SPECIES MOVEMENT AND HABITAT CONNECTIVITY

ISSUE STATEMENT

Habitat loss and fragmentation threaten the future integrity of the Sierra Nevada by disrupting important ecological interactions and patterns of movement. Concerns about loss and fragmentation of habitat extend from aquatic to terrestrial systems in this region (Centers for Water and Wildland Resources 1996). Increases in temperature and changes in precipitation due to climate change are likely to exacerbate these effects on habitat through changes in disturbance cycles and seasonal weather patterns. To adapt to climate-driven shifts in habitat, species may need to adjust their range and movement patterns. Barriers to dispersal could result in plant and wildlife populations that are highly vulnerable to extirpation and extinction. Maintaining and re-establishing connectivity of healthy habitats across landscape gradients would facilitate climate-induced species migration and increase the potential for successful adaptation in the face of climate variability and other human induced stressors (Blate et al. 2009, Moritz et al. 2008, Innes et al. 2009).

The concerns about habitat fragmentation and barriers to movement are widespread. The scientific community has been studying the issues related to habitat fragmentation and wildlife persistence for decades. More recently, multiple state and federal agencies have identified the importance of providing for habitat connectivity in the face of climate change and other stressors (Western Governor's Association 2008; Spencer et al. 2010; US Fish and Wildlife Service 2010). Further, the California Department of Fish and Game and other state agencies have determined that a functional network of connected wildlands is essential to the continued support of California's diverse natural communities in the face of both human development and climate change (California Department of Fish and Game 2010).

Planning for Connectivity in the Sierra Nevada

We examined several recent approaches to identifying areas important to sustaining the flow of species and processes across the landscape in an effort to identify attributes that were common among them. We use this information as a basis for our recommendations on how to use the forest plans to address habitat connectivity.

The Sierra Nevada Forest Plan Amendment (USDA Forest Service 2001 and 2004) specifically identified a land allocation focused on enhancing old forest values. This approach was taken, in part, based on recommendations in the Sierra Nevada Ecosystem Project (Franklin et al. 1996). This land allocation, Old Forest Emphasis Area (OFEA), was designed as a network of areas intended to maintain moderate to dense canopy cover across Sierra Nevada landscapes (USDA Forest Service 2001). The OFEAs occupy about 30 percent of the Forest Service land base in the Sierra Nevada. This network largely consisted of internally connected areas and ranged from lower elevation mixed-conifer hardwood types to subalpine areas that intersected with Wilderness Areas. We compared the extent of this network with three recent strategies to identify connectivity in the Sierra Nevada to assess the degree to which the OFEA approach incorporated areas identified as important to connectivity in these independent assessments. The following frameworks were examined:

> **Framework 1: California Essential Habitat Connectivity Project: A Strategy for Conserving a Connected California** (Spencer et al. 2010): The California Department of Transportation and California Department of Fish and Game commissioned this project because a functional network of connected wildlands is essential to the continued support of California's diverse natural communities in the face of human development and climate change. The strategy is intended to make transportation and land-use planning more

efficient and less costly, while helping reduce dangerous wildlife-vehicle collisions.

Framework 2: Decision Support Maps and Recommendations for Conserving Rare Carnivores in the Inland Mountains of California (Spencer and Rustigian-Romsos 2012): This report provides maps and guidance based on spatially explicit, empirical models intended to support forest planning to sustain populations of four imperiled forest carnivores in the inland mountain ranges of California: Pacific marten (*Martes caurina*), fisher (*Martes pennanti*), wolverine (*Gulo gulo*), and Sierra Nevada red fox (*Vulpes vulpes necator*). The maps depict the distribution of populations and habitat for each species as well as habitat connectivity areas that are important to maintaining species' movements and demographic and genetic processes.

Framework 3: Framework for Cooperative Conservation and Climate Adaptation for the Southern Sierra Nevada and Tehachapi Mountains, California, USA (Southern Sierra Nevada Partnership 2010): This regional conservation framework identifies a network of core areas and connections that support high biodiversity and valuable ecosystem services. The design includes landscape features likely to support adaptation and zones projected to be climatically stable within the existing ranges of common trees and shrubs and key systems.

We examined the degree to which the areas important to conservation and identified in these three assessments overlapped geographically with the OFEAs identified in the existing forest plans in the Sierra Nevada. Our analysis subdivided the 11 national forests in the Sierra Nevada region into five subregions: Northeast California (Modoc National Forest), northern Sierra Nevada (Lassen and Plumas national forests), central Sierra Nevada (Tahoe and Eldorado national forests and Lake Tahoe Basin Management Unit), eastern Sierra Nevada (Humboldt-Toiyabe and Inyo national forests), and southern Sierra Nevada (Sequoia, Sierra and Stanislaus national forests). Our assessment indicated that there was significant overlap among the conservation areas identified in the three studies above and the OFEAs for the northern, central and southern SN subregions (Table IV.F-1). Overlap was substantially less apparent for the other two regions. More specifically, areas determined by these three assessments had fairly high representation in the existing OFEA network on national forests in these subregions.

Table IV.F-1. Evaluation of representation of the Old Forest Emphasis Area land allocation in three frameworks that identify areas important to connectivity (Framework 1: Spencer et al. 2010; Framework 2: Spencer et al. 2012; Framework 3: Southern Sierra Nevada Partnership 2010).

Region (national forest)	Framework 1		Framework 2		Framework 3
	Corridors	Cores	Corridors	Cores	All Priority Areas
Northeast California (Modoc)	5%	26%	0%	98%	n/a
Northern Sierra Nevada (Lassen and Plumas)	60%	48%	65%	92%	n/a
Central Sierra Nevada (Tahoe and Eldorado, Lake Tahoe Basin Management Unit)	74%	47%	77%	73%	n/a
Eastern Sierra Nevada (Inyo and Humboldt-Toiyabe)	17%	2%	15%	15%	73%
Southern Sierra Nevada (Stanislaus, Sierra, Sequoia)	87%	68%	93%	92%	66%

The fairly high degree of coincidence of the OFEA land allocation with these other strategies, designed to specifically address connectivity, indicates that OFEAs are the place to begin in designing a strategy that addresses habitat connectivity for the Sierra Nevada. For the Inyo and Humboldt-Toiyabe national forests, the OFEA land allocation should be revised to incorporate features from the three assessments where geographically appropriate. The Modoc National Forest is not well represented in any of the three assessments and should be examined in light of conservation planning in the Klamath–Siskiyou and Great Basin regions.

Connectivity does not have a universally accepted definition, but generally refers to the effect of terrestrial, freshwater, or marine ecosystem structure on organisms' ability to move and survive within and among patches of resources (Society for Conservation Biology 2010). Connectivity also refers to propagation of processes, such as fire or flooding, or flows of water and nutrients. A successful and effective management strategy in the Sierra Nevada must plan for the connection among all components of the ecosystem by addressing the composition, structures, and processes inherent to the landscape. Further, a successful strategy will require planning and coordination among national forests and other jurisdictions. Absent a robust habitat connectivity commitment, forest plans will struggle to maintain and enhance biodiversity in a changing and uncertain future.

Science-based connectivity strategies must be supported by monitoring to ensure that species movement and viability is the outcome from our best effort to design and implement measures to protect biodiversity.

POLICY ACTIONS NEEDED

Proposal for Revision to Forest Plan Direction

A. Desired Condition *The following statements represent the desired future condition of the landscape and may not reflect the current conditions.*

Desired Condition CON-1. Connectivity is maintained or restored along gradients of elevation and aspect, linking alpine communities with downslope ecosystems.

Desired Condition CON-2. East-west and north-south connectivity are maintained or restored.

Desired Condition CON-3. Disturbance and other ecological cycles are allowed to function without disruption across the majority of the landscape.

Desired Condition CON-4. Wide-ranging species are able to move freely among habitats.

B. Objectives

Objective CON-1. By year 5 of the forest plan, 50 percent of the roads identified as contributing to fragmentation in the Old Forest and Connectivity (OFC) land allocation have been closed or decommissioned.

Objective CON-2. Opportunities for public-private partnerships to address connectivity and species movement have been explored, documented, and prioritized for action by year two of the forest plan.

Objective CON-3. The forest plan addresses potential effects of changing climate on connectivity and actively plans for shifts in range for species and communities.

Objective CON-4. Landscape analysis and monitoring data will support the identification of restoration actions that reduce fragmentation in the OFC land allocation and that area a high priority for action.

Objective CON-5. Landscape analysis evaluates the potential for changed flow regimes resulting from climate change to create barriers to aquatic species movement. This assessment should include an evaluation of the effect of the water infrastructure (e.g., dams, diversions, conveyances, and culverts) on aquatic connectivity under changed flow regimes.

Objective CON-6. Areas critical for the connectivity of aquatic or terrestrial habitats are managed in the short term to minimize the effects of disturbance and to preserve the functional connection.

C. Standards

Standard CON-1. Road construction is avoided in the OFC land allocation.

Standard CON-2. Stream crossings are redesigned to ensure the movement of water in high and low water years.

Standard CON-3. Projects are designed to enhance connectivity and reduce or eliminate barriers to connectivity that have been identified in landscape analysis.

Standard CON-4. Avoid actions that disrupt habitat characteristics, e.g., hiding or dispersal cover, in areas critical to the connectivity of aquatic or terrestrial habitats, as identified by the OFE land allocation or during other assessment processes.

D. Land Allocations

All land allocations, with the exception of the Community Zone (CZ), can contribute in substantial ways to maintaining connectivity of habitats. Several key land allocations are noted below due to their emphasis on maintaining existing low road density, actively reducing road density, supporting the natural disturbance cycles, and emphasizing protection of biodiversity.

We propose that the land allocations below be used as the starting point for each national forest in assessing landscape connectivity and designing management actions to protect, restore and enhance the connections among habitats. Further, we propose that the existing OFEA land allocation be revised based on on the three studies mentioned above and any other appropriate landscape level assessments to more comprehensively address connectivity and the land allocation Old Forest and Connectivity (OFC) replace the existing OFEA.

Table IV.F-1. Principle land allocations supporting species movement and connectivity.

Land Allocation	General Description	Management Objective
Wilderness Area (WA), Wild and Scenic Rivers (WSR)	Congressionally designated areas.	Preserving the wild nature of these areas
Research Natural Areas (RNAs)	Designated by agreement among the national forest and research station.	Maintain biological diversity Provide baseline ecological information Support non-manipulative research Encourage research and university natural-history education.
Recommended Wilderness (RW)	Area that is recommended for inclusion in the NWPS by the USFS.	Preserve the wilderness character of these lands until Congress accepts or rejects the recommendations in whole or in part.
Backcountry Management Area (BMA)	An inventoried roadless area (IRA) or citizen's inventoried roadless areas (CIRA) that do not contain any national forest system roads or motorized trails.	Preserve the roadless and backcountry character of these lands. Manage them under the Roadless Area Conservation Rule with exception, prohibiting motorized over-snow vehicle use and the construction of new motorized trails.
Old Forest and Connectivity (OFC)	Area in which old forest qualities are emphasized Area critical to the movement and flow of species associated with all habitat types across the landscape. Designed as an adaptation to climate change and other stressors.	Restore ecological process where doing so does not threaten critical values. Maintain movement opportunities across the landscape. Manage to achieve high representation (greater than 60 to 80 percent) of old forest condition.
Riparian Conservation Area (RCA)	Management zones focused on the protection and enhancement of aquatic features	Restore ecological process where doing so does not threaten critical values. Maintain, restore, enhance, and protect. Limited levels of ground and vegetation disturbance allowed. Avoid actions that retard or prevent attainment of aquatic conservation objectives.
Aquatic Diversity Emphasis (ADE)	Watershed in which protecting or maintaining aquatic diversity is the priority.	Restore ecological process where doing so does not threaten critical values. Avoid actions that retard or prevent attainment of aquatic conservation objectives. Promote low road density generally <1.5 mi/mi^2 in the matrix, less in sensitive habitats.

Recommended Actions at the National Forest Level Not Directly Addressed in the Forest Plan

- Identify areas within the OFC land allocation in which it is important to limit severe fire as a means to ensure that the habitat connection and quality are preserved; define the appropriate fire management response and incorporate this information into fire plans and other planning documents.

Recommendations for New Regional Direction or Policy

- Provide guidance to the national forests on practices to achieve connected landscapes that draws on the planning and analysis developed by other agencies such as the California Department of Fish and Game (Spencer et al. 2010) and Southern Sierra Nevada Partnership (2010).

- Develop information on the role of climate refugia or climate stable areas in conservation planning and identify for the national forests how to incorporate these areas into the forest plans.

- Convene a multi-agency committee on biodiversity to inform regional and local managers regarding landscape planning, habitat needs, connectivity designs, mitigation of stressors and other issues pertaining to wildlife ecology, viability and movement monitored across the landscape over time.

- Utilize the anticipated report from the panel of experts that will be reviewing the monitoring plan associated with the management indicator species amendment (USDA Forest Service 2007) to inform the development of appropriately scaled designs for population monitoring in the Sierra Nevada.

Additional Recommendations

- Participate in cooperative learning and management projects like the Southern Sierra Nevada Partnership and California Landscape Conservation Cooperative.

- Identify for land trusts land acquisition projects that would make significant contributions to improving connectivity.

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