad definition of assisted migration. In fact, even moving a genotype outside its current range falls within the broadest definition of assisted migration and is practiced regularly, since reforestation programs routinely use seed from parent trees (*in situ* or from seed orchards) that have never been on the restoration site.

Ecosystem AM aims to ensure that plantings of widespread species are established using seed sources that will be climatically adapted for decades to come. Maintaining climatic adaptation has been proposed to preserve forest health and productivity (O'Neill and Nigh 2011), which is necessary to maintain the continued flow of ecosystem services provided by forests, such as wildlife habitat, erosion prevention, timber, and carbon sequestration. Typically these plantings involve the use of seed sources outside of current seed zone delineations, but generally within a species' range. *Species Rescue AM* is aimed at conserving species at risk of extinction in light of rapid climate change and/or other stressors. This often involves moving a species outside its historical range to where conditions are thought to be better suited for the species than its current home sites. The Forest Service currently lacks specific guidance related to assisted migration. Current policies and guidance within the Forest Service are limited and do not distinguish between these two types of assisted migration. The risks and potential for success varies considerably between *Ecosystem AM* and *Species Rescue AM* and justifies the need for different policies (see Table 1, from Pedlar et al. 2012).

CURRENT FOREST SERVICE AM GOALS, PRINCIPLES, STRATEGIES, POLICIES, AND GUIDANCE

The mission of the Forest Service is to sustain the health, productivity and diversity of the nation's forests and grasslands to meet the needs of current and future generations. The list of stressors affecting ecosystem health, productivity, and diversity continues to grow, with climate change direct and indirect effects poised to trump the entire list. With accelerating changes imminent, the agency is going to be hard pressed to sustain the health, productivity and diversity as the nation's ecosystems quickly change. Waiting for the crisis may well result in triage management, or saving those species with a chance to exist and letting others perish. Is this the legacy of management the FS wants to have written about it in the history books? A better historical account should include well-reasoned goals, strategies, and actions designed to maintain the health, productivity and diversity of the nation's ecosystems.

Existing FS Policies Forest Service AM policies are limited. However, some domestic and international research efforts include analysis and development of guidelines for assisted migration, such as the North American Forest Commission's Forest Genetics Working Group Task 54: "develop guidelines for managed relocation of forest species and populations in response to climate change" (NAFC 2008). Another example is the Forest Tree Genetic Resource Management model of the Forest Genetics Council of British Columbia in Canada. Strategies include the use of managed relocation of tree species and seed sources as an adaptation tool (O'Neill 2008).

[1]A seed source is seed collected from the locality in which the seedlings are to be grown.

Table 1. Comparison between forestry assisted migration (AM; referred to as Ecosystem AM in this document) and species rescue AM (from Pedlar et al. 2012).

Topic	Forestry AM	Species Rescue AM
Intended outcome	Maintain forest productivity and health under climate change	Avoid extinctions among threatened by climate change
Target species	Widespread, commercially valuable species	Species of conservation concern
Focal biological unit	Focuses on the movement of populations	Focuses on the movement of species
Movement logistics	Often within the current range of the species or within modest range extensions	Often well outside the natural range of species
Risks	Limited potential for creating an exotic invasive, limited potential to hybridize with new species, and limited potential to introduce disease to new populations or to other species	Some potential for creating an exotic invasive, some potential to hybridize with new species, and some potential to introduce disease to other species
Feasibility of science-based implementation	Provenance data for many commercial tree species, established seed procurement and storage methods, established best practices around plantation establishment, and autecology often well described	Provenance data not typically available, seeds not typically procured or stored, establishment best practices often not known, and autecology often well described
Scope	Potential to be employed across the millions of hectares that are regenerated annually in North America	Likely limited to suitable microsites
Cost	Adds little to existing forest regeneration costs (see the text for caveats)	Costs vary widely with the scope of the initiative
Practice	Already implemented in several regions	Very few known cases being implemented

Numerous environmental laws guide the agency to conserve and preserve the existing environment and, to the extent possible, restore ecosystem conditions (Marris 2008). Assisted migration changes the land management focus from past to future, and from small scale to large-scale solutions. It raises questions about laws intended to maintain the ecological status quo that may inhibit progress and requires modifying long-held views in conservation biology that are also supported, directly or indirectly, by federal laws and policies. Scientific and policy debates are expected to be controversial. There are a number of policies in the Forest Service Manual that impact assisted migration, including:

Reforestation Policy – FSM 2472.03

- Do not use seed and seedlings of exotic tree species or native species from an offsite source, except where:
  a. Scientific studies have proven they are adaptable to the area in question.
  b. Administrative studies or tests are being carefully planned with the cooperation or assistance from knowledgeable research scientists.

Genetic Resources Management – FSM 2475.03

- Use seedlings that are adapted to local climatic conditions. Use seedlings from distant sources only after successful performance in evaluation trials. Seedlings from distant sources may be used to accommodate projected changes in climate. Monitoring protocols should be established to track survival and performance of seedlings from distant sources. (*Note: this is new draft language from the FY12 manual revision*).

Native Plant Material Policy - FSM 2070.3

- Ensure genetically appropriate native plant materials are given primary consideration. (*Note; the policy defines genetically appropriate plants as being adapted to target site conditions with good establishment, vigor, and reproductive capabilities; sufficiently genetically diverse to respond and adapt to changing climates and environment conditions; unlikely to cause genetic contamination and undermine local adaptations, community interactions and function of resident native species within the ecosystem; not likely to become (not natural or inappropriate) invasive and displace other native species; and not likely to be a source of non-native invasive pathogens; likely to maintain critical connections with pollinators*).

- Select non-native plants as interim, non-persistent plant materials provided they will not hybridize with local species, will not permanently displace native species or offer serious long-term competition to the recovery of endemic plants, and are designed to aid in the reestablishment of native plant communities.

Management of Wildlife and Fish in Wilderness – FSM 2323.3

- Provide an environment where the forces of natural selection and survival rather than human actions determine which and what numbers of wildlife species will exist.
- Reintroduce wildlife species only if the species was once indigenous to an area and was extirpated by human induced events.

Threatened, Endangered, and Sensitive Plants and Animals: Experimental Populations – FSM 2671.43

- Experimental populations are those populations of threatened and endangered species so declared by the Secretary of the Interior, which are wholly separate geographically from naturally occurring populations of the same species. Experimental populations are exempt from the full protective measures of the Endangered Species Act of 1973, as amended, in order to encourage reintroductions of listed species and experimental approaches to accelerate recovery.

- All experimental populations shall receive the same treatment as "threatened" species.
- The Secretary of the Interior may issue regulations to allow for appropriate conditions and levels of "takings."
- Critical habitat is not declared for experimental populations.
- The Secretary of Interior may declare further that certain experimental populations are "nonessential" to the continued existence of the species.
- For the purposes of consultation requirements, nonessential experimental populations receive the same treatment as species proposed for listing. Consequently, the Forest Service must "confer" with the Secretary of the Interior or Commerce in accordance with requirements for proposed species (FSM 2671.45b).

In general, these statements imply that the only instance one should engage in assisted migration on an operational basis is when past scientific research supports success. In addition, untested assisted migration can take place if it is part of a research or administrative study. In all cases, monitoring is required. Presently, this limits operational assisted migration to only the handful of species that have provenance trial data available from longer-term field trials and those species where seed sources have been moved previously.

In terms of U.S. Forest Service strategy and guidance, both the USDA Strategic Plan for 2010-2015 and the agency's *National Roadmap for Responding to Climate Change* (USDA Forest Service, July 2010) encourage the use of practices that result in resilient landscapes and the need to conserve our genetic resources. Neither specifically addresses the specifics of assisted migration.

NFS geneticists and Research and Development (R&D) research geneticists recently completed a national white paper containing recommendations for adapting forest tree species to climate change (Erickson et al. 2012). The white paper identified a number of priority action items to facilitate implementation of assisted migration and other management recommendations aimed at enhancing forest resilience and resistance to changing climates. The premise is that assisted migration should only be done operationally when seed movement studies had been done for the specific species in question or when forest health, regeneration or productivity monitoring data indicate there are climate change related problems. The white paper encouraged the establishment of additional assisted migration trials. The principles emphasized in the document are in appendix 1. The general guidelines from this effort were:

- Starting point: consider species and local seed sources that have worked well in the past (locally adapted seed sources).
- If reforestation problems exist, expand local sources with germplasm better matched to the changed conditions. Emphasize genetic diversity, including the use of multiple species and diverse seed sources, and the maintenance of large populations with high connectivity and opportunity for migration of

adapted genes (via seed and pollen) in the direction of trending climates.
- Utilize a 10-20 year planning horizon for decision making (to minimize risks at the highly vulnerable seedling/sapling stage).
- Take high-risk actions (e.g., Species Rescue AM) over small areas on an experimental basis, or for genetic rescue of species and populations at imminent risk of extirpation.
- Take low-risk actions (moving a seed source within as species range) over larger areas.

POLICY NEEDS

The current lack of specific policies on assisted migration for commercially-important species, species targeted for use in restoration, and species of conservation concern leaves a gap in the ability of the Forest Service to make decisions on these important issues. Efforts are already underway to develop climate change adaptation strategies on our national forests, and assisted migration is a tool that may become necessary if we are to conserve species and maintain productivity under changing climatic conditions. Schwartz et al. (2012) suggest that federal agencies need to develop and adopt best practices that consider ethics, law, policy and ecology.

Present policy suggests that one should consider the success of a species/seed source in experimental trials before undertaking any assisted migration; this policy is conservative, and possibly rightly so since species distribution models (also called "climate envelopes") have not always accurately or consistently predicted past and current range shifts (e.g., see Crimmins et al. 2011; Zhu et al. 2012). In addition, there is the concern that a translocated species may become invasive in its new environment or cause other problems such as introduction of novel insects or pathogens, or disruption of critical plant-pollinator connections (see Riccciardi and Simberloff 2009). The suggestion that translocation trials are kept small ensures that if a species or seed source becomes a problem there is the possibility of containment or eradication.

Assisted migration studies will help inform managers on the possibility of successfully moving a species or seed source, but this does not address all of the concerns that are voiced in the literature (e.g., Richardson et al. 2009; Aubin et al. 2011; Schwartz et al. 2012). The literature suggests that any policy concerning assisted migration actions should undergo a thorough and transparent risk-benefit analysis before one makes a decision. Factors to be examined include:

- Success probability of the species/population being moved.
- Risk of the species becoming extinct with no action / probability of a stand becoming less productive with no action (or using local seed sources).
- Potential for the transplanted species/population to become invasive.
- Risks of moving invasive insects or pathogens along with transplanted species/population.
- Legal concerns around possible laws prohibiting movements.
- Ethical concerns and social acceptance.

Along these lines, Richardson et al. (2009) present a framework for evaluation that includes examining ecological and social criteria for four categories: focal impact, collateral impact, feasibility, and acceptability. This framework, or something similar, would be a useful tool to evaluate Forest Service assisted migration proposals. Pedlar et al. (2012) used a similar framework to compare Species rescue AM and Forestry AM (very similar to Ecosystem AM defined here) and demonstrated that there are much fewer risks involved in Ecosystem/Forestry AM than Species rescue AM (Table 1). Future policy must be realistic, as well as thorough; so that requirements are not so arduous that it would be impossible to proceed with appropriate management actions.

CURRENT FOREST SERVICE ASSISTED MIGRATION ACTIVITIES

Assisted migration activities within the Forest Service are limited and include:

- Many of the past and current provenance studies (very small scale Ecosystem AM).
- Operationally using seed from seed zones one elevation zone lower than planting site.
- Moving some southeastern conifer species north one seed zone.
- Using native cultivars in restoration whose original source was from a different seed zone or ecoregion.

CONCLUSIONS

Forest Service policy on assisted migration is minimal at present; only calling for scientific evidence that a move would be successful. For most species, such information is lacking and this may hinder proactive efforts to adapt NFS lands to projected changes in climate. In order for assisted migration to be socially acceptable, it will be necessary to expand policy to examine the multiple risks and benefits that could arise from the different types of assisted migration efforts that are being considered. The risks and benefits will vary depending on the type of assisted migration (Ecosystem AM or Species Rescue AM) and the species being considered.

For any policy, implementation can, and will, vary depending on who is doing the implementing. Factors that vary among people (and organizations) include:

- Overall objectives of the agency (company) and/or restoration project.
- Mindset / frame of reference. Some see management as a logical way to maintain the flow of ecosystem goods and services; others feel that nature will take care of itself and see management as an unwanted-intrusion into nature (Aubin et al. 2011). For example, Schwartz et al. 2012 makes the statement: *"The magnitude of projected climate change, however, suggests that humans may be forced to choose between the unfortunate alternatives of witnessing extinctions and intentionally manipulating species' distributions in efforts to prevent extinction and maintain biodiversity.*" To many the choice is obvious, but the obvious choice can differ between any two people. In the case of the Forest Service, our mission is to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations; this implies the need to manage and not sit back and watch.
- Risk adverseness. Individuals differ in the amount of risk with which they are comfortable.

The Forest Service will have to weigh these factors when considering the best course of action for the Agency as it develops policies for assisted migration.

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