BEFORE THE SECRETARY OF INTERIOR

PETITION TO LIST THE SAN BERNARDINO FLYING SQUIRREL (*Glaucomys sabrinus californicus*) AS THREATENED OR ENDANGERED UNDER THE UNITED STATES ENDANGERED SPECIES ACT

Northern flying squirrel, Dr. Lloyd Glenn Ingles © California Academy of Sciences

CENTER FOR BIOLOGICAL DIVERSITY, PETITIONER
AUGUST 24, 2010

NOTICE OF PETITION

Ken Salazar, Secretary of the Interior
U.S. Department of the Interior
1849 C Street, N.W.
Washington, DC 20240
Phone: (202) 208-3100
exsec@ios.doi.gov

Ren Lohoefener, Regional Director
U.S. Fish and Wildlife Service Region 8
2800 Cottage Way, W-2606
Sacramento, CA 95825
Phone: (503) 231-6118
ren_lohoefener@fws.gov

Rowan Gould, Acting Director
U.S. Fish and Wildlife Service
1849 C Street, NW, Mail Stop 3012
Washington, D.C. 20240
Phone: (202) 208-4717
Fax: (202) 208-6965
rowan_gould@fws.gov

PETITIONER

Shaye Wolf, Ph.D.
Center for Biological Diversity
351 California Street, Suite 600
San Francisco, CA 94104
office: (415) 632-5301
cell: (415) 385-5746
fax: (415) 436-9683
swolf@biologicaldiversity.org

Shaye Wolf

_____   Date this 24th day of August, 2010

Pursuant to Section 4(b) of the Endangered Species Act ("ESA"), 16 U.S.C. §1533(b), Section 553(3) of the Administrative Procedures Act, 5 U.S.C. § 553(e), and 50 C.F.R. § 424.14(a), the Center for Biological Diversity hereby petitions the Secretary of the Interior, through the United States Fish and Wildlife Service ("USFWS"), to list the San Bernardino flying squirrel (*Glaucomys sabrinus californicus*) as a threatened or endangered species and to designate critical habitat to ensure its survival and recovery.

The Center for Biological Diversity works through science, law, and policy to secure a future for all species, great or small, hovering on the brink of extinction. The Center has over 42,000 members throughout California and the United States. The Center and its members are concerned

with the conservation of endangered species, including the San Bernardino flying squirrel, and the effective implementation of the ESA.

USFWS has jurisdiction over this petition. This petition sets in motion a specific process, placing definite response requirements on USFWS. Specifically, USFWS must issue an initial finding as to whether the petition "presents substantial scientific or commercial information indicating that the petitioned action may be warranted." 16 U.S.C. §1533(b)(3)(A). USFWS must make this initial finding "[t]o the maximum extent practicable, within 90 days after receiving the petition." *Id.* Petitioners need not demonstrate that listing *is* warranted, rather, Petitioners must only present information demonstrating that such listing *may* be warranted. While Petitioner believes that the best available science demonstrates that listing the San Bernardino flying squirrel as endangered *is* in fact warranted, there can be no reasonable dispute that the available information indicates that listing the species as either threatened or endangered *may* be warranted. As such, USFWS must promptly make a positive initial finding on the petition an commence a status review as required by 16 U.S.C. § 1533(b)(3)(B).

The term "species" is defined broadly under the ESA to include "any subspecies of fish or wildlife or plants and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature." 16 U.S.C. § 1532 (16). A Distinct Population Segment ("DPS") of a vertebrate species can be protected as a "species" under the ESA even though it has not formally been described as a separate "species" or "subspecies" in the scientific literature. A species may be composed of several DPSs, some or all of which warrant listing under the ESA. As described in this petition, the San Bernardino flying squirrel (*Glaucomys sabrinus californicus*) is a currently recognized subspecies of the northern flying squirrel (*Glaucomys sabrinus*) and therefore meets the definition of a "species" eligible for listing under the ESA. In the event USFWS does not recognize the taxonomic validity of the San Bernardino flying squirrel as described in this petition, we request that USFWS evaluate whether the San Bernardino flying squirrel of southern California that is the subject of this petition constitutes a DPS of the full northern flying squirrel species.

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EXECUTIVE SUMMARY

The San Bernardino flying squirrel (*Glaucomys sabrinus californicus*) is a wood-brown, nocturnally active, arboreal squirrel that is distinguished by the furred membranes extending from wrist to ankle that allow squirrels to glide through the air between trees at distances up to 300 feet (91 meters). The San Bernardino flying squirrel is the most southerly distributed subspecies of northern flying squirrel (*Glaucomys sabrinus*) and is paler in color and smaller than most other northern flying squirrel subspecies. It inhabits high-elevation mixed conifer forests comprised of white fir, Jeffrey pine, and black oak between ~4,000 to 8,500 feet. It has specific habitat requirements that include associations with mature forests, large trees and snags, closed canopy, downed woody debris, and riparian areas, and it is sensitive to habitat fragmentation. It specializes in eating truffles (e.g. hypogeous mycorrhizal sporocarps) buried in the forest floor as well as arboreal lichens in winter when truffles are covered with snow and unavailable.

The historic range of the San Bernardino flying squirrel lies within the high-elevation mixed conifer forests of the San Bernardino and San Jacinto Mountain ranges of San Bernardino and Riverside counties in southern California. Although the San Bernardino flying squirrel is still extant in the San Bernardino Mountains, surveys, studies, and anecdotal observations indicate that it has been extirpated or near-extirpated (i.e. at a low population size) from the San Jacinto Mountains. In the San Bernardino Mountains, a low density estimate and capture rates from the 1990s suggest that the flying squirrel occurs at relatively low abundance, comparable to the federally endangered Carolina northern flying squirrel (*G. s. coloratus*).

The San Bernardino flying squirrel's highly restricted and isolated range, small population size, habitat and diet specificity, and sensitivity to habitat fragmentation make it especially vulnerable to threats that reduce habitat quality and quantity. Current, ongoing threats that jeopardize the San Bernardino flying squirrel by modifying and destroying habitat include anthropogenic climate change, forest management practices, air pollution, and urban development.

Anthropogenic climate change poses a significant threat to the long-term survival of the San Bernardino flying squirrel. Climate change has already resulted in substantially warmer and drier conditions in the San Bernardino and San Jacinto Mountains. Temperatures and heat wave activity have increased, drought severity and duration have risen, more precipitation is falling as rain instead of snow, the timing of runoff and snowmelt-driven streamflow has advanced, and streamflow has increased in winter months and decreased in summer months leading to higher summer water stress. The San Bernardino flying squirrel is particularly vulnerable to climate change. It occurs at the southern limit of the species' range where climate change impacts are expected to be more pronounced. However, as a high-elevation species restricted to one to two isolated mountain ranges, it has limited options for movement in response to climate change. As climatic zones shift upward in elevation, its habitat will be compressed upward and it risks running out of suitable habitat. Two of the most significant threats to the San Bernardino flying squirrel from climate change are the upward shift of its high-elevation forest habitat which has already been documented in the Santa Rosa Mountains adjacent to the San Jacinto range, and the decline of its mycorrhizal food sources as conditions become warmer and drier.

Fuels reduction projects on the San Bernardino National Forest threaten the San Bernardino flying squirrel by removing critical habitat features including canopy cover, snags, coarse woody debris, and understory cover. High levels of nitrogen deposition and ozone enrichment in the San Bernardino Mountains resulting from air pollution from the Los Angeles metropolitan area threaten the San Bernardino flying squirrel by decreasing the abundance of arboreal lichen and potentially mycorrhizal forage species, reducing the diversity of understory cover, and increasing the susceptibility of conifers to drought. The cumulative impacts of habitat loss and fragmentation from ever-increasing urban development in the San Bernardino and San Jacinto Mountains threaten the flying squirrel as existing communities and ski resorts expand, new areas are developed, and Wildland/Urban Interface Defense and Threat Zones are created and maintained around growing communities. Additionally, the San Bernardino flying squirrel is jeopardized by the failure of existing regulatory mechanisms to ameliorate these threats. For these reasons the Department of the Interior should act promptly to protect the San Bernardino flying squirrel and its critical habitat under the U.S. Endangered Species Act.

NATURAL HISTORY AND BIOLOGY OF THE SAN BERNARDINO FLYING SQUIRREL

I.   Species Description

The northern flying squirrel (*Glaucomys sabrinus*) is medium-sized, nocturnally active, arboreal rodent distinguished by the furred membranes extending from wrist to ankle that allow squirrels to glide through the air (Wells-Gosling and Heaney 1984). The northern flying squirrel's generic name, *Glaucomys*, is from the Greek *glaukos* (silver, gray) and *mys* (mouse), while *sabrinus* is derived from the Latin word *sabrina* (river-nymph) which refers to the squirrel's habitat association with streams and rivers (Wells-Gosling and Heaney 1984). Northern flying squirrels are generally gray to wood-brown to cinnamon in the coloration of their upperparts, excluding the nose, forehead, flying membrane, fore and hind legs, and tail terminus (Wells-Gosling and Heaney 1984). The underside of the body, head, and limbs are a nearly uniform pale, buffy, or yellowish gray (Wells-Gosling and Heaney 1984). The sides of the head and the face are sometimes gray, often with a buffy or cinnamon wash (Wells-Gosling and Heaney 1984). However, color varies widely by subspecies (Wells-Gosling and Heaney 1984).

The San Bernardino flying squirrel (*Glaucomys sabrinus californicus*) is a subspecies of the northern flying squirrel that is separated geographically and is distinct in color and morphology from other northern flying squirrel subspecies. Rhoads (1897) described the San Bernardino flying squirrel as paler in color, "somewhat smaller and with a relatively shorter hind foot and tail" (p. 323) compared to other subspecies:

> Above, including whole upper surface, except nose, forehead, flying membrane, fore and bind legs and terminal of tail, between drab-gray and wood-brown; bases of upper body hairs slate color, this shade predominating on upper surfaces of flying membrane and the fore and hind legs. Hind and fore feet brownish smoke-gray, fading on the toes to whitish smoke-gray. Upper basal third of tail like back, remainder of tail becoming dark smoke-gray. Sides of face and neck and across rostrum pale ashen smoke-gray. Black whiskers fading to smoke-gray along the terminal half. Ears drab-gray within and without. Mouse-gray orbital ring scarcely appreciable. Whole underside of body, head and limbs nearly uniform pale, buffy or yellowish-gray, with a French gray cast caused by the darkening of the exposed basal portions of the hairs and becoming nearly pure white on throat, lower fore legs and inner margins of thighs. Furred soles of hind feet and whole underside of tail pale drab. (Rhoads 1897: 323).

> The San Bernardino or Sierra Madre flying squirrel, true to its environment, has assumed the characteristic paleness of the Southern California mountain mammalia as contrasted with their new allies of the Cascade Range. In size and general proportions it seems to be intermediate between *fuliginosus* and *oregonensis*; in color it probably comes closest to *alpinus*, but is much grayer. Its skull is almost as small as in *oregonensis*, and the characteristic relative narrowness of the posterior frontal constriction distinguishing the *alpinus* group from *sabinus* is very pronounced. (Rhoads 1897: 324).

Size of northern flying squirrels varies geographically in a north-south cline along the Pacific Coast (Wells-Gosling and Heaney 1984), with the largest individuals in Alaska and British Columbia and the San Bernardino flying squirrel at the smaller end of the spectrum. Sexual dimorphism in color or size is not evident (Wells-Gosling and Heaney 1984). Adult San Bernardino flying squirrels range from 98 to 158 grams in weight and 277 to 312 mm in total length. In the San Bernardino Mountains, twelve adult males trapped in June-September 1926 near Big Bear Lake averaged 115.2 grams in weight, 291.3 mm in total length, and 37.5 mm in tail length; five adult females averaged 137.1 grams in weight, 298.8 mm in total length, and 39.1 mm in tail length (Sumner 1927). Of 22 squirrels trapped near Bear Mountain and Little Green Valley in May-August 1991, adult males ranged from 100 to 158 grams while adult females ranged from 98 to 140 grams (Butler et al. 1991: Table 1). A female trapped at Squirrel Inn, San Bernardino Mountains, in June 1896 measured 286 mm in total length (Rhoads 1897). Three female squirrels trapped near Bear Lake and Bluff Lake in the San Bernardino Mountains in August-September 1905 measured 304, 312, and 297 mm in total length (Grinnell 1908). In the San Jacinto Mountains, a female colleted in July 1908 in Strawberry Canyon was 312 mm in total length (Grinnell and Swarth 1913).

Like other northern flying squirrels, the San Bernardino flying squirrel is nocturnally active. It does not hibernate and is active year-round (Wells-Gosling and Heaney 1984). The squirrel glides between trees using the furred plagiopatagium on either side of the body supported by a slender cartilaginous styliform process (i.e. a finger-like projection) that articulates with the bones of the wrist and is attached to the pisiform bone. A smaller gliding membrane, the propatagium, extends between the cheek and the wrist in front of the forelimb, and the uropatagium extends between the hind limbs and tail (Wells-Gosling and Heaney 1984). Average observed glide lengths for San Bernardino flying squirrels are 60 feet (18 meters), with the longest observed glide at 300 feet (91 meters) down a 35% well-treed slope (Butler et al. 1991).

II.   Taxonomy

The San Bernardino flying squirrel (*Glaucomys sabrinus californicus*) is one of 24 subspecies of northern flying squirrel (*Glaucomys sabrinus*) recognized by Hall (1981) (Figure 1), and one of 25 subspecies recognized by Wells-Gosling and Heaney (1984). The San Bernardino flying squirrel was first described by Rhoads (1897) as the subspecies *Sciuropterus alpinus californicus* based on four specimens collected in the San Bernardino Mountains. The subspecies was renamed *Glaucomys sabrinus californicus* by Howell in 1918 (Hall 1981) which was later reaffirmed by Grinnell (1933). Based on mitochondrial DNA analysis, Arbogast (1999, 2007) recognized the San Bernardino flying squirrel as the subspecies *G. sabrinus californicus* that is genetically distinct from the populations of *G. sabrinus* found further north (Figure 2). Thus, as a recognized subspecies, the San Bernardino flying squirrel fits into the definition of "species" as defined by the ESA.

Figure 1. Subspecies of the northern flying squirrel *Glaucomys sabrinus.*
Source: Hall (1981): Map 260.
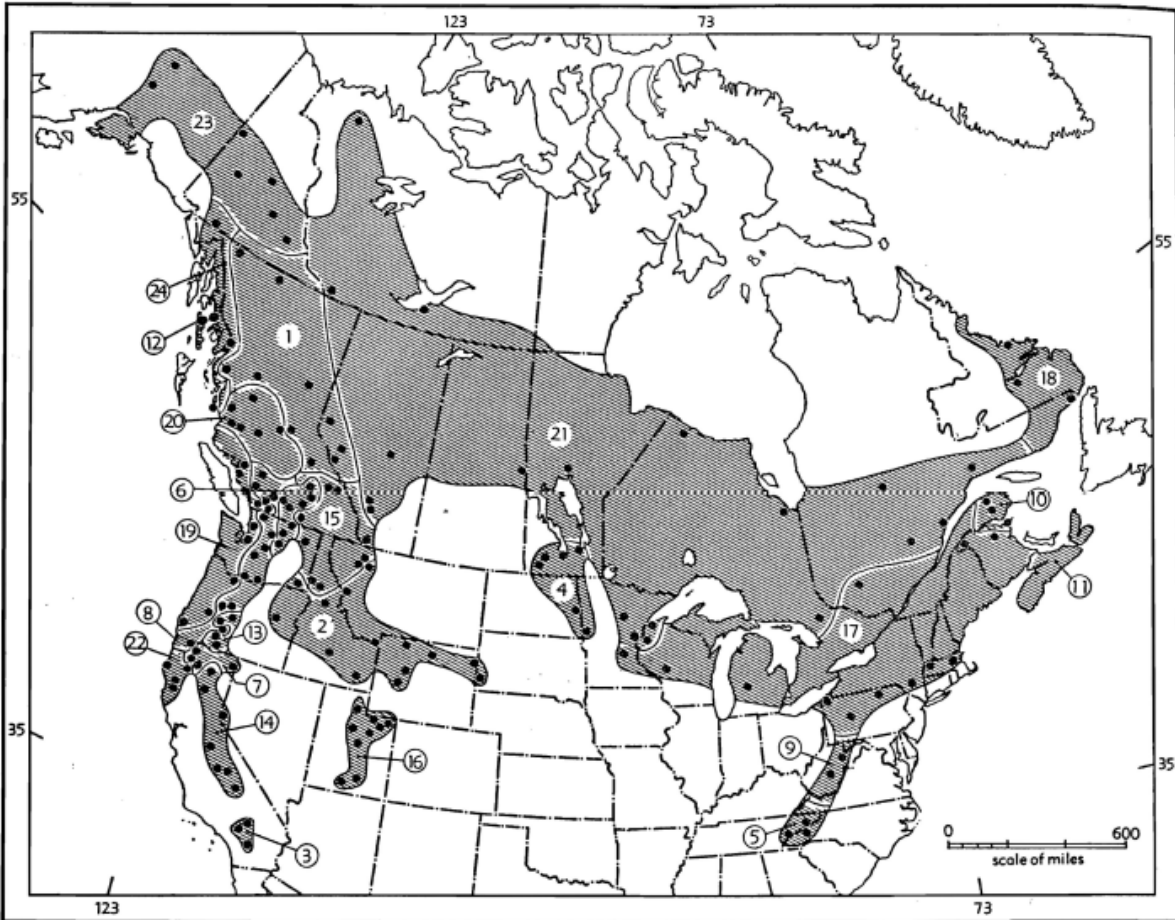
Map 260. *Glaucomys sabrinus.*

1. *G. s. alpinus*	7. *G. s. flaviventris*	13. *G. s. klamathensis*	19. *G. s. oregonensis*
2. *G. s. bangsi*	8. *G. s. fuliginosus*	14. *G. s. lascivus*	20. *G. s. reductus*
3. *G. s. californicus*	9. *G. s. fuscus*	15. *G. s. latipes*	21. *G. s. sabrinus*
4. *G. s. canescens*	10. *G. s. goodwini*	16. *G. s. lucifugus*	22. *G. s. stephensi*
5. *G. s. coloratus*	11. *G. s. gouldi*	17. *G. s. macrotis*	23. *G. s. yukonensis*
6. *G. s. columbiensis*	12. *G. s. griseifrons*	18. *G. s. makkovikensis*	24. *G. s. zaphaeus*

Figure 2. Neighbor-joining tree showing evolutionary relationships among populations of the 2 species of *Glaucomys* based on analysis of the mitochondrial DNA cytochrome-b gene. This tree is presented as a phylogram (branch lengths are proportional except for that between Hylopetes and the ingroup taxa). Bootstrap values >50% for the outgroup analysis are shown above the line at each node, followed parenthetically by those estimated with the outgroup taxon removed. Localities (state or province abbreviations and number of individuals showing a given haplotype) are indicated at each terminal branch.
Source: Arbogast (2007): Figure 3.

```
                                    West Virginia*
                                 North Carolina*, Michigan
                                          Utah
                                          Washington
                                   Alaska, Washington,
                                   British Columbia
                                   Washington
                                   Alaska
                                            Alberta
                                         Michigan
                                   Alberta
                                 Michigan
                                North Carolina*
```

G. sabrinus
Continental
Clade

84 (93)

74

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                             Louisiana
                             Missouri, North Carolina,
                             Pennsylvania, West Virginia
                                North Carolina
                                Missouri
                                Missouri
                                Pennsylvania
                         Louisiana, Florida
                      Florida
```

G. volans
Eastern North
American Clade

98

```
                                California
                             Washington
                           Washington
                         Oregon
                      Oregon
                    Oregon
```

62 (99)

G. sabrinus
Pacific Coastal
Clade

Hylopetes

The San Bernardino flying squirrel is in the Order Rodentia, Suborder Sciuromorpha, Superfamily Sciuroidea, Family Sciuridae, Subfamily Petauristinae, Genus *Glaucomys*, Species *sabrinus*, Subspecies *californicus* (Wells-Gosling and Heaney 1984). Worldwide, 15 genera and 44 species of flying squirrels are recognized with the majority occurring in Eurasia, especially Southeast Asia (Arbogast 2007). *Glaucomys* is the only genus to occur outside of Eurasia; it is restricted to North America and Mesoamerica and is comprised of two species, the northern flying squirrel (*G. sabrinus*) and the southern flying squirrel (*G. volans*) (Arbogast 2007).

Arbrogast (1999) found evidence from mitochondrial DNA analysis for the existence of two distinct lineages within the northern flying squirrel: a western lineage occurring in the Cascades, Coast, Sierra Nevada, and Transverse ranges of Washington, Oregon, California, and Nevada, to which the San Bernardino flying squirrel belongs (the Pacific coastal clade); and a northern and eastern lineage that occupies the rest of the species' range (continental clade) (Figure 3) (Arbogast 1999). Arbogast (2007) concluded that populations of *G. sabrinus* currently found west of the Cascades and Sierra Nevada in Washington, Oregon and California appear to be derived from an ancestral population that persisted in a coniferous forest refugium that existed along the Pacific coast of the United States.

Figure 3. Geographic distribution of the northern flying squirrel (*G. sabrinus*) with the Pacific Coastal mitochondrial DNA (mtDNA clade) shown in black and the Continental mtDNA clade shown in gray. The 2 clades overlap geographically in a narrow region in northwestern North America.
Source: Arbogast (2007): Figure 2.
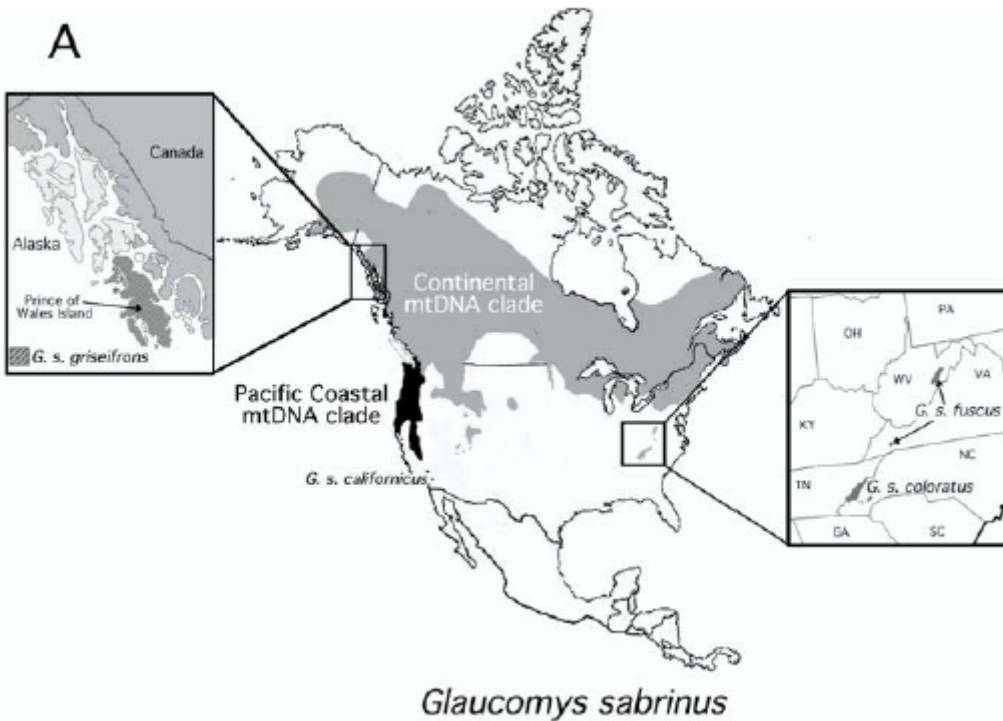
III.   Range and Distribution

The San Bernardino flying squirrel has most southerly distribution of all northern flying squirrel subspecies, followed by the endangered Carolina northern flying squirrel (*G. s. coloratus*). The historic range of the San Bernardino flying squirrel lies within the high-elevation forests of the San Bernardino and San Jacinto Mountain ranges of San Bernardino and Riverside counties in southern California (Figure 4) (Grinnell 1908, Grinnell and Swarth 1913, Grinnell 1933, Sumner 1927, Butler et al. 1991). Its habitat is encompassed largely within the San Bernardino National Forest (Butler et al. 1991). However, this subspecies appears to be extirpated or near-extirpated from the San Jacinto Mountains, as discussed in detail below. It is still extant in the San Bernardino Mountains as confirmed by recent sightings and museum records from multiple localities in this mountain range. Vaughan (1954) reported this subspecies in the San Gabriel Mountains, but there is no documented evidence to support this claim.

Figure 4. Museum records for the San Bernardino flying squirrel. Red circles indicate general area of collection accompanied by dates of collection followed by the number of specimens collected on each date in parentheses. Data from the California Natural Diversity Database.

San Bernardino flying squirrel museum records from the CNDDB

⬭ Year (# collections)

The most comprehensive information on the distribution of the San Bernardino flying squirrel in the San Bernardino Mountains comes from collection locations of California spotted owl (*Strix occidentalis occidentalis*) pellets containing flying squirrel remains. Based on a study

that found 172 flying squirrel occurrences in pellets from 43 California spotted owl nest sites collected between 1987-1991, habitat presumed occupied by flying squirrels within the San Bernardino Mountains comprises a swath from Sugarpine Mountain and Lake Silverwood in the west, east across the spine of the mountain range to the Lake Arrowhead and Big Bear Lake regions, then moving south to include parts of San Gorgonio Wilderness down to the Thurman Flats area along Mill Creek and the Raywood Flat area along the Gorgonio River (Butler et al. 1991). This study found flying squirrel remains in pellets collected between 3,960 to 8,140 feet (1207-2481 meters) with a mean of 6,077 feet (1852 meters) (Butler et al. 1991). Based on this information, it is thought that the San Bernardino flying squirrel occurs at elevations between 4,000 to 8,400 feet in the San Bernardino Mountains (U.S. Forest Service 2005d).

Additional distributional information for the San Bernardino Mountains comes from recent museum records, squirrel captures during trapping studies, and anecdotal reports. Museum records indicate that flying squirrels have been collected between 4,600 and 7,550 feet in elevation in the San Bernardino Mountains at Cedar Pines Park, Crestline, Harrison Mountain, Little Green Valley, Bluff Lake, Big Bear Lake, and Camp Angeles, with the most recent collection in 2001 near Harrison Mountain (Figure 4) (CNDDB 2010). A trapping study in the Mountaintop Ranger District in 1990-1991 was conducted on four plots on or adjacent to the Bear Mountain Ski Area in addition to 5 plots near Snow Valley Ski Area, Ski Green Valley, Little Green Valley Camp, Little Bear Springs, and Grays Peak, all near where flying squirrels were found in spotted owl pellets except for Ski Green Valley (Butler et al. 1991). Nine squirrels were caught west of Bear Mountain, one squirrel was caught in Deer Canyon, and nine squirrels were caught in Little Green Valley (Butler et al. 1991). A smaller trapping effort in 1998 caught six flying squirrels at a site near Fawnskin and three squirrels at a site near Bear Mountain (Driessen et al. 1998). Anecdotal reports of flying squirrels in residential areas throughout Big Bear, Angeles Oaks, Fawnskin, and Lake Arrowhead include observations at birdfeeders under porch lights and flying squirrels caught by house cats (U.S. Forest Service 2005d).

The distribution of the San Bernardino flying squirrel in the San Jacinto Mountains is not well documented, although museum records from the early 1900s indicate that the flying squirrel was present in the upper elevation forests near the town of Idyllwild. Grinnell and Swarth (1913) captured one flying squirrel in the San Jacinto Mountains in Strawberry Valley near Idyllwild at 6,000 feet elevation while camped from July 4-15, 1908. Although they captured only one squirrel, they noted the presence of flying squirrels almost every night suggesting that the subspecies was not uncommon: "While camped here, July 4 to 15, we heard almost every night the chuckling of *Sciuropterus* in the black oaks and yellow pines around our beds." (p. 328). The California Natural Diversity Database reports collections of two female and three male flying squirrels during 22-28 September, 1916, by L. Wyman from the "San Jacinto Mountains, Idyllwild" (CNDDB 2010). Anecdotal sightings of San Bernardino flying squirrels in Idyllwild reportedly occurred through the 1970s and 1980s. In the 1970s the local Idyllwild newspaper included a picture of a child holding a flying squirrel that was reportedly caught in Fern Valley. As detailed below (Population Status and Trends), recent studies suggest that the San Bernardino flying squirrel is extirpated or near-extirpated in the San Jacinto Mountains.

Unlike most *G. sabrinus* subspecies which are distributed across relatively continuous geographic ranges, the San Bernardino flying squirrel is isolated on habitat patches in the San

Bernardino and historically the San Jacinto Mountain ranges. It is separated from populations in the southern Sierra Nevada Mountains by the Mojave Desert by more than 150 miles (Butler et al. 1991). Movements between mountain ranges are obstructed by the Cajon Pass between the San Gabriel and San Bernardino Mountains and the San Gorgonio Pass/Banning Pass between the San Bernardino and San Jacinto Mountains. The San Bernardino flying squirrel's isolated distribution is similar to that of the federally listed subspecies, the Carolina northern flying squirrel (*G. s. coloratus*) (U.S. Forest Service 2005d).

IV.   Habitat Associations

The San Bernardino flying squirrel, like other northern flying squirrel subspecies, appears to have specific habitat requirements, including associations with mature forests, large trees, closed canopy, large snags, downed woody debris, and riparian areas. The section below describes known habitat associations for the San Bernardino flying squirrel followed by a discussion of habitat associations found for other northern flying squirrel subspecies in California and the western United States that provide additional insights.

A.   San Bernardino Flying Squirrel Habitat Associations

The San Bernardino flying squirrel occurs in white fir (*Abies concolor*) and Jeffrey pine (*Pinus jeffreyi*) mixed conifer forests with black oak (*Quercus kelloggii*) components at higher elevations (Rhoads 1897, Sumner 1927, Grinnell 1933, Butler et al. 1991). Rhoads (1897) described the San Bernardino flying squirrel in the San Bernardino Mountains as inhabiting the "mixed pine and oak belt of the mountains" (p. 323), where all squirrels were taken from "dead pine trees or stumps, in holes made by the red-shafted flicker, from 10 to 30 feet from the ground" (p. 324). Summer (1927) reported the flying squirrel's habitat in the San Bernardino Mountains as white fir and black oak woodlands. Grinnell (1933) stated that the flying squirrel "inhabits woods where black oaks or white firs are conspicuously present" (p. 136). In the San Jacinto Mountains, Grinnell and Swarth (1913) reported the squirrels in yellow pines and black oaks.

Studies conducted on the Mountaintop Ranger District in the San Bernardino Mountains in 1990-1991 (Butler et al. 1991) indicate that San Bernardino flying squirrel habitat at successful trapping sites was characterized by mature to over-mature mixed conifer forests with high numbers snags and downed logs, a relatively closed canopy, relatively open habitat lacking a dense undergrowth component, a relatively heavy duff layer, and moister microhabitats near riparian areas (U.S. Forest Service 2005d). The dominant tree species included white fir and Jeffrey pine and included black oaks (U.S. Forest Service 2005d). All successful trapping sites were on north-facing or northeast-facing slopes which are generally cooler and moister than surrounding areas (U.S. Forest Service 2005d). All sites also had water sources in close proximity such as ephemeral streams, springs, or intermittent streams with riparian vegetation (U.S. Forest Service 2005d). Stephenson and Calcarone (1999) reported San Bernardino flying squirrel habitat as follows:

> The San Bernardino flying squirrel is known from mid- to upper-elevation
> coniferous forest habitats. Distributional information from spotted owl pellets

indicates that flying squirrels do not inhabit lower montane bigcone Douglas-fir/canyon live oak forests. Flying squirrels use cavities in large trees, snags, and logs for cover. Habitats are typically mature, dense conifer forest, particularly those containing white fir, in close proximity to riparian areas (Zeiner et al. 1990b). (Stephenson and Calcarone 1999: 204).

Studies of nest tree selection are limited for San Bernardino flying squirrels. However, the study conducted by the Mountaintop Ranger District in the San Bernardino Mountains in 1991 indicates that San Bernardino flying squirrels use tree cavities and stick nests in large live trees and large snags of white fir and Jeffrey pine (Butler et al. 1991). Eight of nine trees with den sites or stick nests were over 100 feet (30 meters) tall with a diameter at breast height (DBH) between 32 to 44 inches (Butler et al. 1991: Table 4). Of four trees with stick nests, two were white fir and two were Jeffrey pine. Of five trees with cavity nests, three were white fir (two snags) while two were Jeffrey pine (Butler et al. 1991: Table 4).

B.   Northern Flying Squirrel Habitat Associations

Research on habitat associations for other northern flying squirrel subspecies in California and the Pacific Northwest provides insights into the habitat requirements of *G. s. californicus*. These studies have found that the local abundance of northern flying squirrels is directly related to habitat features typical of old-growth and mature forest (Smith 2007). As detailed below, flying squirrel density is positively correlated with the density of large-diameter trees (Volz 1986, Witt 1992, Carey 1995, Waters and Zabel 1995), canopy cover (Lehmkuhl et al. 2006), large snags (Volz 1986, Carey 1995), coarse woody debris, particularly decayed downed logs (Carey 1995, 2000, Pyare and Longland 2002, Meyer et al. 2007a), understory cover (Pyare and Longland 2002), hypogeous mycorrhizal fungi (truffle) abundance (Waters and Zabel 1995, Lehmkuhl et al. 2006), and proximity to riparian areas (Meyer et al. 2007a).

Studies in the Pacific Northwest and British Columbia found that flying squirrels occur in greater abundance in old-growth and mature forests compared with second-growth and younger, managed forests lacking old-growth habitat components (Witt 1992, Carey 1995, Lehmkuhl et al. 2006, Herbers and Klenner 2007). For example, Carey (1995) found that *G. sabrinus* in the Pacific Northwest were twice as abundant in old forests than in young, managed forests without old-forest legacies (large live trees, large snags and large, decaying fallen trees). Herbers and Klenner (2007) found that northern flying squirrel density averaged 60% lower in harvested forests of all harvest intensity and logging pattern types from one year and up to four years after logging in mature inland Douglas fir forests in south-central British Columbia.

Studies in California's Sierra Nevada Mountains found higher northern flying squirrel densities in association with older forests (Waters and Zabel 1995), higher truffle abundance (Waters and Zabel 1995, Pyare and Longland 2002), greater understory cover (Pyare and Longland 2002), shorter distances to riparian areas (Meyer et al. 2007a), greater litter depth in burned forests (Meyer et al. 2007a), and higher canopy cover in thinned forests (Meyer et al. 2007a). Specifically, Waters and Zabel (1995) found that flying squirrel densities in Lassen National Forest in northeastern California were significantly greater in old fir stands (3.29 squirrels/ha) compared to young stands (2.28 squirrels/ha) and shelterwood-logged stands (0.37 squirrels/ ha). Low densities in shelterwood cut stands (e.g. ~14 trees per acre and 55 foot

spacing between 100-foot trees) suggested that logging and intensive site preparation negatively affected flying squirrel populations (Waters and Zabel 1995). Meyer et al. (2007a) examined the effects of prescribed burning and mechanical thinning on northern flying squirrels in the mixed conifer forest of the southern Sierra Nevada by characterizing the microhabitat associations in burned, thinned and control stands. The probability of flying squirrel capture increased with decreasing distance to a perennial creek and increasing litter depth in untreated stands, increased canopy cover in thinned stands, and increased litter depth in burned stands (Meyer et al. 2007). Pyare and Longland (2002) found that higher flying squirrel densities in old growth forest in the Sierra Nevada were associated with truffle diggings, higher truffle densities, and greater understory cover. The authors hypothesized that squirrels chose old-growth forests based on aboveground forest characteristics, while their microhabitat use was influenced by fine-scale changes in the availability of highly preferred and ephemeral truffles.

Habitat associations of *G. sabrinus* were scale and context dependent in some cases. In drier forest of the Sierra Nevada, northern flying squirrel densities were higher in closer proximity to streams (Meyer et al. 2005a, 2007a), while in more mesic forests, densities were not as linked to riparian areas (Meyer et al. 2007b).

C.   Microhabitat Associations

A large body of research suggests that northern flying squirrels are associated with microhabitat features of old-growth forests because these features provide refuge from predators, increase the relative availability of truffle and arboreal lichen biomass, provide nest and dens substrates, and enhance movement, as detailed below.

Large-diameter trees. Large-diameter trees provide northern flying squirrels with habitat suitable for gliding, sites for cavity nesting, and food sources such as lichens and fungi (Smith 2007). In relation to gliding, large-diameter trees appear to provide better landing pads, and launching from taller trees allows squirrels to glide farther than from smaller ones (Williams et al. 1992). Large trees produce large-diameter snags that are important for flying squirrel nesting sites (Volz 1986). In terms of food resources, large trees support distinctive communities of epiphytic lichens on their upper branches which provide an important winter food source for flying squirrels (Volz 1986). Hypogeous mycorrhizae also appear to achieve their greatest abundance (total biomass) and highest diversity in old growth, as compared to younger, managed forests (North et al. 1997).

Canopy cover. Greater canopy cover is thought to allow flying squirrels to achieve more efficient movement through the canopy, provide protection from predators, and provide a sheltered, moist microclimate that is more conducive to the growth of truffles and the use of stick nests by flying squirrels (Carey 2000). Canopy connectivity that has been reduced by forest thinning may impede travel through the canopy and force squirrels to use gliding more often, potentially increasing their exposure to predation by owls (Carey 2000). Since stick nests are more vulnerable to weather extremes like heavy precipitation and wind, canopy cover provides a more sheltered environment that may facilitate the use of external nests (Carey 2000).

Large snags. Flying squirrels use cavities in snags for nests and dens (Volz 1986). Large snags may be especially important for providing cavities of sufficient size for females to rear young and for multiple squirrels to share a denning cavity during inclement winter weather.

Coarse woody debris and decayed logs. The activity, abundance, and carrying capacities of flying squirrels appear to be tied to coarse woody debris through its influence on promoting the production of fruiting bodies of hypogeous ectomycorrhizal fungi, and by providing protective cover from predators (Carey 2000, Meyer and North 2005). Truffles (and most fungi) favor cool, mesic to wet microenvironments with relatively large amounts of decayed logs or coarse woody debris across the forest floor (Amaranthus et al. 1994). Decayed logs and organic litter provide important reservoirs of moisture and nutrients for fungi, especially in forests where soils are relatively dry (Pyare and Longland 2002, Lehmkuhl et al. 2004, Meyer et al. 2007a). Flying squirrels appear to associate decaying organic debris, such as logs, with truffles; flying squirrels in captivity tend to forage near logs for buried truffles (Pyare and Longland 2001b, a). The mean density of down logs and snags generally increases with stand age (Christensen et al. 2008), illustrating the importance of mature forests for flying squirrels. In contrast, thinned forests and legacy retention forests are depauperate in coarse woody debris compared to unlogged old-growth forests (Carey 2000).

Understory. Understory cover is thought to provide flying squirrels with protective cover from aerial predators like owls, especially when squirrels are foraging for truffles and other food items on the forest floor (Pyare and Longland 2002). Understory cover is also thought to influence the occurrence of mammalian predators. In the Pacific Northwest, heavy understory development in the thinned forest favors ermine (*Mustela erminea*) which prey on small rodents, whereas an open forest floor favors long-tailed weasels (*M. frenata*) which are more likely than ermine to prey on flying squirrels (Carey 2000).

Riparian areas. Riparian areas including intermittent and perennial creeks appear to foster greater production of truffles (Meyer and North 2005) and provide important resources for northern flying squirrels including drinking water particularly in dry summer months (Meyer et al. 2007a), a higher availability of secondary food items such as fruits and seeds (Meyer et al. 2007a), more stable temperatures (Smith 2007), and more friable soils for digging (Smith 2007). A study in old-growth mixed conifer forest in the southern Sierra Nevada found that riparian sites near a perennial creek (where soil moisture was higher) had greater frequency, biomass, and species richness of truffles compared to upland sites in spring and summer (Meyer and North 2005). Truffle biomass was also positively correlated with June-August rainfall in upland but not riparian sites, indicating that soil moisture may limit truffle biomass during dry summer months in areas away from riparian zones (Meyer and North 2005).

D.   Habitat Associations for Nests and Dens

Northern flying squirrels make maternal nests and dens of two types: external stick nests (dreys) constructed on branches and boles, and cavity nests in snags and live trees in natural holes or those made by woodpeckers (Smith 2007). External nests are typically made of intertwining twigs, bark, roots, grasses, and lichens, with one or two entrances, and have also been found in witches' broom, a branch deformity caused by dwarf mistletoe (*Arceuthobium*)

and spruce rust (*Chrysomyxa arctostaphyli*) (Smith 2007). Cavities appear to provide better protection from inclement weather like wind and heavy precipitation, especially during winter months when squirrels are at higher risk of hyperthermia (Smith 2007). Cavities may also provide better protection from predators, which may explain why females almost exclusively use cavities for rearing young when they are available (Smith 2007). Suitable dens are vital for raising young and providing thermoregulation, refuge, storage and feeding sites (Volz 1986).

Across regions and forest types, northern flying squirrels appear to select den trees (including both live trees and snags) that are older, larger, and taller than what is randomly available throughout the stand (Meyer et al. 2005a, Meyer et al. 2007b, Smith 2007). Larger live trees and snags likely provide more suitable cavities, greater thermal insulation, reduced predation risk, and greater biomass of arboreal forage lichens (Meyer et al. 2005a). Northern flying squirrels also may select nest and den trees according to the availability of nearby food resources, and the proximity to a permanent water source (Meyer et al. 2005a). A study of nest-tree selection in a xeric old-growth, mixed conifer and red fir forest of the southern Sierra Nevada of California found that flying squirrels appear to require large trees and snags within 150 m of perennial creeks for their critical habitat needs (Myer et al. 2005a). Flying squirrels selected nest trees that were larger in diameter and taller than random trees, and preferred nest trees in close proximity to riparian habitat (Meyer et al. 2005a). Meyer et al. (2005a) suggested that in xeric forests, nest trees near riparian zones may be especially important for squirrels because they offer greater nearby abundance of food (i.e., truffles, canopy forage lichens) than trees outside riparian zones.

E.   **Habitat Fragmentation**

Northern flying squirrels appear to be adversely affected by habitat fragmentation which decreases habitat quantity and quality, constrains the movement of individuals, and impedes the colonization of unoccupied habitat patches (Smith 2007). Rosenberg and Raphael (1984) cited in Smith (2007) studied the effects of fragmentation in mature mixed-evergreen forests in northwestern California, and found that the frequency of occurrence of northern flying squirrels increased with stand size. Approximately 75 percent of stands over 100 hectares had flying squirrels whereas only one stand less than 20 hectares had a flying squirrel. They also found a negative correlation between frequency of occurrence and percentage of insularity (percentage of stand perimeter surrounded by clearcut edge), where more isolated patches had lower squirrel occurrence. A sharp decline occurred in stands with over 75 percent insularity. Wilson (2003) cited in Smith (2007) found that large clear-cuts pose barriers to *G. sabrinus* undergoing natal dispersal or searching for females for at least 20 to 35 years after harvest. In southeastern Alaska, movement rates through recent clear-cuts averaged an order of magnitude lower than in old-growth forest, while movement rates through young, second-growth stands were half that in old-growth forest (Smith 2007).

V.   **Home Range, Movement, Dispersal**

Home range size estimates vary among populations of northern flying squirrels and are likely associated with habitat quality and food resources (Smith 2007). There are no data available for home range size for San Bernardino flying squirrels. Reported home ranges for

other subspecies vary in size from 29.3 ha in the Sierra Nevada (Wilson et al. 2008), 3.4 to 4.9 ha in Oregon (Witt 1992), 5.9 ha for males and 3.9 ha for females in Oregon (Martin and Anthony 1999), and 54.2 ha for males and 15.3 ha for females for the Virginia northern flying squirrel (Menzel et al. 2006).

Studies using mark–recapture and radiotelemetry indicate that average daily movements for northern flying squirrels are typically less than 100 m and tend to differ little between sexes or among habitats (Smith 2007). Although core home ranges and average daily movements are relatively small, individuals can make extensive daily movements of several kilometers when searching for food or mates (Weigl 2007). Daily movements by males during the breeding season can exceed 1.5 km (Weigl et al. 1999). For the San Bernardino flying squirrel, one male flying squirrel was documented moving at least 900 feet (274 m) (Butler et al. 1991). Likewise, juveniles can make daily movements of several kilometers while dispersing from natal areas (Smith 2007). When maximum movements are taken into account, flying squirrels likely use larger expanses of habitat than commonly reported (Weigl 2007).

VI.   Diet and Forging Behavior

An analysis of San Bernardino flying squirrel diet based on fecal pellets collected from squirrels captured in the San Bernardino Mountains in the summer of 1991 indicated that squirrels consumed hypogeous fungi from three genera: *Melanogaster*, *Hymenogaster*, and *Gymnomyces* (Butler et al. 1991). All of these genera are truffles known to form ectomycorrhizal symbiotic relationships with tree species (Butler et al. 1991). Other materials found in fecal pellets in descending order of abundance included Jeffrey pine pollen, unidentified dicot plant material (leaf parts, trichomes), monocot plant material, unidentified spores from epigeous fungi (associated with decomposing wood and litter), and insect parts (Butler et al. 1991).

Studies of other subspecies indicate that the northern flying squirrel is primarily mycophagous and that its diet varies seasonally (Smith 2007). The northern flying squirrel in California consumes primarily hypogeous mycorrhizal fungi (truffles) in summer and arboreal lichens (hair moss) during winter when snow covers the more nutritious, high-quality fungi (McKeever 1960, Hall 1991, Waters and Zabel 1995, Smith 2007). Hall (1991) hypothesized that northern flying squirrels harvest fungi during snow-free months and cache them for consumption in the winter. Northern flying squirrels are hind-gut fermenters (all other squirrels except mycophagists are fore-gut) which allows them to extract nutrients from the lignin in fungus. Northern flying squirrels are also known to eat a variety of secondary foods including seeds, nuts, insects, bird eggs and nestlings, and tree sap (Wells-Gosling and Heaney 1984).

Northern flying squirrels appear to spend considerable time foraging on the ground searching for and digging for truffle fruiting bodies which generally occur 5 to 15 cm below the forest floor (Smith 2007). Field and lab experiments indicate that flying squirrels may detect truffles through three interacting mechanisms: ability to recall locations of productive food patches, olfactory capability that allows them to detect hypogeous fungi with specific chemical signatures (i.e. highly volatile compounds), and microhabitat features (coarse woody debris, downed logs, animal diggings) that serve as fine-scale cues for locating sporocarps (Pyare and Longland 2001a). The expected benefits of timely visits to fungal-rich microhabitats are quite

high because >80% of locations with fruiting bodies in one year have sporocarps present at about the same time in following years (Pyare and Longland 2001a). Studies of movements and patterns of habitat use suggest that northern flying squirrels track short-term temporal and spatial dynamics of truffle fruiting bodies (Smith 2007).

VII. Reproduction

The northern flying squirrel has a low reproductive rate for a small mammal (Weigel 2007). Northern flying squirrels typically produce one litter each year in late spring to early summer (Well-Gosling and Heaney 1984). The gestation period is relatively long at between 37 and 42 days and the litter averages two or three young (Smith 2007). Female flying squirrels are known to seek out maternal dens 1 to 2 weeks before parturition (Wells-Gosling and Heaney 1984). Females alone care for young. During gestation and lactation females appear to invest a substantial amount of energy in each offspring (Smith 2007).

Flying squirrels are born hairless and altricial with closed eyes and ears and fused toes (Wells-Gosling and Heaney 1984). They weigh 5 to 6 grams at birth and measure ~70 mm in total length (Wells-Gosling and Heaney 1984). At 40 days old, the young can walk and begin to leave the nest (Wells-Gosling and Heaney 1984). Weaning occurring at two months old, but juveniles may remain with the mother for some time after weaning (Wells-Gosling and Heaney 1984). In an Oregon study, young either dispersed in autumn or spent the winter in the nest with their mother (Williams et al. 1992).

Little is known about reproduction in the San Bernardino flying squirrel. During a trapping study in the San Bernardino Mountains in 1991, individuals with enlarged testes and mammaries were caught during late May to late July, indicating that reproductive activities were occurring during these months (Butler et al. 1991). In a 1998 trapping effort in the San Bernardino Mountains, northern flying squirrels caught in the last week of June and first week of July were thought to be offspring of that year based on their weights (Driessen et al.1998). These findings suggest that babies may be born in April or May.

VIII. Predators, Competitors, and Disease

Known avian predators of the northern flying squirrel include barn owls (*Tylo alba*), barred owls (*Strix varia*), great horned owls (*Bubo virginianus*), goshawks (*Accipiter gentilis*), red-tailed hawks (*Buteo jamaicensis*), and spotted owls (*Strix occidentalis*) (Wells-Gosling and Heaney 1984). In the Sierra Nevada, flying squirrels are the spotted owl's primary prey at high elevations (Smith et al. 1999). However, in the San Bernardino Mountains, flying squirrels were a less common prey (2.1% by frequency, 3.0% by biomass) of California spotted owls, possibly due to lower abundance than in the Sierra Nevada (Smith et al. 1999). Known mammalian predators include martens (*Martes americana*), domestic house cats (*Felis catus*), wolves (*Canis lupus*), lynxes (*Lynx lynx*), weasels (*Mustela*), and foxes (*Vulpes and Urocyon*) (Wells-Gosling and Heaney 1984).

Potential competitors of the San Bernardino flying squirrel include other small mammals which also eat fungi, including the western grey squirrel (*Sciurus griseus*) and lodgepole chipmunk (*Tamias speciosus*). In the southern Sierra Nevada, substantial dietary overlap of fungi

occurs throughout the year between *G. sabrinus* and *T speciosus* particularly in frequently consumed taxa (Meyer et al. 2005b).

Numerous external and internal parasites have been recorded from northern flying squirrels (Wells-Gosling and Heaney 1984). In northeastern Oregon, an examination of 29 flying squirrel nests revealed 35 taxa of ectoparasites, whereas 29 taxa of ectoparasites were found on the 31 squirrels examined (Wells-Gosling and Heaney 1984). Ectoparasites include numerous species of fleas, lice, mites and ticks (Wells-Gosling and Heaney 1984, Foley et al. 2007). Endoparasites include nematodes, cestodes, and protozoa (Wells-Gosling and Heaney 1984). A recent study found evidence for infection of northern flying squirrels from Humboldt county, California, by a rickettsial pathogen, *Anaplasma phagocytophilum* (Foley et al. 2007). Additionally, infection by the nematode *Strongyloides robustus* was observed to cause a massive die-off of captured northern flying squirrels in North Carolina (Weigl 2007).

IX.   Ecological Role

The northern flying squirrel plays a key ecological role in maintaining forest health and biodiversity by dispersing truffles (ectomycorrhizal hypogeous fungal sporocarps) (Pyare and Longland 2001b, Meyer et al. 2005b), and providing an important food resource for several predators (Smith 2007). Northern flying squirrels facilitate the obligate symbiotic relationship between mycorrhizal fungi and dominant tree species by digging up and consuming the fungal sporocarps and dispersing the spores across the forest floor through their feces. The spores germinate and establish new colonies or contribute new genetic material to existing colonies. Fungal spores form symbiotic relationships with the roots of conifers, and improve the conifers' ability to absorb water and nutrients. Northern flying squirrels may help inoculate disturbed areas such as burns with mycorrhizae, thereby playing an important role in forest regeneration. Flying squirrels also are important dispersers of epigeous sporocarps (mushrooms) and canopy forage lichens (*Bryoria* spp.) (Meyer et al. 2007a).

X.   Demographic Rates

No published data are available on demographic rates of the San Bernardino flying squirrel. However, information from other subspecies of the northern flying squirrel provides insights. The northern flying squirrel has life history traits and demographic rates characteristic a species with a "slow" or K-selected life history strategy. It is relatively long-lived with longevity of seven years or more, it can exhibit delayed development and a delayed age of first reproduction, it is a seasonal breeder with small litters of 2 to 3 young on average, it has a relatively long gestation period (37-42 days), females appear to invest substantial energy into each offspring during gestation and lactation to produce larger young, it experiences density-dependent population growth, and it inhabits late-seral habitat (Smith 2007).

Sex ratio. A 13-year study of northern flying squirrels by Villa et al. (1999) in the Pacific Northwest found that the sex ratio of populations in all regions was 1:1 in fall. The sex ratio of juveniles captured in nest boxes was 1:1. Sex ratio did not differ among age classes and appeared to be maintained as cohorts aged.

Age of first breeding. Female and male flying squirrels appear to become sexually mature at one year of age, although females in some populations exhibited delayed onset of maturation. Villa et al. (1999) found that males in the Pacific Northwest became reproductively mature in the first January after their birth year (i.e. at one-year-old). Most females (90%) in the Puget Trough population reproduced at one-year old while fewer (39 percent) one-year old to two-year old females in the Coast Range population showed signs of active reproduction (estrus, pregnancy, lactation, or post-lactation). Villa et al. (1999) suggested that the onset of reproductive activity in one-year-old females is density dependent and delayed in high-density populations. They suggested that differences in diet and climatic conditions influence the onset of reproduction in these populations.

Reproductive success. No information is available on reproductive success.

Survival. Several studies of northern flying squirrels indicate that survival can vary by age class, site, and stand type. Annual survival for the Prince of Wales flying squirrel (*Glaucomys sabrinus griseifrons*) in temperate rain forest of southeastern Alaska averaged 0.46-0.47 (Smith and Nichols 2003, Smith and Person 2007). In the eastern Washington Cascades Range, annual survival rates of northern flying squirrels ranged from 0.45 to 0.59 and did not vary across stand types sampled (Lehmkuhl et al. 2006). In contrast, Villa et al. (1999) found that juvenile survival (proportion of squirrels surviving past 7 months) was highest in old-growth forest (0.54) and lowest in young forest (0.07) in the Oregon Coast Range; adult survival in old-growth forest was 0.33 from one to two years old, 0.58 from two to three years old, and 0.18 from three to four years old.

Longevity. Emerging evidence suggests the northern flying squirrel is relatively long-lived with a lifespan of 4-7 years (Weigl 2007). Additionally, multiple individuals older than 7 years have been reported in the Pacific Northwest (Villa et al. 1999).

POPULATION STATUS AND TRENDS

The best available information indicates that the San Bernardino flying squirrel persists in the San Bernardino Mountains but is extirpated or near-extirpated (i.e. at a low population size) in the San Jacinto Mountains. No abundance estimates are available for the San Bernardino Mountain population. However, a density estimate from 1991 from the Big Bear Lake region is relatively low compared to estimates for northern flying squirrel subspecies in northern California and Oregon, and is close to densities observed for the federally endangered Carolina northern flying squirrel (*G. s. coloratus*).

The San Bernardino flying squirrel is designated a Species of Special Concern by the California Department of Fish and Game and as a Sensitive Species by the U.S Forest Service (CDFG 2009). This species is included on the Special Concern list because of its occurrence in restricted, disjunct populations, the comparatively low densities of individuals in populations that have been studied, and ongoing habitat fragmentation as a result of development and forest practices within the species range (Brylski 1998).

I.   Current Abundance

The best available information on the abundance of the San Bernardino flying squirrel in the San Bernardino Mountains is from trapping efforts in the Mountaintop Ranger District in 1990-1991 (Butler et al. 1991). Trapping occurred in four grids on and adjacent to Bear Mountain ski resort (Butler et al. 1991). Captures occurred on three grids, for a total of 13 flying squirrels in 14361 functional trap-nights (FTN) or 0.92 squirrels per 1000 FTN. The greatest number of individuals (nine) was captured in Grid 2 on the west side of Bear Mountain Ski Area (3.6 squirrels per 1000 FTN). These capture rates are relatively low. In the most successful trapping area (Grid 2), Butler et al. (1991) calculated a density estimate of 0.94 squirrels per hectare using first-order Jacknife estimate from program CAPTURE. Although the authors called for further studies to validate this density estimate, it represents the best available information.

The density estimate of 0.94 from the Bear Mountain region of the San Bernardino Mountains is relatively low compared to density estimates ranging from 0.9 to 3.3 squirrels per hectare for northern flying squirrel populations in California and Oregon (Brylski 1998). These density estimates vary depending on forest type, seral stage, and management history, with higher densities typically occurring in old-growth and mature forests. In a study in northern California, 3.29 flying squirrels were found per hectare in old-growth stands, 2.28 per hectare in second-growth stands, and 0.37 per hectare in shelterwood stands (Waters and Zabel 1995). Densities in Oregon ranged from 3.07 squirrels per hectare in old-growth forests to 1.41 squirrels per hectare in mature stands (Volz 1986). Another study in Oregon by Rosenberg and Anthony (1992) found 2.3 flying squirrels per hectare in old-growth Douglas-fir and 2.0 squirrels per hectare in second-growth Douglas-fir. In Oregon, Carey (2000) reported mean densities of 2.3 and 1.9 squirrels per hectare in old-growth Douglas-fir and 1.9 and 0.9 per hectare in second-growth Douglas-fir in the Western Cascades and Coast Range, respectively. Population densities for the federally endangered Carolina northern flying squirrel (*G. s. coloratus*) are 0.33-0.5 flying squirrels/ha (1 squirrel/2-3 ha) (U.S. Fish and Wildlife Service (1990) cited in U.S. Forest Service (2005d)). Thus the estimated population density of *G. s. californicus* is more comparable to densities observed for *G. s. coloratus* (Brylski 1998).

Capture success for San Bernardino flying squirrel in the nine grids where Butler et al. (1991) trapped lends additional insights into population abundance across this region. In the Bear Mountain region, trapping occurred in two grids in Deer Canyon, a site completely insulated due to ski trails surrounding all sides, and two grids on the west side of Bear Mountain which were not isolated. The capture rate in the two Deer Canyon trapping grids in 1991 was 0 and 0.3 squirrels per 1000 FTN compared to 3.6 and 2.5 squirrels per 1000 FTN in the non-isolated sites (Butler et al. 1991). Butler et al. (1991) suggested that the "the island-like nature of forested habitat currently there [in Deer Canyon] may have already excluded flying squirrels from using this area" (p. 14). This finding indicates that flying squirrels likely avoid isolated, island-like habitat patches, consistent with studies that report the negative effects of habitat fragmentation on the species. Of the remaining five grids (Snow Valley Ski Area, Ski Green Valley, Little Green Valley Camp, Little Bear Springs, and Grays Peak), four of which were sited where flying squirrels were found in spotted owl pellets, flying squirrels were captured in just one grid—Little Green Valley—where nine squirrels were caught. The failure to capture squirrels in four of five grids is suggestive of low abundance. Overall, the best available information suggests that flying

squirrels may be a low population abundance levels in the San Bernardino Mountains. As summarized by the U.S. Forest Service:

> Comparison between San Bernardino flying squirrel study data with those from studies of two endangered Appalachian subspecies of flying squirrels suggests that the San Bernardino subspecies may be similarly rare and isolated in localized populations (Butler and others 1991). The pattern of captures, recaptures, and rate of captures/trap night appeared to be similar to the Appalachian subspecies (Butler and others 1991). These comparisons may indicate that this subspecies is in fact in jeopardy. (U.S. Forest Service 2005d)

II.   Trends in Abundance and Distribution

The best available information from museum records, trapping efforts, nest box studies, owl pellet analyses, and anecdotal observations suggests that the San Bernardino flying squirrel has been extirpated from the San Jacinto Mountains or persists at very low abundance. As described above, San Bernardino flying squirrels were documented in the Idyllwild region of the San Jacinto Mountains through collections in 1908 and 1916 (Grinnell and Swarth 1913, CNDDB 2010). Anecdotal sightings became more infrequent, and the last confirmed sightings appear to be from the 1970s and 1980s. In addition, Stephenson and Calcarone (1999) reported that "analysis of a substantial number of owl pellets from the San Jacinto Mountains did not turn up any flying squirrel remains (W. LaHaye, unpubl. data)" (p. 204). Several recent studies that have attempted to detect San Bernardino flying squirrels in the San Jacinto Mountains have not found evidence of flying squirrel presence. U.S. Forest Service studies have not found San Bernardino flying squirrel remains in owl pellets collected from the San Jacinto Mountains in the early 2000s; nor were flying squirrels detected in a trapping effort for San Bernardino flying squirrels in 2007 in the San Jacinto Wilderness or in a nest box study from 2007 to present in the San Jacinto Wilderness (Anne Poopatanapong, District Wildlife Biologist, San Bernardino National Forest - Idyllwild Ranger Station, personal communication, August 2010). Small mammal trapping efforts in the University of California James Reserve in the San Jacinto Mountains have not detected San Bernardino flying squirrels. Additionally, the San Jacinto Centennial Resurvey that began in 2008 has not detected San Bernardino flying squirrels at any site sampled so far (http://www.sdnhm.org/research/sanjacinto/index.php). The San Diego Natural History Museum, in cooperation with the University of California, Berkeley and Riverside, is resampling sites in the San Jacinto Mountains that were visited and catalogued by Grinnell and colleagues in 1908 in order to document changes to the region's wildlife over the past century. Although sampling of historic sites is still in progress through 2013, San Jacinto Centennial Resurvey biologists have not yet detected San Bernardino flying squirrels, including lack of detections from traps and camera traps in areas of good quality habitat—Tahquitz Valley, Round Valley, May Valley, and Fuller's Mill (Scott Tremor, Mammalogist, Department of Birds and Mammals, San Diego Natural History Museum, personal communication, August 2010).

Trends in abundance and distribution of the San Bernardino flying squirrel in the San Bernardino Mountains are unknown. The larger habitat area and the greater number of museum collections from the San Bernardino Mountains in the early-to-mid 1900s compared to the San Jacintos (Figure 4, CNDDB 2010) suggests that San Bernardino flying squirrels may have been

comparatively more common and widespread in the San Bernardino Mountains, although this difference could also reflect potentially greater trapping effort in the San Bernardinos. An account by Sumner (1927) suggested "relative scarcity" in the San Bernardinos in the 1920s based on the low capture rates:

> Considering the small number of this species previously procured, and in view of the fact that to obtain the number which we did, most of our eighty traps were in continuous operation for sixty-nine days over a line some twelve miles long, entailing a total distance of several hundred miles walked during the summer (although not more than eight miles were worked at any one time), it appears that the San Bernardino flying squirrels are very difficult to trap, not because they are particularly wary (sometimes we caught them the first night in a new set), but because of their relative scarcity, their arboreal habits, which do not lend to ordinary trapping methods, and perhaps because an ideal bait has not yet been discovered. (Sumner 1927: 316).

Overall, only two studies have been conducted in the San Bernardino Mountains to understand presence and/or abundance—the Butler et al. (1991) study in 1990-1991 and the minimal trapping effort in 1998 (Driessen et al. 1998) in the Mountaintop Ranger District. However, no studies have been conducted since to monitor trends in abundance and distribution.

THE SAN BERNARDINO FLYING SQUIRREL WARRANTS LISTING UNDER THE ESA

I.   Criteria for Listing Species as Endangered or Threatened

Under the ESA, 16 U.S.C. § 1533(a)(1), USFWS is required to list a species for protection if it is in danger of extinction or threatened by possible extinction in all or a significant portion of its range. In making such a determination, USFWS must analyze the species' status in light of five statutory listing factors:

> (A) the present or threatened destruction, modification, or curtailment of its habitat or range;
> (B) overutilization for commercial, recreational, scientific, or educational purposes;
> (C) disease or predation;
> (D) the inadequacy of existing regulatory mechanisms;
> (E) other natural or manmade factors affecting its continued existence.

16 U.S.C. § 1533(a)(1)(A)-(E); 50 C.F.R. § 424.11(c)(1) - (5).

A species is "endangered" if it is "in danger of extinction throughout all or a significant portion of its range" due to one or more of the five listing factors. 16 U.S.C. § 1531(6). A species is "threatened" if it is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." 16 U.S.C. § 1531(20). While the ESA does not define the "foreseeable future," the FWS must use a definition that is reasonable, that ensures protection of the petitioned species, and that gives the benefit of the doubt regarding any scientific uncertainty to the species.

Because global warming is a foremost threat to the San Bernardino flying squirrel, the USFWS should consider the timeframes used in climate modeling. The minimum time period that meets these criteria is 100 years. Projections of climatic changes over the next century or more are routine in the climate literature, demonstrating that impacts within this timeframe are inherently "foreseeable." Moreover, in planning for species recovery, the USFWS (as well as its sister agency, the National Marine Fisheries Service) routinely considers a 75-200 year foreseeable future threshold (Suckling 2006). For example, the Alaska Region has previously stated in the Steller's Eider Recovery Plan:

> The Alaska-breeding population will be considered for delisting from threatened status when: The Alaska-breeding populations has <1% probability of extinction in the next 100 years; AND Subpopulations in each of the northern and western subpopulations have <10% probability of extinction in 100 years and are stable or increasing. The Alaska-breeding population will be considered for reclassification from Threatened to Endangered when: The populations has > 20% probability of extinction in the next 100 years for 3 consecutive years; OR The population has > 20% probability of extinction in the next 100 years and is decreasing in abundance (USFWS 2002 (emphasis added)).

With regard to the Mount Graham red squirrel, the USFWS stated "At least 10 years will be needed to stabilize the Mt. Graham red squirrel population and at least 100 to 300 years will be needed to restore Mt. Graham red squirrel habitat" (Suckling 2006 (emphasis added)). With regard to the Utah prairie dog, the Service defined the delisting criteria as "[t]o establish and maintain the species as a self-sustaining, viable unit with retention of 90 percent of its genetic diversity for 200 years" (Sucking 2006 (emphasis added)). The National Marine Fisheries Service stated of the Northern right whale: "[g]iven the small size of the North Atlantic population, downlisting to threatened may take 150 years even in good conditions" (Suckling 2006 (emphasis added)).

Perhaps most importantly, the time period used by the USFWS in its listing decision must be long enough so that actions can be taken to ameliorate the threats to the petitioned species and prevent extinction. Slowing and reversing impacts from anthropogenic greenhouse gas emissions, a primary threat to the San Bernardino flying squirrel, will be a long-term process for a number of reasons, including the long lived nature of carbon dioxide and other greenhouse gases and the lag time between emissions and climate changes. For all these reasons, Petitioner suggests a minimum of 100 years as the "foreseeable future" for analyzing the threats to the continued survival of the San Bernardino flying squirrel. The use of less than 100 years as the "foreseeable future" in this rulemaking would be clearly be unreasonable, frustrate the intent of Congress to have imperiled species protected promptly and proactively, and fail to give the benefit of the doubt to the species as required by law. USFWS must include these considerations in its listing decision.

II. The San Bernardino Flying Squirrel Qualifies For Listing Under The Endangered Species Act

The San Bernardino flying squirrel has population characteristics that make it particularly vulnerable to extinction. It has a small range restricted to the San Bernardino Mountains and it has likely been extirpated from the San Jacinto Mountains; it is isolated by geographic barriers which prevent it from moving to new habitat areas (e.g. Mojave Desert to the north; significant habitat gaps and/or major highways to the east, west, and south); and it is likely at low abundance in the San Bernardino Mountains, and at extremely low abundance in the San Jacinto Mountains if it still persists there. Furthermore, it is a habitat specialist with a narrow diet and a relatively low reproductive rate, which make it vulnerable to habitat loss and slow to recover from population declines. Small, isolated populations like that of the San Bernardino flying squirrel are particularly vulnerable to extinction because they are prone to entering an "extinction vortex" where losses of genetic diversity, environmental and demographic stochasticity, and Allee effects interact to prompt further declines (Gilpin and Soulé 1986).

In addition to having a small, isolated population, the San Bernardino flying squirrel faces a multitude of interacting threats that jeopardize its continued existence. Primary threats are habitat loss and degradation resulting from climate change, forest management practices, air pollution, and urban development, as well as the inadequacy of existing regulatory mechanisms for reducing greenhouse gas emissions and other threats, as detailed below.

A.   The Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

The restricted range of the San Bernardino flying squirrel and its sensitivity to habitat fragmentation make it especially vulnerable to threats that reduce habitat quality and quantity. Current, ongoing threats that are modifying and destroying the habitat of the San Bernardino flying squirrel include (1) anthropogenic climate change that threatens its forest habitat and food supply, (2) forest management practices that are removing essential habitat features, (3) air pollution that is directly impacting habitat and food sources, and (4) urban development that is destroying and fragmenting habitat.

1.   Anthropogenic Climate Change

Anthropogenic climate change poses a significant threat to the long-term survival of the San Bernardino flying squirrel. Climate change has already resulted in significantly warmer and drier conditions in the San Bernardino and San Jacinto Mountains. Temperatures and heat wave activity have increased, drought severity and duration have increased, more precipitation is falling as rain instead of snow, the timing of runoff and snowmelt-driven streamflow has advanced, and streamflow has increased in winter months and decreased in summer months leading to higher summer water stress.

The San Bernardino flying squirrel is particularly vulnerable to climate change. It occurs at the southern limit of the species' range where climate change impacts are expected to be more pronounced. However, as a high elevation species restricted to one to two isolated mountain ranges, it has limited options for movement in response to climate change. As climatic zones shift upward in elevation, its habitat will be compressed upward and it risks running out of

suitable habitat (USGCRP 2009). As climate change alters its habitat, it has no option for northward movement to more suitable areas due to the significant barrier of the Mojave Desert.

The section below documents two of the most significant threats to the San Bernardino flying squirrel from climate change: the upward shift of its high-elevation forest habitat and the decline of its mycorrhizal food sources as conditions become warmer and drier. This section reviews the best-available scientific information regarding (a) recent syntheses of the climate change science, (b) observed and (c) projected climate change in the range of San Bernardino flying squirrel, (d) threats to the San Bernardino flying squirrel from climate change, and (e) greenhouse gas reductions needed to protect the San Bernardino flying squirrel.

a. Climate change is unequivocal, primarily human-caused, and is having greater impacts than assessed by the IPCC in 2007

In the 2007 Fourth Assessment Report (AR4), the Intergovernmental Panel on Climate Change (IPCC) expressed in the strongest language possible its finding that global warming is occurring: "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level" (IPCC 2007: 30). The international scientific consensus of the IPCC is that most of the recent warming observed has been caused by human activities (IPCC 2007b). The U.S. Global Change Research Program in its 2009 report *Climate Change Impacts in the United States* also stated that "global warming is unequivocal and primarily human-induced" (USGCRP 2009: 12).

Although the IPCC AR4 provides an important synthesis of the climate change science, numerous studies published since the AR4 indicate that many climate change risks are substantially greater than assessed in the AR4. Key updates that synthesize the most recent climate science include *Climate Change Science Compendium* compiled by the United Nations Environment Programme (McMullen and Jabbour 2009), *Climate Change: Global Risks, Challenges and Decisions Synthesis Report* compiled by the International Alliance of Research Universities (Richardson et al. 2009), *The Copenhagen Diagnosis* (Allison et al. 2009), Smith et al. (2009), Lenton et al. (2008), and Fussel (2009). These updates indicate that many climate impacts are occurring at lower surface temperatures than previously estimated; temperature change during this century will be greater than previously projected; and the climate is approaching tipping points beyond which the climate system will switch to a different state.

In addition, the rate of increase of total atmospheric carbon dioxide concentration is accelerating, with especially rapid increases observed in the 2000s (Canadell et al. 2007, Raupach et al. 2007). The emissions growth rate rose from 1.1% per year from 1990-1999 to 3.5 % per year from 2000-2007 (McMullen and Jabbour 2009). The emissions growth rate since 2000 has been tracking that of the most fossil-fuel intensive IPCC SRES emissions scenario, A1FI (Figure 5) (Raupach et al. 2007, Richardon et al. 2009, McMullen and Jabbour 2009). These increased emissions have been attributed to rises in fossil fuel burning and cement production (average proportional growth increased from 1.3% yr^{-1} to 3.3% yr^{-1}) rather than emissions from land-use change which remained approximately constant (Canadell et al. 2007). During the past 50 years, carbon dioxide sinks on land and in the oceans have become less

efficient in absorbing atmospheric carbon dioxide, which is also contributing to the observed rapid rise (Canadell et al. 2007). With atmospheric carbon dioxide at ~390 ppm and worldwide emissions continuing to increase by more than 2 ppm each year, rapid and substantial reductions are clearly needed immediately.

Figure 5. Observed CO_2 emissions from 1990-2007 from U.S. Department of Energy Information Administration (EIA) data and U.S. Department of Energy Carbon Dioxide Information and Analysis (CDIAC) data, compared with six IPCC emissions scenarios and with stabilization trajectories describing emissions pathways for stabilization of atmospheric CO_2 at 450 and 650 ppm.
Source: Richardson et al. (2009): 11.
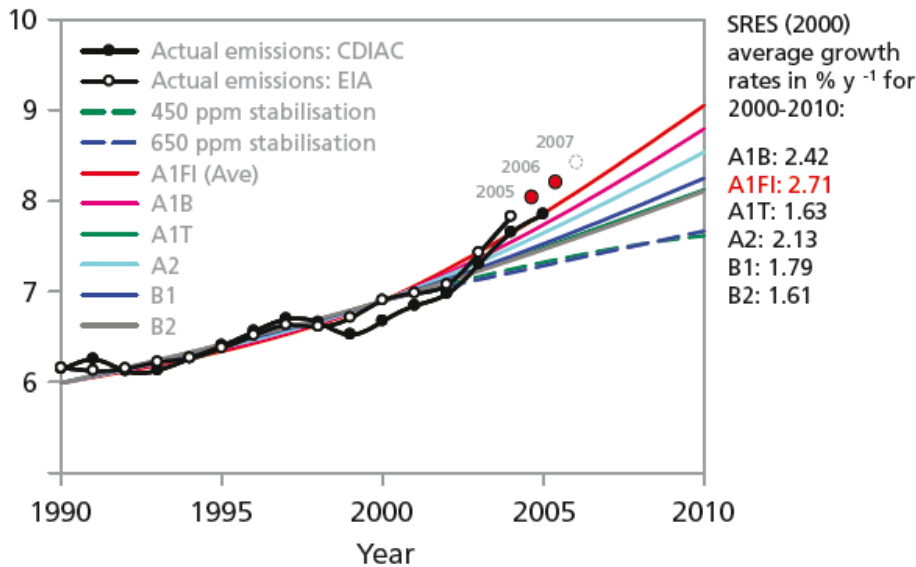
b. Observed climate change in the range of the San Bernardino flying squirrel: western U.S., California, and the San Bernardino/San Jacinto Mountains

Climate change is profoundly affecting the western United States and particularly the Southwest. As summarized by Overpeck and Udall (2010): "The climate changes in western North America, particularly the Southwest, have outstripped change elsewhere on the continent, save perhaps in the Arctic" (p. 1642). The U.S. Global Change Research Program's 2009 report *Climate Change Impacts in the United States* found that average temperature in the United States rose more than 1.1ºC (2ºF) over the past 50 years, and extreme weather events including heat waves and regional droughts became more frequent and intense during the past 40 to 50 years (USGCRP 2009). In the western United States, widespread temperature-related reductions in snowpack occurred over the last 50 years, with the largest reductions in lower elevation mountains in the Northwest and California where snowfall occurs at temperatures close to the freezing point; more precipitation is falling as rain instead of snow during the last 50 years; and runoff in snowmelt-dominated areas is occurring up to 20 days earlier (USGCRP 2009). In the southwestern United States, precipitation has decreased during the summer and fall, and

temperature increases have made drought more severe (USGCRP 2009). According to the USGCRP, "[r]ecent warming [in the Southwest] is among the most rapid in the nation, significantly more than the global average in some areas." Importantly, the report found that "scientific analyses to determine the causes of recent changes in snowpack, runoff timing, and increased winter temperatures have attributed these changes to human-caused climate change" (USGCRP 2009: 46).

Numerous studies that have analyzed climate change in California's mountain regions indicate that there has been rapid warming and a shift in the character of mountain precipitation, with more winter precipitation falling as rain instead of snow, earlier snowmelt, and associated changes in river flow. Specifically, temperatures have increased across California including its mountain regions, with the largest increases in winter and spring (Bonfils et al. 2008a, Bonfils et al. 2008b). Heat wave activity has increased (Gershunov and Cayan 2008). Precipitation has changed, although not consistently across the state, but appears to be decreasing in southern California. Drought duration and severity has increased (Andreadis and Lettenmaier 2006). With warming temperatures, more precipitation is falling as rain instead of snow (Knowles et al. 2006), and snowpack has decreased especially in the low and middle altitudes, which has lead to a significant decline in spring snow-water equivalent (Mote et al. 2005, Hamlet et al. 2006, Mote 2006, Pierce et al. 2008). As snowpack melts earlier in spring, the timing of runoff and snowmelt-driven streamflow has advanced (Stewart et al. 2004, Barnett et al. 2008, Hidalgo et al. 2009). As a result, streamflow has increased in winter and spring and decreased in summer months (Stewart et al. 2004, Das et al. 2009).

Detection and attribution studies that analyze whether climatic changes in the western United States and California have occurred due to natural climatic variations or human influence from greenhouse gas pollution have found that these climatic trends were unlikely to have arisen exclusively from natural internal climate variability, and are attributable in large part to greenhouse gas forcing. Bonfils et al. (2008b) showed that rising temperatures across the mountainous regions of the western U.S. in winter and spring are unlikely to have occurred because of natural variations; rather greenhouse gas pollution is causing a large part of the recent changes. Similarly, Pierce et al. (2008), Hidalgo et al. (2009), and Das et al. (2009) showed that changes in snowpack volume (measured in terms of snow-water equivalent as a fraction of precipitation, SWE/P), changes in the timing of streamflow (measured as the center of timing of streamflow, CT), and changes in hydrologic variables (e.g. winter-total snowy days, spring snow water equivalent, and winter runoff) across the western United States are very unlikely to have arisen from natural variability alone. In a study examining the mountainous regions of the western U.S., Barnett et al. (2008) found that up to 60% of the trends in snowpack, timing of runoff of the major western rivers, and winter minimum daily air temperature in the mountainous regions of the western United States between 1950 and 1999 are attributable to human-induced climate change from greenhouse gases and aerosols.

i. Temperature rise in the western U.S., California, and the San Bernardino/San Jacinto Mountains

Temperatures have risen significantly across the western United States, California, and the San Bernardino/San Jacinto Mountains in recent decades. Across the western U.S. during

1950-1999, daily maximum and minimum temperatures in winter (January to March) increased by 1.83°C and 1.54°C (Bonfils et al. 2008b). In concert with rising temperatures, the number of frost days in winter decreased by 7.6 days, while the number of degree-days above 0°C increased between 1950 and 1999 (Figure 6) (Bonfils et al. 2008b). These trends were significant at the 5% level even after the removal of effects from El Niño Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) variability. Importantly, temperature trends showed spatially and elevationally coherent patterns of warming, meaning that these trends were observed across mountainous regions, including the San Bernardino and San Jacinto Ranges (Figure 6).

Figure 6. Observed and simulated 1950-99 changes in (a) JFM Tmin, (b) Tmax, (c) FD, and (d) DD>0 over the western United States. Frost day trends are large except where frost occurrences are rare (desert and Central Valley), and degree-day trends are small or zero at high elevations where temperatures are too low to exceed the 0°C threshold.
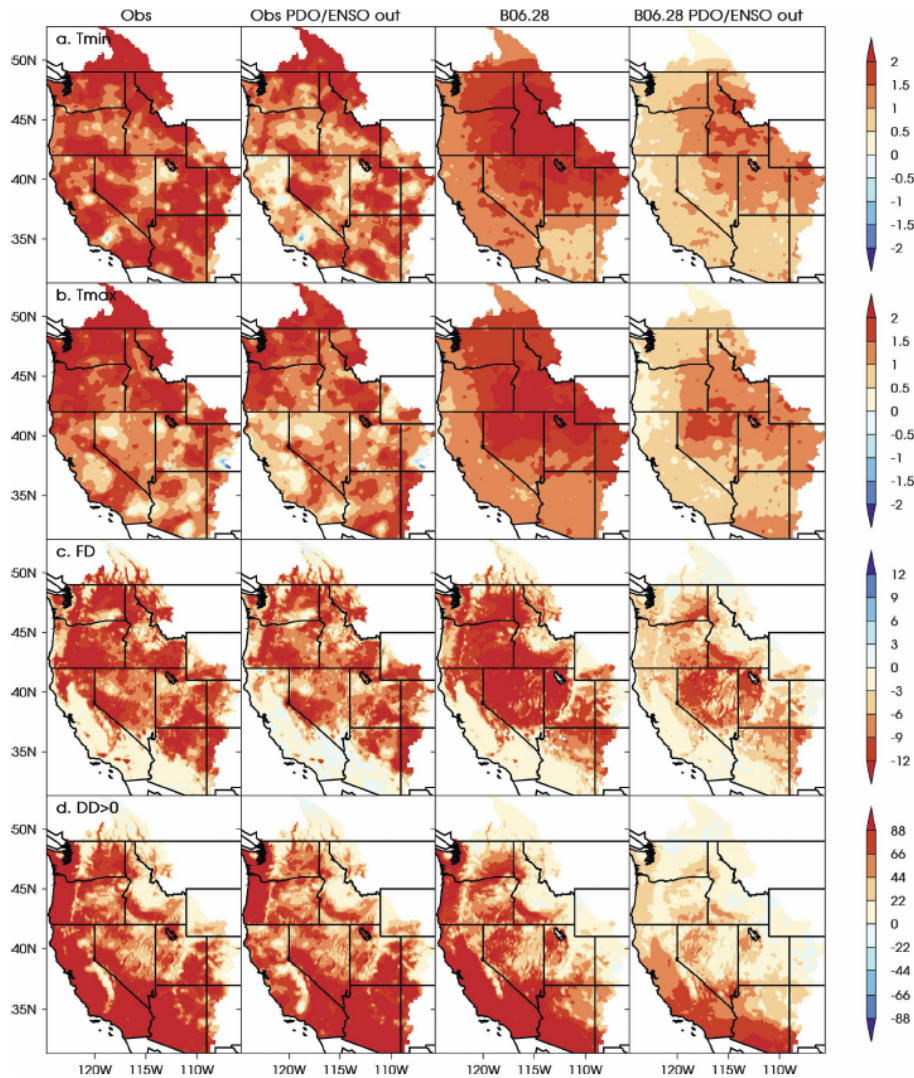Source: Bonfils et al. (2008b): Figure 4.

FIG. 4. Observed and one example of simulated 1950–99 changes in (a) JFM T_{min}, (b) T_{max}, (c) FD, and (d) DD > 0 over the western United States. Trends have been computed from the UW and one PCM-ANTH1 realization (B06.28), using raw data (columns 1 and 3) and data in which observed or simulated PDO and ENSO are regressed out (columns 2 and 4). The color scale is chosen such that red indicates an increase in T_{min} and T_{max}, an increase of DD > 0, and a decrease in FD.

In a California-specific analysis, Bonfils et al. (2008a) found that mean and maximum daily temperatures increased in late winter and early spring between 1915 and 2000, and that minimum daily temperatures increased from January to September. Bonfils et al. (2008a) concluded that "the warming of Californian winters over the twentieth century is associated with human-induced changes in large-scale atmospheric circulation."

Kelly and Goulden (2008) analyzed data from seven climate stations in inland southern California in or adjacent to the San Jacinto Mountains and found significant increases in mean and minimum temperature between 1947-to-1976 to 1977-to-2006 (Table 1).

Table 1. Climatic changes in inland Southern California between 1947-1976 and 1977-2006. Source: Kelly and Goulden (2008): Table 2.

Climate variable	Mean annual value		Change	95% CI	Elevation change, m
	1947–1976	1977–2006			
Precipitation, cm	40.0	47.3	7.3**	3.3	−138
Precipitation c_v (σ / μ)	0.48	0.61	0.13**	0.06	678
Snow / rain ratio	0.18	0.12	−0.06**	0.05	327
Maximum T, °C	24.8	25.0	0.19	0.50	24
Minimum T, °C	8.3	8.9	0.63**	0.53	83
Mean T, °C	16.5	16.9	0.41**	0.24	56

CI, confidence interval. **, $P < 0.05$.

ii. Increases in heat waves in California, especially in inland higher elevation regions

Daytime and nighttime heat wave activity has increased across California from 1948 to 2006 (Gershunov and Cayan 2008). The increase in nighttime summer heat wave events is consistent with the trend of increasing summer nighttime temperatures in California. Gershunov and Cayan (2008) highlighted that warmer nighttime temperatures encourage hotter daytime temperatures since days begin warmer, and lead to increased heat wave duration and area. They noted that nighttime heat waves increase heat stress to wildlife by eliminating the thermal refuge of cooler temperatures at night:

> During a persistent daytime heat wave, cool nights provide respite from the stressful effects of heat on the health and general well-being of plants and animals, as well as for the energy sector, and prepare nature and society to face another day of scorching heat. Heat waves strongly manifested at night eliminate this badly needed opportunity for rejuvenation and increase the chances for catastrophic failure in natural and human systems.(Gershunov and Cayan 2008: 3).

They concluded that this increase in nighttime heat wave activity is consistent with climate change globally and can be expected to continue for the long term.

Gershunov and Cayan (2008) also found that daytime heat wave activity is increasing, with most of the increase occurring since the 1970s. Daytime heat wave activity has intensified more rapidly over the high-elevation interior of California compared to the lowland valleys. The researchers hypothesize that California's high-elevation interior is becoming more vulnerable to daytime heat waves due to the combined impacts of decreasing snowpack and earlier snowmelt and runoff that are making the interior drier:

> [I]t appears likely that the highlands, which are drying in summer due to progressively decreasing snow/rain ratio (Knowles et al. 2006), earlier spring snowmelt and runoff (Cayan et al. 2001, Stewart et al. 2005) and generally decreasing snowpack (Mote et al. 2005), are becoming relatively more prone to intensified daytime heat wave activity. (Gershunov and Cayan 2008: 10).

iii.   Changes in precipitation

Although annual precipitation increased over most of North America between 1901 and 2005, annual precipitation in the Southwest U.S. decreased over the past century by 1 to 2% per decade, as drought prevailed in recent years (Trenberth et al. 2007). In California, average annual precipitation during the past century (1895 to 2009) appears to have increased (+2.76 ± 3.13 inches) on a state-wide level (Figure 7). However, precipitation trends varied across regions and time periods analyzed. For interior southern California which includes the San Bernardino/San Jacinto Mountains, precipitation increased between 1947-to-1976 to 1977-to-2006 (Table 1) (Kelly and Goulden 2008). However, when a longer time period is considered (1895 to 2009) for this region, precipitation in interior southern California appears to have declined slightly over the past century (-0.92 ± 3.89 inches), particularly in recent decades (Figure 8).

Figure 7. California statewide precipitation (1895-2009)
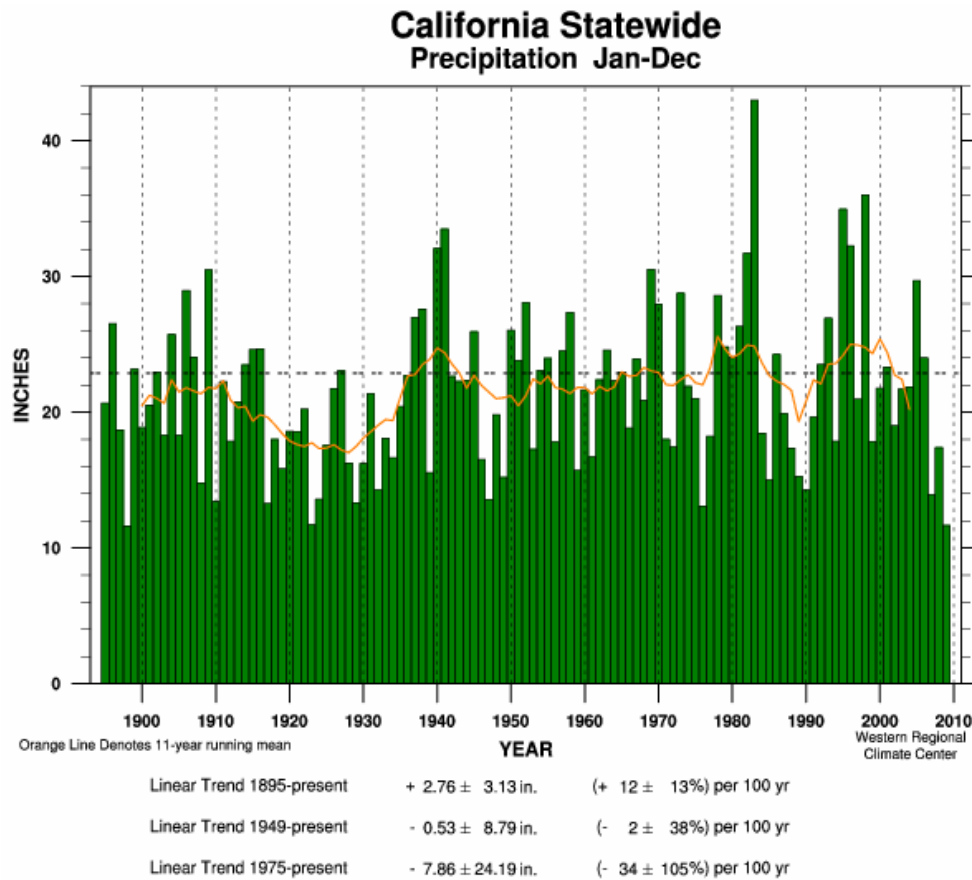Source: Western Regional Climate Center, http://www.wrcc.dri.edu/monitor/cal-mon/index.html

Figure 8. Southern Interior California precipitation trends (1895-2009).
Source: Western Regional Climate Center, http://www.wrcc.dri.edu/monitor/cal-mon/index.html

Southern Interior Region
Precipitation Jan-Dec

Orange Line Denotes 11-year running mean

Western Regional Climate Center

Linear Trend 1895-present	- 0.92 ± 3.89 in.	(- 5 ± 22%) per 100 yr
Linear Trend 1949-present	+ 0.62 ± 10.95 in.	(+ 3 ± 61%) per 100 yr
Linear Trend 1975-present	-24.11 ± 27.28 in.	(- 136 ± 154%) per 100 yr
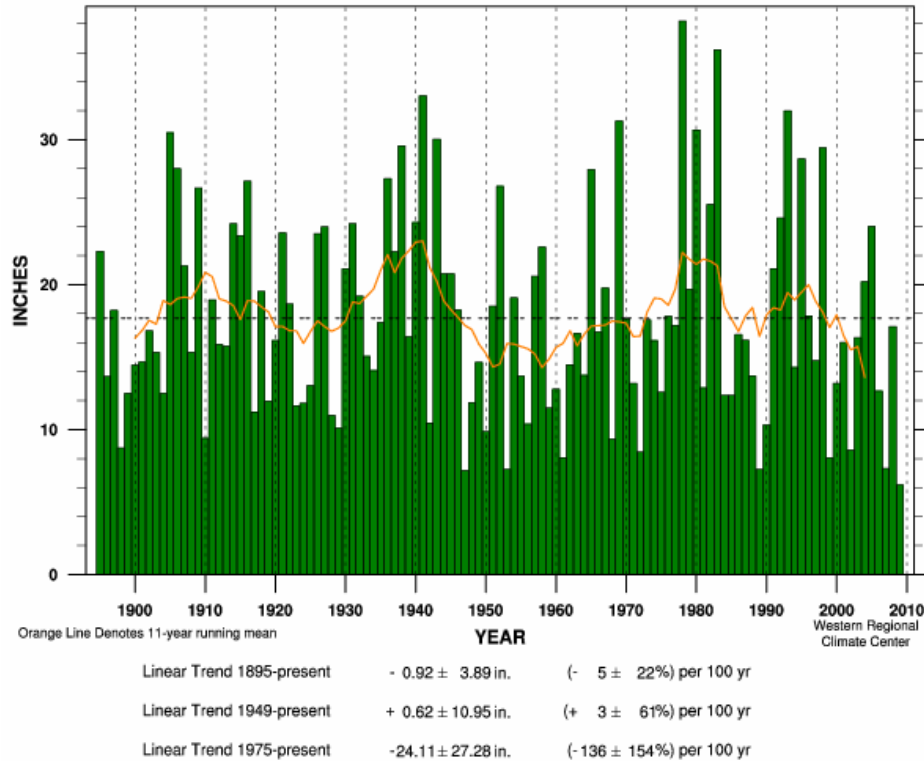
iv.   Increased drought duration and severity and lower soil moisture

A study of 20th century trends in soil moisture, runoff, and drought characteristics over the conterminous U.S. detected trends toward increased drought duration and severity and lower soil moisture in southern California including the San Bernardino/San Jacinto Mountains region (Figures 9, 10) (Andreadis and Lettenmaier 2006).

Figure 9. Trends in drought severity. Upward trends shown in red triangles and downward trends shown in blue triangles.
Source: Andreadis and Lettenmaier (2006): Figure 4.

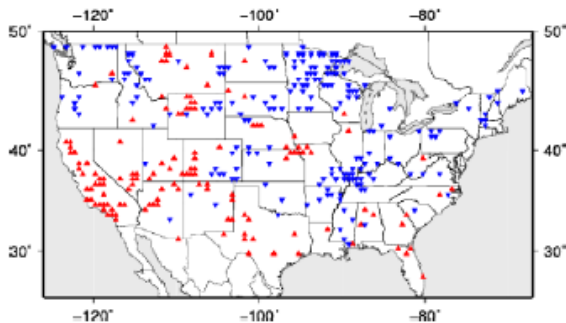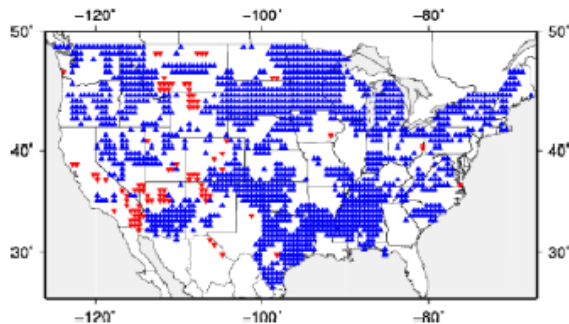Figure 10. Annual trends in soil moisture. Blue triangles show upward trends, while red triangles show downward trends.
Source: Andreadis and Lettenmaier (2006): Figure 1.

v.   Reduced snowpack in California mountains

In the western U.S. and California, more winter precipitation is falling as rain instead of snow and snowpack is decreasing (Hamlet et al. 2005, Mote et al. 2005, Knowles et al. 2006, Mote 2006, Pierce et al. 2008). As detailed below, these studies indicate that these same changes are occuring in the San Bernardino and San Jacinto Mountains region.

Hamlet et al. (2005) detected downward trends in spring snowpack, measured as the 1 April snow-water equivalent (SWE), across the western United States between 1916 and 2003. Hamlet et al. (2005) showed that large-scale, long-term declines in snowpack are primarily attributable to rising temperatures rather than changes in precipitation or PDO variability. As indicated by Figure 11, downward trends in SWE were observed in the San Bernardino and San Jacinto Mountain regions. Additionally, Kelly and Goulden (2008) analyzed data from seven climate stations in inland southern California in or adjacent to the San Jacinto Mountains and found significant decreases in the proportion of precipitation falling as snow between 1947-to-1976 to 1977-to-2006 (Table 1).

Figure 11. Relative trends (%/year) in simulated SWE for three calendar dates for the period from 1916 to 2003. (Black pixels in the spatial plots are off scale on the low side.
Source: Hamlet et al. (2005): Figure 2.
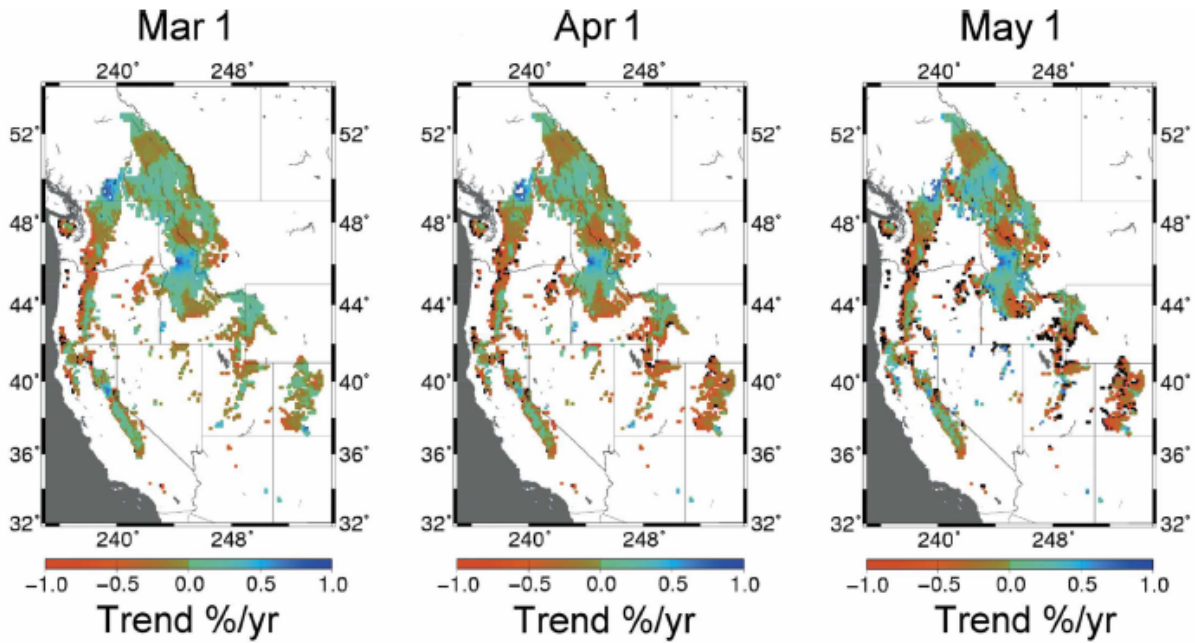
Knowles et al. (2006) detected a trend toward reduced winter-total snowfall water equivalent (SFE) to winter-total precipitation (*P*) during the period 1949–2004. Trends toward reduced SFE are a response to warming across the region, with the most significant reductions occurring where winter wet-day minimum temperatures were warmer than -5°C. As indicated by Figure 12, downward trends in SWE were observed in the San Bernardino and San Jacinto Mountains region.

Figure 12. Fractional change in winter snowfall water equivalent after removing the effects of trends in precipitation.
Sources: Knowles et al. (2006): Figure 7.
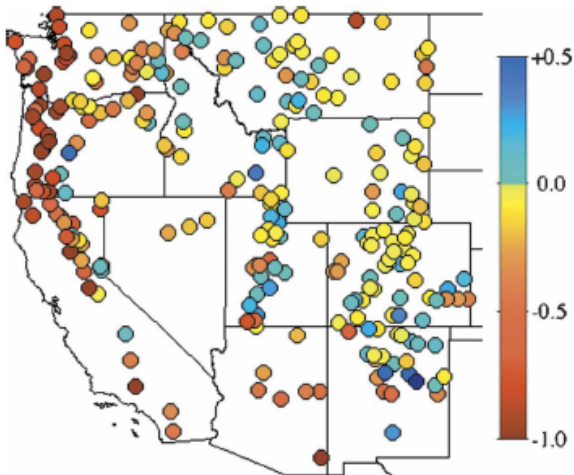
Das et al. (2009) detected trends across the western U.S. toward a decrease in winter-total snowy days as a fraction of winter-total wet days, a decrease in the spring snow water equivalent (1 April snow water equivalent as a fraction of October–March precipitation), and an increase in

winter accumulated runoff as a fraction of water-year accumulated runoff, which were also observed in the San Bernardino and San Jacinto Mountains region (Figure 13).

Figure 13. Observational trends for 1950-99 for (a) JFM average temperature, (b) snowy days as a fraction of wet days, (c) SWE/Precip (OND JFM), and (d) JFM accumulated runoff as a fraction of water-year-accumulated runoff for snow-affected regions.
Source: Das et al. (2009): Figure 5.
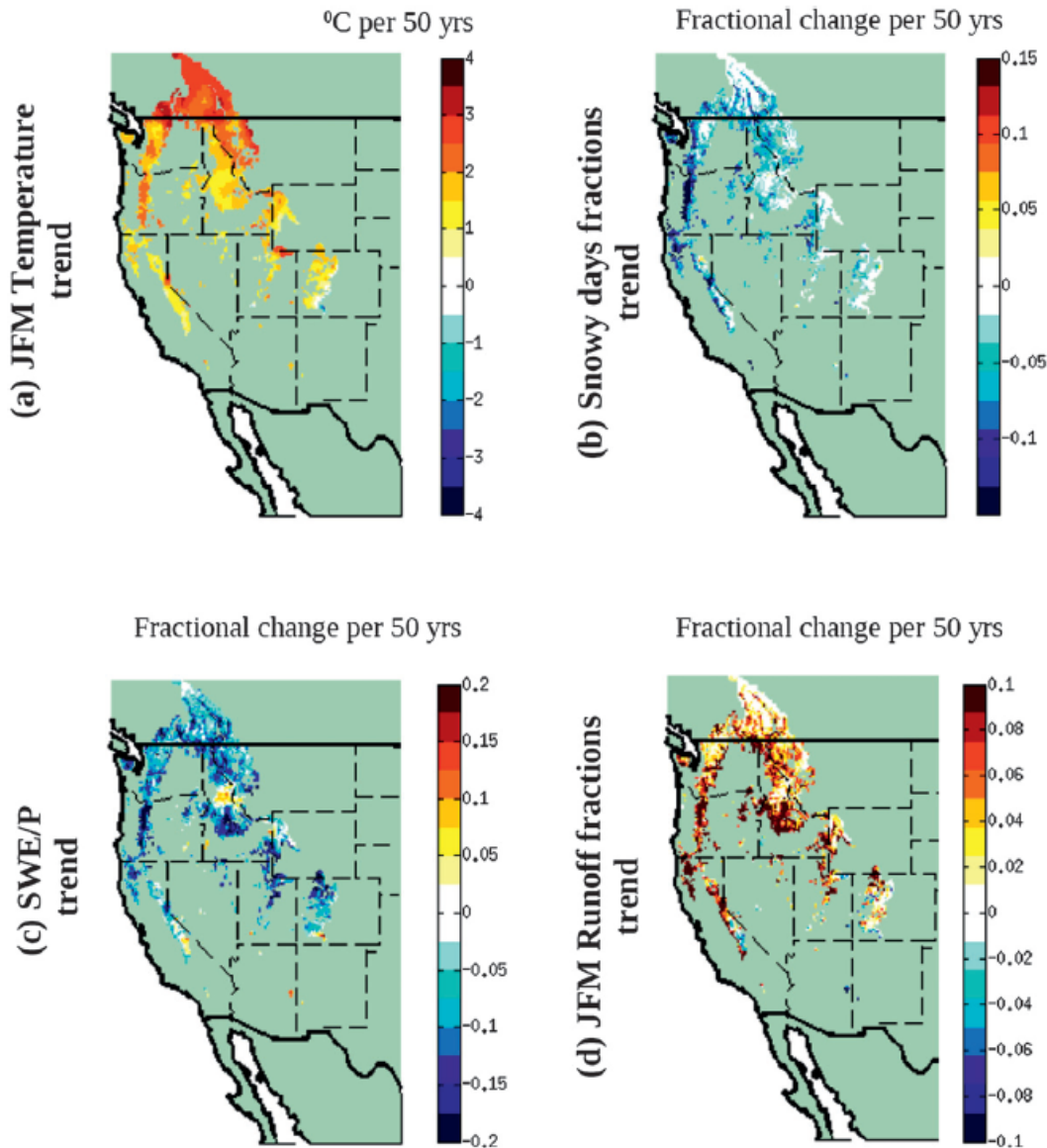
vi.   Earlier timing of streamflow and runoff

Stewart et al. (2004) detected an earlier shift in timing of streamflow due to earlier springtime snowmelt during 1948–2000 across the western U.S., including the San Bernardino and San Jacinto Mountains region (Figure 14).

Figure 14. Observed changes in the timing of the center of mass of flow (CT), 1948-2000. Larger circles indicate statistically significant trends at the 90% confidence level; smaller circles correspond to trends that do not meet statistically significant thresholds at the 90% level. Source: Stewart et al. (2004): Figure 2.

c.   **Projected climate change in the range of the San Bernardino flying squirrel within this century: western U.S., California, and the San Bernardino/San Jacinto Mountains**

Climate projections indicate that the western United States will continue to become warmer, precipitation will decrease especiall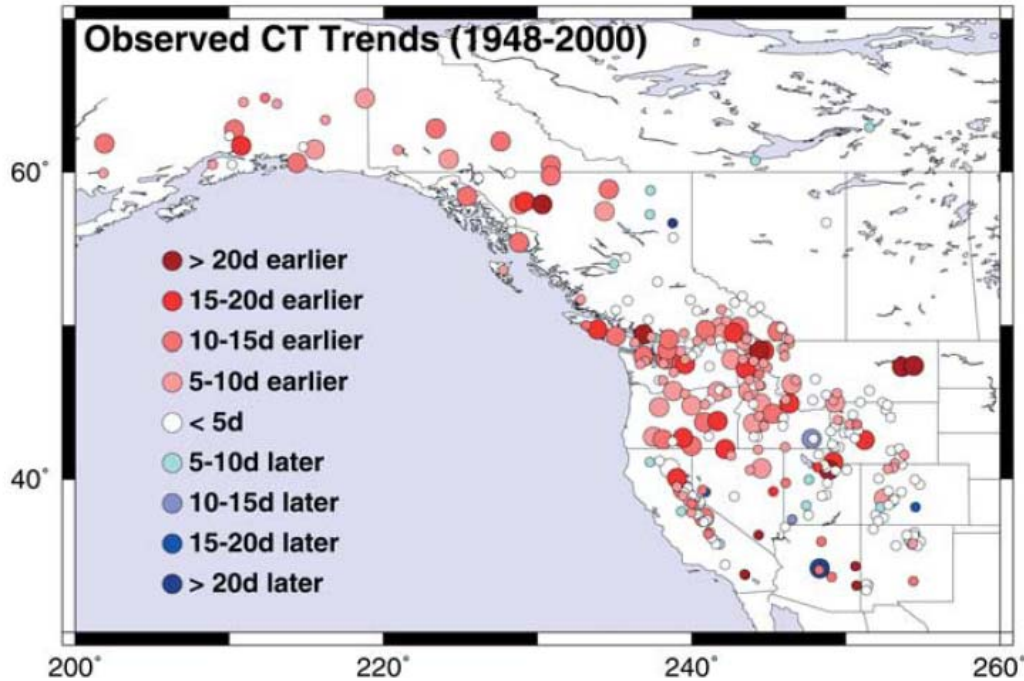y in the Southwest, snowpack will continue to decline, and the timing of snowmelt runoff in most snowmelt-dominated basins in the West will consistently shift earlier in spring, up to 60 days earlier in some areas, leading to increased winter runoff and reduced summer streamflow volumes (USGCRP 2009). Projections for the Southwest indicate that the probability of drought will increase, and precipitation, streamflow, and runoff are likely to decrease in spring and summer (USGCRP 2009). Similarly in California, temperatures will continue to rise; hot events, droughts, and extreme precipitation events will become more frequent; snowpack will continue to decrease; and streamflow will continue to shift earlier (Cayan et al. 2008).

i.   **Rising temperatures and more heat waves**

Cayan et al. (2008) found that temperatures over California are projected to warm significantly during the twenty-first century, with more warming in the summer than winter in most simulations. Mean annual temperatures are projected to increase by 1.5°C to 2.7°C under the B1 emissions scenario and 2.5°C to 4.5°C under the A2 scenario by 2070-2099. On a

seasonal basis, summer (June to August) temperatures are projected to increase by 1.5°C to 3.7°C under the B1 and 2.6°C to 6.4°C under the A2 scenario, while winter (December to February) temperatures increase by 1.6°C to 2.3°C under the B1 and 2.4°C to 3.4°C under the A2 scenario. These projections are especially worrisome given that the worldwide emissions growth rate since 2000 has vastly exceeded both the B1 and A2 scenarios and is tracking that of the most-fossil fuel intensive IPCC SRES emissions scenario, A1FI (Raupach et al. 2007).

The occurrence of extremely warm days is also projected to increase significantly. Under the A2 scenario, the occurrence of extremely warm daily mean temperatures that exceed the 99.9 percentile of their historical distributions for June to September is projected to increase to 50 to 500 times their historical frequency by 2070–2099, while the incidence of even moderately cool daily mean winter temperatures decreases markedly (Cayan et al. 2008). Cayan et al. (2008) warned that these temperature increases are outside the range of local experience and that temperatures will continue to rise into the twenty-second century:
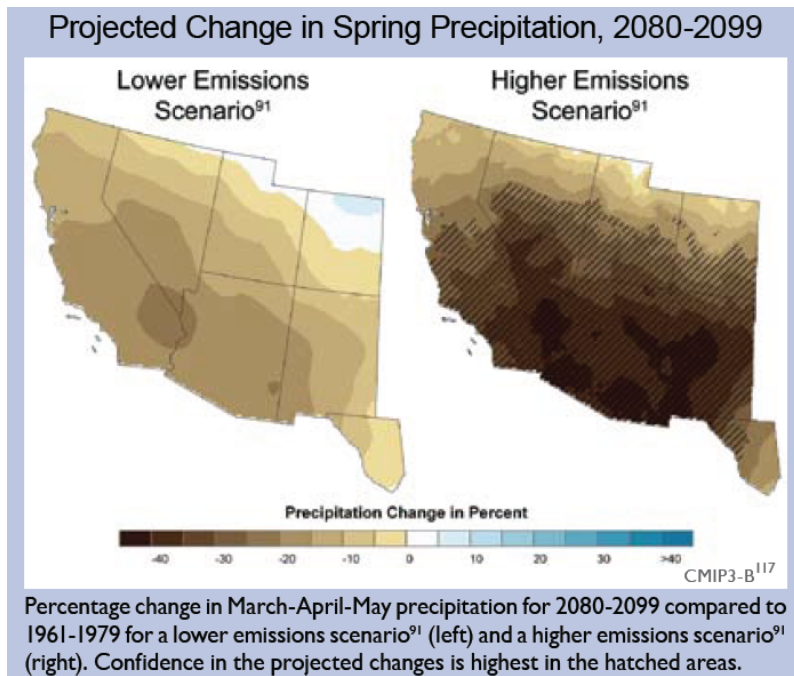
> Such climate changes would be, in the words of Hansen et al. 2007, "climate changes outside of the range of local experience." A noteworthy feature in the temperature projections is that the warming through the twenty-first Century does not level off, especially in projections using the medium and high greenhouse gas emission scenarios, implying that California's climate would continue to warm in (at least) the subsequent decades of the twenty-second century. (Cayan et al. 2008: S40).

ii.   Changes in precipitation and increases in precipitation extremes

Precipitation projections for California are mixed. Cayan et al. (2008) projected relatively small (less than ~10%) changes in overall precipitation in California, with no clear projections for increases or decreases in southern California. These researchers noted that analyses using a larger suite of IPCC AR4 climate models under three different emissions scenarios (A1B, A2, B1) yielded larger changes in total precipitation of 5-20%. Cayan et al. (2008) highlighted that a 10–20% change in annual precipitation can be significant, since historically a 15% loss in precipitation placed that year in the lowest third of the annual totals and can profoundly affect runoff. In contrast, Hayhoe et al. (2004) found that mean precipitation in California is projected to decrease in the winter and summer under most emissions scenarios. Similarly, the U.S. Global Change Research Program projected decreases in spring precipitation in California at the end of the century (Figure 15) (USGCRP 2009).

The intensity of precipitation events is projected to increase throughout the western U.S. due to the higher water-holding capacity of warmer air, leading to more flooding (Christensen et al. 2007). For example, Leung et al. (2004) found that extreme precipitation events during the winter will increase in the Sierra Nevada of California by 10-20% by 2040-2060.

Figure 15. Projected change in spring precipitation across the Southwest, 2080-2099. Source: USGCRP (2009): 130.

Projected Change in Spring Precipitation, 2080-2099

Lower Emissions Scenario[91]

Higher Emissions Scenario[91]

Precipitation Change in Percent

-40 -30 -20 -10 0 10 20 30 >40

CMIP3-B[117]

Percentage change in March-April-May precipitation for 2080-2099 compared to 1961-1979 for a lower emissions scenario[91] (left) and a higher emissions scenario[91] (right). Confidence in the projected changes is highest in the hatched areas.

iii.   More frequent droughts

A modeling effort using 19 models from the IPCC AR4 gave robust predictions of increasing aridity and higher frequency of severe drought in the southwest U.S., including California, within decades (Seager et al. 2007). Droughts in the Southwest in the historical record have been attributed to persistent La Niña–like conditions in the tropical Pacific Ocean. Although the most severe future droughts are still projected to occur during La Niña events, they are projected to be worse because the La Niña conditions will overlay a more arid base state (Seager et al. 2007). Seager et al. (2007) concluded that "[i]f these models are correct, the levels of aridity of the recent multiyear drought or the Dust Bowl and the 1950s droughts will become the new climatology of the American Southwest within a time frame of years to decades." As reported by the USGCRP (2009), the projections for an increasing probability of drought in the Southwest are consistent with observed climate trends including a northward shift in winter and spring storm tracks.

Building on Seager et al. (2007), Dominguez et al. (2010) found that winter aridity would likely be more intense than previously projected. Dominguez et al. (2010) conducted a targeted assessment of how future ENSO variability would affect climate conditions over the Southwest, using a subset IPCC models that best captured seasonal precipitation and temperature over the region and realistically represented ENSO variability. They showed that La Niña conditions would "dramatically amplify" the future aridity of the Southwest even more than previous climate projections had indicated. Temperatures would be even higher (~0.5∘C) and precipitation even lower (~3 mm/mnt) than previously projected trends.

iv.   Decreases in snowpack

Using a downscaling technique to project changes in snow accumulation on California's mountainous terrain, Cayan et al. (2008) detected marked future declines in spring snow accumulation that become progressively larger as warming increases within this century. By 2070–2099, virtually no snow is left below 1,000 m under the A2 scenario. By the end of the century, decreases in snow accumulation range from 60 to 93% between ~1,000 and 2,000 m (3,280 to 6,560 ft) and from 25 to 79% between 2,000 to 3,000 m (6,560 to 9,840 ft).
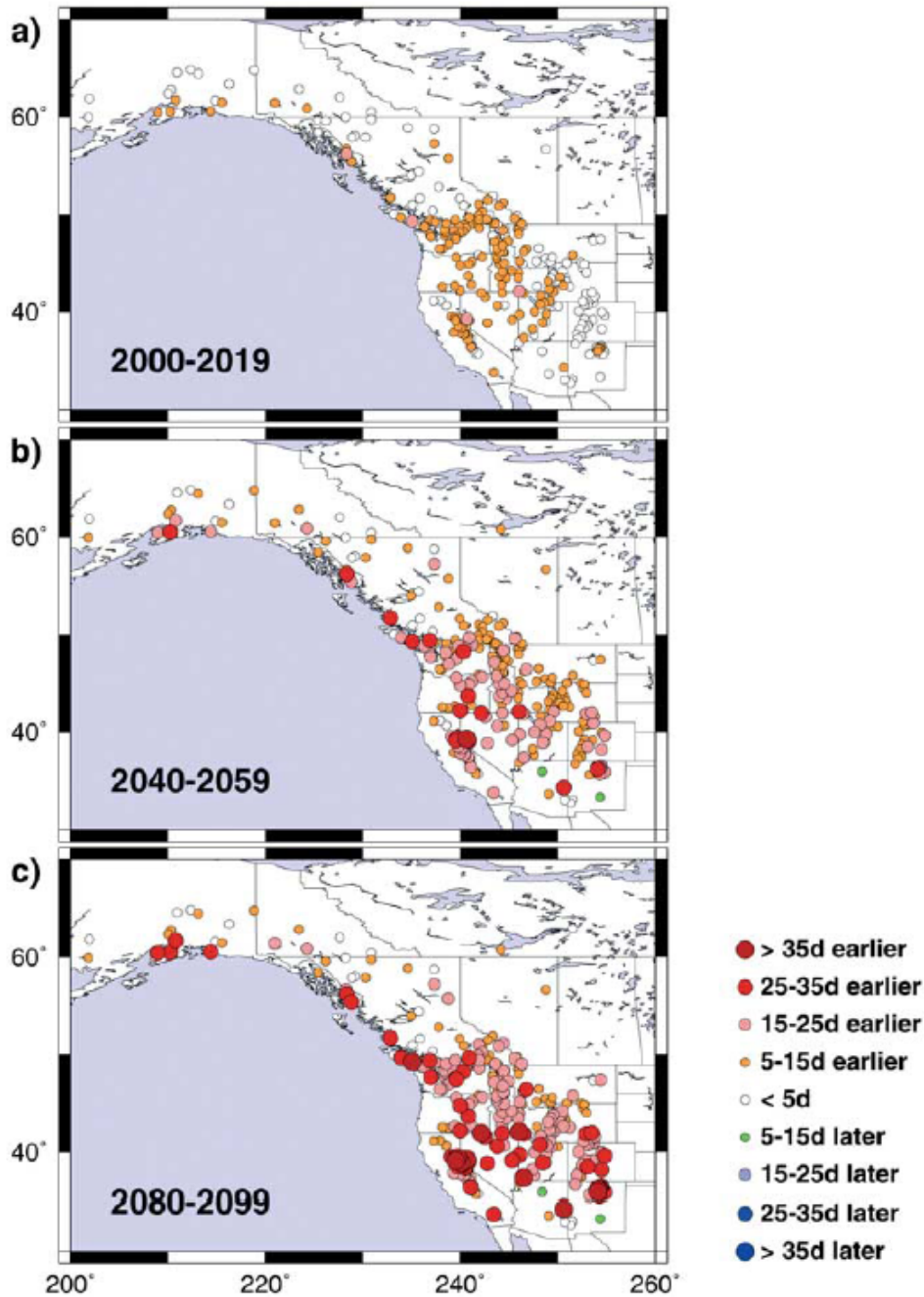
v.   Earlier spring runoff and streamflow

Rauscher et al. (2008) used a high-resolution climate model to project future changes in snowmelt-driven runoff in the western United States and found that hydrological conditions will continue to trend towards earlier snowmelt and drier summer conditions. Under an end-of-the-century A2 emissions scenario, increased temperatures forced by greenhouse gas emissions were projected to result in early-season snowmelt-driven runoff as much as two months earlier than present. Throughout most of the western mountainous areas, snowmelt-driven runoff was projected to occur at least 15 days earlier in early-, middle-, and late-season flow. These changes were driven primarily by increases in winter temperature that amplify the snow-albedo feedback. Specifically, higher temperatures reduce snow cover and consequently decrease surface albedo which increases the amount of absorbed surface radiation and further increases surface warming, leading to a positive feedback loop. Rauscher et al. (2008) concluded that reduced snowpack and early runoff are likely to result in substantial modifications to the hydrologic cycle, including reduced river flow and reduced natural snow and soil storage.

Stewart et al. (2004) found that streamflow would continue to get earlier across the western U.S., including the San Bernardino and San Jacinto Mountains region, with many rivers running 30-40 days earlier by the end of the century (Figure 16). Projected changes in the temporal centroid of streamflow (CT) each year were dominated by increases in temperature.

Figure 16. 20-year averages of projected changes in CT [days] averaged over (a) 2000-2019; (b) 2040-2059; and (c) 2080-2099.
Source: Stewart et al. (2004): Figure 8.

a) 60° 40° 2000-2019

b) 60° 40° 2040-2059

c) 60° 40° 2080-2099

200°   220°   240°   260°

● > 35d earlier
● 25-35d earlier
● 15-25d earlier
● 5-15d earlier
○ < 5d
● 5-15d later
● 15-25d later
● 25-35d later
● > 35d later

d.   Climate change threats to the San Bernardino flying squirrel

The ecological impacts of climate change have been well-documented by numerous studies, including evidence for changes in distribution, phenology, physiology, demographic rates, and genetics (Walther et al. 2002, Parmesan and Yohe 2003, Root et al. 2003, Walther et al. 2005, Parmesan 2006, Walther 2010). Particularly relevant to mountaintop species like the San Bernardino flying squirrel, many species are shifting their ranges upslope and northward as climate changes (Parmesan 2006). A meta-analysis of range shifts across Northern Hemisphere species including trees, birds, and butterflies found that species had shifted their upper range

boundaries an average of 6.1 km per decade northward and their upper elevational boundaries an average of 6.1 m per decade upward (Parmesan and Yohe 2003). Climate-change-related northward expansion of the southern flying squirrel is already thought to be occurring in Canada (Garroway et al. 2010). Because climate change is occurring at an unprecedented pace with multiple synergistic impacts, climate change is predicted to result in catastrophic species losses during this century. The IPCC has warned that 20 to 30% of plant and animal species will face an increased risk of extinction if increases in global average temperature exceed 1.5 to 2.5°C (relative to 1980-1999), with an increased risk of extinction for up to 70% of species worldwide if increases in global average temperature exceed 3.5°C relative to 1980-1999 (IPCC 2007b). Thomas et al. (2004) projected that 15-37% of species will be committed to extinction by 2050 under a mid-level emissions scenario, which the world has been exceeding.

The San Bernardino flying squirrel is particularly vulnerable to climate change. It occurs at the southern limit of the species' range where climate change impacts are expected to be more pronounced. However, as a high elevation species restricted to one to two isolated mountain ranges, it has limited options for movement in response to climate change. As climatic zones shift upward in elevation, its habitat will be compressed upward and it risks running out of suitable habitat (USGCRP 2009). As climate change alters its habitat, it has no option for northward movement to more suitable areas due to the significant barrier of the Mojave Desert. The apparent extirpation of the San Bernardino flying squirrel in the San Jacinto Mountains may represent a climate-change-related northward shift in its range. The section below documents two of the most significant threats to the San Bernardino flying squirrel from climate change: the upward shift of its high-elevation forest habitat and the decline of its mycorrhizal food sources as conditions become warmer and drier.

i.   Loss of upper-elevation mixed conifer/black oak forest habitat

The San Bernardino flying squirrel is threatened by habitat loss due to the upslope shift of its mixed conifer/black oak forest habitat, a trend that is already occurring in the Santa Rosa Mountains of southern California which are adjacent to the San Jacinto Mountains (Kelly and Goulden 2008). Kelly and Goulden (2008) documented a significant upslope shift in conifer forest, including the primary tree species used by the San Bernardino flying squirrel, in the Santa Rosa Mountains. Kelly and Goulden (2008) compared surveys of plant cover from 1977 and 2006–2007 along a 2,314-m elevation gradient in Deep Canyon. They found that the mean elevation of the dominant plant species rose by an average of ~65 m between the surveys, including montane, chaparral, and desert species. The white fir and Jeffrey pine, which are primary tree species used by the San Bernardino flying squirrel, experienced upslope shifts of 96 and 28 m respectively over the 30-year time period. In addition, the border between conifer forest and evergreen broadleaf woodland shifted upward as a result of *Pinus jeffreyi* mortality in the lower parts of its range and the proliferation of *Quercus chrysolepis* in the upper parts of its range. Overall, plant cover declined by a median of 46% from 1977 to 2006–2007 in the lower parts of species' original ranges and increased by 12% in the upper parts of their original ranges.

Kelly and Goulden (2008) concluded that the upward shift in plant distribution was best explained by changes in regional climate. Climate changed significantly in the region between two 30-year periods, 1947-to-1976 to 1977-to-2006, as indicated by climate data from seven

stations near Deep Canyon. Mean and minimum air temperature increased; variability in mean precipitation and interannual precipitation variability increased significantly, indicative of a higher occurrence of drought; and the ratio of snowfall to total precipitation decreased at the three montane stations that historically received snow. At the Idyllwild station in the San Jacinto Mountains, mean temperature increased by 0.71°C, the precipitation coefficient of variation increased by 0.14, and the ratio of snow to precipitation decreased by 0.09. Based on the average temperature lapse rate in the region, mean temperature shifted upward by 56 m overall.

Kelly and Goulden (2008) based their conclusion that climate change was the most likely driver of the plant distributional shift, rather than changes in air pollution or fire frequency, based on several observations. First, vegetation shifts were uniform across elevation, suggesting that the ultimate causal factor was uniformly distributed across elevation. Regional climatic changes do not appear to vary strongly with elevation, whereas fire regime perturbation and air pollution deposition do vary substantially with elevation. Second, the upward shifts in vegetation are consistent with the expected pattern under increased temperature, rising snowline, and occurrence of severe drought. These changes would increase plant stress in some years, decreasing their ability to survive in the drier, warmer lower limits of the range but increasing their competitive ability and tolerance in the upper limits of the range. Kelly and Goulden (2008) hypothesized that species redistribution occurred episodically, with accelerated mortality in the lower parts of species' ranges during drought periods while infilling occurred across species' entire ranges during unusually wet periods.

As summarized by Kelly and Goulden (2008), their work in the Santa Rosa Mountains indicates that climate-change related vegetation shifts can be quite rapid: "Our results imply that surprisingly rapid shifts in the distribution of plants can be expected with climate change, at least in areas where dispersal is not a major constraint, and that global climate change may already be impacting the distribution of vegetation" (p. 11825). Overall, the rapid upslope vegetation shift over a 30-year period in the Santa Rosa Mountains indicates that the San Bernardino flying squirrel is vulnerable to habitat loss and alteration in the nearby San Jacinto and San Bernardino ranges which are experiencing similar shifts in temperature and precipitation.

On a final note, although changes in small mammal communities have not been analyzed in the San Jacinto/San Bernardino Mountains, climate change-related upslope movements of high-elevation small mammals has already been documented in the Sierra Nevada. Moritz et al. (2008) quantified the impact of nearly a century of climate change on the small-mammal community of Yosemite National Park by resampling a broad elevational transect (60 to 3300 m above sea level) that Grinnell and colleagues surveyed from 1914 to 1920. Moritz et al. (2008) found a striking pattern of significant upward range shifts for high-elevation mammal species which they attributed to climate change. Although Moritz et al. (2008) did not sample northern flying squirrels, they found that nine mid-to-high elevation species exhibited a range contraction, while only one mid-to-high elevation species expanded its range. Of the nine mid-to-high elevation species with range contractions, six experienced an upward shift in their lower range limit ranging, while three experienced a range collapse where their lower limit shifted upward and upper limit shifted downward (Moritz et al. 2008: Table 1). Moritz et al. (2008) noted that the ~500-m average increase in elevation for affected species is consistent with estimated warming of +3°C, assuming a change of temperature with elevation of ~6°C per km. Finally,

Moritz et al. (2008) cautioned that the trends in range contraction "do not bode well" for mid- to high-elevation species and especially for endemic species.

ii. Drier conditions leading to declines in mycorrhizal food

Climatic trends toward drier conditions in the San Bernardino and San Jacinto Mountains threaten to result in declines in the abundance and species richness of hypogeous mycorrhizal fungi (i.e. truffles) which are the primary food source for the San Bernardino flying squirrel. Truffles favor cool, mesic to wet microenvironments (Amaranthus et al. 1994). As detailed above, in the xeric upper-elevation forests of the southern Sierra Nevada, truffle biomass, frequency, and species richness is significantly higher near riparian zones (Meyer and North 2005). Truffle biomass is also positively correlated with June-August rainfall in upland sites but not riparian sites, indicating that soil moisture likely limits truffle biomass during summer months in drier areas away from riparian zones (Meyer and North 2005). Flying squirrels in the xeric forests of the southern Sierra Nevada occur in higher densities near riparian areas, including intermittent and perennial creeks, likely due to the higher availability of fungi, drinking water particularly in dry summer months, and secondary food items such as fruits and seeds (Meyer et al. 2007a). Climate change in southern California is leading to drier conditions, particularly in summer months, in the San Bernardino and San Jacinto Mountains. As detailed above, temperatures are rising, drought duration and severity are increasing, snowpack is decreasing, and spring runoff is getting earlier, leading to reduced summer streamflow and greater summer water stress. Climate projections for southern California indicate that conditions will continue to get drier under future climate conditions. Thus, climate change is likely to have negative effects on truffle abundance and species richness by making conditions drier and more unsuitable (Smith 2007).

e. Climate commitment, irreversible climate change, tipping points, feedbacks, and greenhouse gas concentrations needed to avoid dangerous climate change

Scientists have highlighted several processes that delay the full impacts of greenhouse gases and make climate change impacts extremely long-lasting. When weighing extinction risk to the San Bernardino flying squirrel from climate change, the Service should take the following processes into account: (1) the climate commitment (i.e. future warming resulting from present greenhouse gas levels); (2) the irreversibility of climate change from CO_2 emissions; (3) the triggering of tipping points; and (4) the enhancement of positive feedback cycles that amplify climate change. Numerous scientific studies indicate that current warming and the climate commitment already constitute 'dangerous anthropogenic interference' with the climate system in regard to species and ecosystems, and that the safe upper limit for atmospheric CO_2 needed to avoid 'dangerous climate change' is at most 350 ppm.

i. The climate commitment

Due to thermal inertia in the climate system, there is a time lag between the emission of greenhouse gases and the full physical climate response to those emissions (IPCC 2007a, b). Thus, the climatic changes experienced so far are only part of the full response expected from the

greenhouse gases already in the atmosphere (IPCC 2007a,b, Hansen et al. 2008). The delayed effects from existing emissions are known as the "climate commitment." Based on the greenhouse gases already emitted, the Earth is committed to additional warming estimated at 0.6°C to 1.6°C within this century (Meehl et al. 2007, Ramanathan and Feng 2008), and up to 2°C in the long-term (Hansen et al. 2008). This committed warming poses a significant threat to the San Bernardino flying squirrel.

ii. Irreversible impacts of CO_2 emissions

Although largely under-appreciated, climate changes, including temperature increases and sea level rise, that result from increases in CO_2 concentrations are largely irreversible for 1,000 years after emissions cease (Archer and Brovkin 2009, Solomon et al. 2009). An important contributing factor is the long atmospheric lifetime of CO_2 compared to other greenhouse gases. A significant fraction of anthropogenic CO_2, ranging from 20–60%, remains airborne for a thousand years or longer after emissions cease (Archer and Brovkin 2008, Solomon et al. 2009). In the case of temperature, although some of the anthropogenic CO_2 is removed from the atmosphere by deep ocean mixing, global average temperatures do not drop significantly for at least 1,000 years after the cessation of emissions because the removal of CO_2 by deep-ocean mixing is largely compensated by the loss of heat from the ocean (Solomon et al. 2009). In addition, the long tail of fossil fuel CO_2 in the atmosphere may trigger slow processes and feedbacks including methane hydrate release from the ocean and methane release from melting permafrost (Archer and Brovkin 2008).

As stated by Solomon et al. (2009):

It is sometimes imagined that slow processes such as climate changes pose small risks, on the basis of the assumption that a choice can always be made to quickly reduce emissions and thereby reverse any harm within a few years or decades. We have shown that this assumption is incorrect for carbon dioxide emissions, because of the longevity of the atmospheric CO_2 perturbation and ocean warming. Irreversible climate changes due to carbon dioxide emissions have already taken place, and future carbon dioxide emissions would imply further irreversible effects on the planet, with attendant long legacies for choices made by contemporary society. (Soloman et al. 2009: 1708-1709).

According to Archer and Brovkin (2008):

The notion is pervasive in the climate science community and in the public at large that the climate impacts of fossil fuel CO_2 release will only persist for a few centuries. This conclusion has no basis in theory or models of the atmosphere/ocean carbon cycle, which we review here. The largest fraction of the CO_2 recovery will take place on time scales of centuries, as CO_2 invades the ocean, but a significant fraction of the fossil fuel CO_2, ranging in published models in the literature from 20–60%, remains airborne for a thousand years or longer. Ultimate recovery takes place on time scales of hundreds of thousands of years, a geologic longevity typically associated in public perceptions with

nuclear waste. The glacial/interglacial climate cycles demonstrate that ice sheets and sea level respond dramatically to millennial-timescale changes in climate forcing. There are also potential positive feedbacks in the carbon cycle, including methane hydrates in the ocean, and peat frozen in permafrost, that are most sensitive to the long tail of the fossil fuel CO_2 in the atmosphere.
(Archer and Brovkin 2008: 283).

Certainly, the Service must consider the long legacy of impacts from anthropogenic CO_2 on extinction risk for the San Bernardino flying squirrel. The Service must act in time to protect the flying squirrel while actions can still be taken to ameliorate threats and before irreversible climate impacts commit it to extinction.

iii. Tipping points and feedbacks

Current climate forcings have the potential to trigger "tipping points," critical points where the rapid climate changes proceed practically out of our control without any additional forcing (Hansen et al. 2008) wherein the system shifts to qualitatively different state (Lenton et al. 2008). In reviewing the "tipping elements" in the Earth's climate system that could be altered by anthropogenic climate forcing, Lenton et al. (2008) reported that the Arctic summer sea-ice and Greenland ice sheet are extremely close to reaching a tipping point. Climate forcings can also trigger reinforcing positive feedbacks that can further amplify warming. For example, the Arctic ice-albedo feedback loop is already occurring, where the loss of sea ice due to warming reduces the surface albedo and makes the Arctic more vulnerable to future warming. Scientific studies indicate that increased warming will trigger other feedbacks, including the mobilization of carbon in tropical peatlands which are vulnerable to land clearing and drainage, and the release of methane from Arctic permafrost due to warming, a potent greenhouse gas that will result in more warming (Richardson et al. 2009). Thus, the Service must take into account the potential for non-linear and rapid effects of climate change on the San Bernardino flying squirrel.

iv. Greenhouse gas reductions needed to avoid dangerous climate change and protect the flying squirrel

Hansen et al. (2008) presented evidence that atmospheric CO_2 must be reduced from the current concentration of ~390 ppm to at most 350 ppm to avoid "dangerous climate change" and "maintain the climate to which humanity, wildlife, and the rest of the biosphere are adapted." Hansen et al. (2008) found that our current CO_2 level has committed us to a dangerous warming commitment of ~2°C temperature rise still to come and is already resulting in dangerous changes: the rapid loss of Arctic sea-ice cover, 4° poleward latitudinal shift in subtropical regions leading to increased aridity in many regions of the earth; the near-global retreat of alpine glaciers affecting water supply during the summer; accelerating mass loss from the Greenland and west Antarctic ice sheets; and increasing stress to coral reefs from rising temperatures and ocean acidification. Hansen et al. (2008) concluded that the overall target of at most 350 ppm CO_2 must be pursued on a timescale of decades since paleoclimatic evidence and ongoing changes suggest that it would be dangerous to allow emissions to overshoot this target for an extended period of time:

If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, paleoclimate evidence and ongoing climate change suggest that CO_2 will need to be reduced from its current 385 ppm to at most 350 ppm, but likely less than that. (Hansen et al. 2008:217).

Numerous scientific studies also indicate that climate change resulting from greenhouse gases currently in the atmosphere constitutes "dangerous anthropogenic interference" (DAI) with regard to species and ecosystems (Warren 2006, Hansen et al. 2008, Lenton et al. 2008, Jones et al. 2009, Smith et al. 2009). With atmospheric carbon dioxide at ~390 ppm and worldwide emissions continuing to increase by more than 2 ppm each year, rapid and substantial reductions are clearly needed immediately to protect the San Bernardino flying squirrel and avoid dangerous climate change.

2.   Forest Management Practices in the San Bernardino National Forest

The forest and riparian habitat of the San Bernardino flying squirrel has been degraded by past and current forest management practices on the San Bernardino National Forest, including logging, fuels reduction, past and current fire suppression, and livestock grazing (Stephenson and Calcarone 1999). Current forest management practices that pose a significant threat to the San Bernardino flying squirrel through loss and degradation of its habitat are "fuels reduction" projects that are removing habitat features that are critical for the San Bernardino flying squirrel, including canopy cover, snags, coarse woody debris, and understory cover (U.S. Forest Service 2005d). The U.S. Forest Service identified the major threat to the San Bernardino flying squirrel as "private land developments and <u>fuels management</u> that change mature forest habitats into more open areas with lower tree densities and less forest floor structure" (emphasis added) (U.S. Forest Service 2005d).

As discussed below, forest management practices pose a threat to the flying squirrel because (a) fuels reduction projects are degrading flying squirrel habitat in the mixed conifer forests of the San Bernardino and San Jacinto mountains; (b) the Forest Service is not monitoring the impacts of fuels reduction projects on the San Bernardino flying squirrel; and (c) fuels reduction projects are based on assumptions about fire risk and fire ecology that are not grounded in the best-available science.

a.   Fuels reduction projects are degrading flying squirrel habitat in the mixed conifer forests of the San Bernardino and San Jacinto Mountains

i.   Impacts of fuels reduction management

A principal objective of the San Bernardino National Forest Land Management Plan ("Forest Plan") is to carry out fuels reduction management with the aim of "reduction of hazardous fuels" (U.S. Forest Service 2005b, a, c). The primary fuels reduction activities include salvage logging to remove trees killed or damaged by fire or bark beetles (i.e. mortality removal) which can be accomplished through commercial timber sales, thinning of living trees including large trees, "hazard tree" removal, thinning and removing shrubs (mechanically, with herbicides,

or prescribed burns), construction and maintenance of fuel breaks, and creation and maintenance of Wildland/Urban Interface (WUI) Defense and Threat Zones (U.S. Forest Service 2005b: 25-27). Importantly, the Forest Service's fuels reduction activities go far beyond the construction of WUI Defense Zones to protect communities, but apply to large areas of the San Bernardino National Forest under the guise of maintaining "forest health" (U.S. Forest Service 2005a: 21-31).

The best available science indicates that the fuels reduction activities required under the Forest Plan can significantly degrade forest ecosystem integrity by damaging soil, vegetation, riparian areas, old-growth stands, organic and inorganic cycles, areas with fragile soils and steep slopes, and the ability of the forest to recover from changes, as detailed below. Of particular concern for the San Bernardino flying squirrel, fuels reduction activities remove habitat components from mixed conifer forests that are critical to the flying squirrel and its mycorrhizal food sources, including canopy cover, snags, coarse woody debris and downed logs, and understory cover (U.S. Forest Service 2005d).

Thinning operations tear up ground-cover plants, remove large trees that shade the understory, decrease canopy cover, and create logging roads that fragment habitat and heighten the risk that human-caused wildfires will be ignited. Salvage logging often is a full-scale, commercial operation that can inflict the same degree of damage to soil, water, vegetation, and wildlife as any other equivalent logging operation. However, it does so during a time period when forest resources are highly susceptible to incremental damage, causing significantly increased adverse effects on forest and watershed resources. Salvage logging can decrease plant regeneration by mechanical soil and plant damage and changes in microclimate, and is likely to have unanticipated consequences concerning microhabitat for species such as soil microbes (Beschta et al. 2004, Donato et al. 2006, Reeves et al. 2006). Heavy equipment disturbs and compacts soils, and removes trees and logs that would otherwise shelter wildlife and new growth, trap moisture, stabilize slopes, and restore nutrients to the soil (Lindenmayer and Noss 2006). Salvage logging reduces downed wood that provides a source of organic matter critical to soil productivity and topsoil formation. As summarized by Lindenmayer and Noss (2006), salvage logging can "reduce or eliminate biological legacies (e.g., burned trees, logs), modify rare post-disturbance habitats, influence populations, alter community composition, impair natural vegetation recovery, facilitate the colonization of invasive species, alter soil properties and nutrient levels, increase erosion, modify hydrological regimes and aquatic ecosystems, and alter patterns of landscape heterogeneity….we believe new terminology is needed. The word salvage implies that something is being saved or recovered, whereas from an ecological perspective this is rarely the case" (p. 949). Hazard tree removal can significantly reduce large trees and snags and often occurs along remote logging roads where very little danger to the public exists. Fuelwood programs can have a detrimental effect on wildlife and forest ecosystems since large snags and large downed logs that are reachable by roads are often targeted.

Also of concern, the Forest Plan specifies the creation of WUI Defense and Threat Zones that are much larger than needed to protect structures and communities as indicated by the best available science. Scientific studies indicate that thinning of brush and small trees in an area of ~100 to 200 feet from homes and structures protects structures and their immediate surroundings from the risk of ignition (Cohen 2008). However, the Forest Plan defines the WUI as "a variable

width up to 1.5 miles from communities at risk or as defined in individual community fire protection plans"; the WUI includes a Defense Zone and a Threat Zone (U.S. Forest Service 2005c: 81). The Defense Zone is "the area directly adjoining structures and evacuation routes that is converted to a less-flammable state" by tree thinning and pruning to meet the standard of no more than 40 percent crown closure, mechanical or hand removal of brush, and the use of prescribed fire (U.S. Forest Service 2005c: 81). The Forest Plan specifies that Defense Zones in forested areas can range from 300 to 1,500 feet in most cases, "although a larger defense zone could be necessary in an extreme situation" (U.S. Forest Service 2005c: 82). In addition to the Defense Zone, the plan requires a Threat Zone that "generally extends approximately 1 1/4 miles out from the Defense Zone boundary" (U.S. Forest Service 2005c: 81). The Plan specifies that Threat Zones in forested areas may also need "significant treatments" including potential thinning to achieve as low as 30 percent crown closure (U.S. Forest Service 2005c: 82). These large WUI zones are of concern because they significantly reduce canopy cover and eliminate or significantly reduce snags and downed logs that are essential habitat features for flying squirrel foraging, reproduction, and movement. As described below, as urban development increases in the San Bernardino National Forest, WUI Defense and Threat Zones will keep pushing further into flying squirrel habitat.

ii. Proposed and recently completed fuels reduction projects in San Bernardino flying squirrel habitat

There are a large number of currently proposed and recently completed fuels reduction projects in the upper-elevation mixed conifer forests of the San Bernardino National Forest in San Bernardino flying squirrel habitat (SBNF 2007-2010) that threaten the flying squirrel on a project-specific and cumulative basis. Proposed fuels reduction projects in the San Bernardino Mountains with the potential to negatively impact San Bernardino flying squirrel habitat include South Big Bear, North Big Bear, Bluff Mesa, Santa Anna, and Baldwin Lake projects (SBNF, SOPA 6/30/2010). Recently completed projects include Butler II Slide (SBNF, SOPA 3/30/2009) and Deep Creek/Green Valley (SBNF, SOPA 12/31/2007). In the San Jacinto Mountains, the May Valley and Santa Rosa Mountain fuel reduction projects (SBNF, SOPA 6/30/2010) have the potential to negatively impact San Bernardino flying squirrel habitat, in addition to the recently completed Thomas Mountain (SBNF, SOPA 9/20/2009) and Miller Canyon projects.

As examples of impacts, the North Big Bear and South Big Bear projects specify four treatment levels depending on distances from property and structures, all of which reduce canopy cover, snag densities, downed log densities, and understory cover. The North Big Bear project specifies the following reductions (U.S. Forest Service 2009):

Treatment level 1, Defense Zone, 598 acres (0-100 feet from roads and property boundaries): no snags or coarse woody debris; canopy cover at 40% maximum; shrub canopy cover averages 20% or less.
Treatment level 2, Defense Zone, 1,673 acres (100-300 feet beyond Treatment Level 1): 2 snags per acre; 6 logs per acre; canopy cover at 40-50% maximum; shrub canopy cover averages 30% or less.

Treatment level 3, Threat Zone, 1,276 acres (outside defense zone): 4 snags per acre; 9 logs per acre; open structure averaging 40% crown cover with an overstory featuring large diameter trees with 10-20 foot spacing between individual tree crowns; shrub canopy cover averages 30% or less.

Treatment level 4a,b, Threat Zone—Resource Protection Area, 1,622 acres (outside defense zone but inside spotted owl habitat): 8 snags per acre; 9 logs per acre; moderate to dense structure; retain existing overstory while thinning the midstory and understory to remove ladder fuels; maintain a minimum of 70% average canopy closure; shrub canopy cover averages 30% or less.

b. The Forest Service does not monitor the impacts of fuels reduction projects on the San Bernardino flying squirrel

Despite its classification as a Sensitive Species, the Forest Plan for the San Bernardino National Forest does not require the Forest Service to determine the habitat requirements for the San Bernardino flying squirrel through appropriate field studies to ensure that fuels reduction projects are not negatively impacting the squirrel. Moreover, the Forest Service does not monitor the impacts of its logging and thinning fuels reduction activities on the San Bernardino flying squirrel, its food supply (mycorrhizae and lichen), or its habitat, nor does the agency monitor the cumulative impacts from multiple projects on the squirrel (U.S. Forest Service 2005b, a, c). However, these projects are removing essential habitat features for the flying squirrel on a large scale. This is especially troubling given that recent U.S. Forest Service Forest Inventory and Analysis (FIA) data from 3,542 fixed plots throughout California found that large snags are in severe deficit across all forested areas of California (Christensen et al. 2008). The analysis found that there are less than two large snags per acre. Specifically, survey units averaged 0.2 snags per acre (range 0.1 to 0.5) in the very large class (>40 inches d.b.h.), fewer than 2 snags per acre in the large class (≥20 inches d.b.h.), and 6 to 14 per acre in the small class (<20 inches d.b.h). In addition, when compared across five forested regions of the state, downed wood was at the second lowest level in Southern California. The Forest Service report concluded that the current level of large snags may not be sufficient for some wildlife species and recommended that studies be conducted to determine the size class distributions needed by wildlife species:

> We tallied dead wood in various size classes throughout California and the estimated density of large snags may not be sufficient for some wildlife species. For example, every survey unit averaged fewer than two large snags ≥20 inches d.b.h. per acre, while smaller snags averaged 6 to 14 per acre in the same areas. Wildlife species favoring even larger snags (≥40 inches d.b.h.) would find only 0.1 to 0.5 per acre in this size class across the state, indicating that large dead wood appears to be uncommon in California habitats. This may signal the need for a more in depth analysis of these important habitat elements, in terms of size class distributions needed by individual wildlife species in different areas of the state. Various types of disturbance can radically change the habitat quality of a forest by shifting the balance of live and dead trees or FWM and CWM. Biologists and land managers may find it advisable to monitor these changes to determine whether the density and size distribution of dead wood are adequate for the wildlife species being managed. (Christensen et al. 2008: 40).

> **c.** **The fuel reduction projects are based on assumptions about fire risk and fire ecology that are not grounded in the best-available science**

The fuels reduction program of the San Bernardino National Forest poses a threat to the San Bernardino flying squirrel not only because management practices are removing essential habitat features but also because these practices are based on the premise that they are improving forest health (U.S. Forest Service 2005b: 24-27), when in fact, a review of the best-available science indicates that these fuels reduction projects can cause significant harm to forest species and ecosystems. Importantly, the justification for the fuels reduction program, as described in the Forest Plan, is premised on several assumptions that are not scientifically well-grounded: (a) forests are unnaturally dense due to fire suppression; (b) the historic fire regime in the conifer forests was characterized by frequent low intensity fire at intervals of less than 20 years; (c) forests that have missed fire cycles are burning more intensely, and thus they must be thinned; (d) fire is burning at unnaturally high levels, especially for high intensity fire; and (e) high intensity fire is ecologically destructive and "unhealthy" (*See* U.S. Forest Service 2005a: 21-31; U.S. Forest Service 2005b: 24-27). Each of these assumptions is briefly examined below to show that the Forest Service fuels reduction program is not grounded in the best-available science, threatens the San Bernardino flying squirrel by removing essential habitat features (U.S. Forest Service 2005d), and should be revised based on the best-available science so as to protect forest ecosystems and species.

> **i.** **Assumption: forests are unnaturally dense due to fire suppression**

Although the fuels reduction program assumes that the mixed conifer forests of the San Bernardino National Forest are unnaturally dense due to fire suppression, there is little historic information for determining the forest structure and density before the era of intensive logging that lasted from the 1850s to the 1990s and the era of fire suppression which began in the early 1900s and continues today. Two frequently cited sources for understanding pre-logging and pre-fire-suppression forest structure--Leiberg (1899a, 1899b) which uses a baseline of 1898 and Minnich et al. (1995) which uses a 1929-1935 baseline--describe the forests well after the forests had already been dramatically altered by logging. As described briefly below, intensive clear-cutting, shelterwood removal, and seed tree removal were already significantly altering the forest of the San Bernardino Mountains by the 1850s and the San Jacinto Mountains by the 1870s.

In the San Bernardino Mountains, large-scale logging (e.g. clearcutting, shelterwood, and seed tree removal) was initiated between 1852-1857 by Mormon settlers, starting in Mill Creek and expanding to the high country from Sawpit Canyon east to Huston Flat (Lake Gregory) (Robinson 1989). This spurred a long era of intensive logging of the western half of the San Bernardino Mountains, which provided a local, abundant source for building San Bernardino and Los Angeles (Robinson 1989). As noted by Robinson (1989): "The Mormon Era was over but the lumbering era in the mountains was just beginning. By the time the whining sawmills were finally stilled half a century later, the mountains would be largely denuded from Sawpit Canyon as far eastward as Running Springs and Green Valley with only isolated patches of tall forest remaining untouched" (Robinson 1989: 23). Logging in the 1880s for building materials, citrus boxes, ties for Santa Fe railroad, and mine shafts reached 4 million board feet in 1881 and 6

million board feet in 1883 (Robinson 1989). In 1891 forests from Hunsaker Flats west to Heap's Ranch and east to Green Valley were reportedly stripped almost bare (Robinson 1989). Logging reportedly peaked in 1900 when a single mill from the Brookings Lumber Company cut 12 million board feet, and subsided in 1912 after three fourths of timber owned or leased had been cut (Robinson 1989). Between the 1910s and 1950s, a profusion of smaller sawmills in Bear Valley and Holcomb Valley continued logging at lower levels (Robinson 1989). Large-scale, high intensity logging in the San Bernardino Mountains was also described by Leiberg (1899a) in 1899:

> From Green Valley to Strawberry Flat there are good stands of young trees, everywhere ten to twenty years old, to replace burnt or logged-off areas…A large quantity of the forest fit for merchantable timber has been logged off. Sawmills have been in operation for many years. Some of the cutting dates back twenty-five or thirty years. Some is recent, and tow sawmills are not running or will soon go into operation. The logged-off areas lie along the main range from Seely Flat to Orchard Canyon. There is also a small tract at the head of City Creek, around the Highland mill, that has been cut over to the extent of 99 per cent. (p. 362).

In the San Jacinto Mountains, much of the forests were cut in the 1870s. As described by Leiberg (1899b) in 1899:

> Timber cutting has been extensive in the upper basins of the North Fork and Middle Fork of the San Jacinto. The beginning dates back between fifteen and twenty years. There are at present three sawmills in the region; two are in operation. Most of the timber lands that are accessible have been surveyed and the title is vested in the Southern Pacific Company or in private individuals (p. 354-355).

Logging in the San Bernardino National Forest continued at a high level from the late 1940s through the mid-1980s through the Forest Service's commercial timber program (Figure 17) (Stephenson and Calcarone 1999). In 1953 the Forest Service initiated a policy to perpetuate second growth by cutting burned and diseased trees, and it contracted with Big Bear Timber Company to select and cut damaged trees (Robinson 1989). In 1954 Big Bear Timber Co. cut 7 million board feet of marketable lumber and an equal amount of unmarketable lumber and snags (Robinson 1989). Following the November 1970 Bear Creek Fire, which burned over 56,000 acres southwest of Big Bear Lake, the Forest Service authorized the logging of 22,000 acres; Big Bear Timber Co. logged 15,000 acres while another 7,000 acres in steep areas were logged by helicopters, yielding 17 million board feet. An estimated 362.3 million board feet of timber was removed from San Bernardino and Los Angeles counties between 1947 and 1990, mostly from the San Bernardino Mountains (McKelvey and Johnston 1992). In sum, almost 130 years of intensive clear-cutting, shelterwood cutting, seed tree removal, and removal of snags and understory trees certainly substantially altered all aspects of forest structure. Determining the pre-logging, pre-fire-suppression structure and density of the San Bernardino National Forest is a difficult task given the lack of historic information, which is not acknowledged in the San Bernardino National Forest Management Plan and vegetation management plan within.

Figure 17. Logging intensity in the San Bernardino and Los Angeles counties, 1947 to 1990. Most of this timber came off the San Bernardino National Forest (from McKelvey and Johnston 1992).
Source: Stephenson and Calcarone (1999): Figure 3.13.
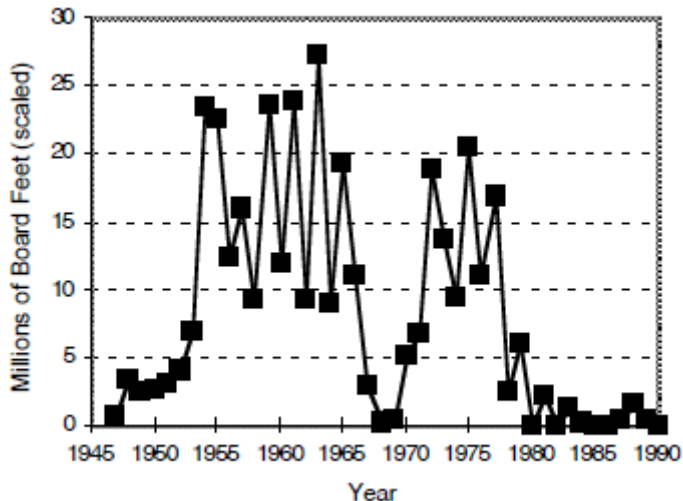
ii.   **Assumption: the historic fire regime in conifer forests was characterized by frequent (<20-year interval) low intensity fire**

Fire-scar studies have suggested that California mixed conifer forests historically burned frequently at fire intervals of less than 20 years at low intensities with little high-intensity fire (Minnich et al. 2000). For exampled, fire-scar dendrochronology studies in California estimated pre-suppression mean fire-return intervals of 1.9 to 6.4 years in ponderosa pine forest of the U.S. Southwest (Savage and Swetnam 1990 cited in Minnich et al. 2000), 9 to 18 years in the Sierra Nevada (Kilgore and Taylor 1979 cited in Minnich et al. 2000), and 10 to 12 years in the ponderosa and Jeffrey pines of the San Bernardino Mountains (McBride and Laven 1976). Because the fire intervals were short, it was assumed that pre-suppression fire intensities were low since the frequent fires would have consumed most fuels (litter, shrubs, seedlings, immature trees, and senescent groups), precluding high intensity fire (Minnich et al. 2000). However, several recent studies counter these conclusions about historic fire regimes.

A fire-scar study of mixed conifer forests of the Sierra San Pedro Martir in Baja California, which have not been subjected to fire suppression, estimated a significantly longer fire interval than pre-suppression estimates for southern California, as well as the occurrence of high-intensity stand-replacing fire. Minnich et al. (2000) estimated a 52-year fire rotation period in these mixed conifer forests. In addition, an average of 16% of stands sampled experienced stand-replacing burns (< 10% surviving forest cover), 23-31% sustained intense surface fires (> 10% mortality of canopy trees), and 58% of experienced low intensity surface fires (< 10% mortality of canopy trees). This study counters the presumption of ~10-year surface fire intervals and negligible levels of high intensity fire in San Bernardino National Forest mixed conifers.

Moreover, a review of fire-scar studies by Baker and Elle (2001) found that fire-scar studies may produce biased estimates of fire return intervals that result in misconceptions about

historic fire regimes and forest structure. First, due to problematic methodologies and assumptions, fire-scar studies tend to estimate overly-short fire return intervals, leading to the conclusion that surface fires were extremely frequent. Furthermore, fire-scar studies cannot detect the occurrence of high intensity fire since most trees are killed, and thus underemphasize the occurrences of these fires. As an example, Baker and Elle (2000) found that the mean fire interval for western ponderosa pine forests was more likely to range between 22 and 308 years rather than the reported mean fire intervals of 2 to 25 years based on fire-scar studies. Baker and Elle (2001) noted that longer mean fire intervals and spatially patchy fires would have produced a greater diversity of forest structures than is commonly assumed, including dense thickets of regenerating trees and dense old patches of trees, rather than a uniformly low-density forest structure. Because dense forests are important to many wildlife species, they cautioned that widespread restoration of low-density forest across the landscape can be detrimental to wildlife. They also found that both surface fires and high-intensity stand-replacing crown fires were important processes that shaped the pre-European ponderosa pine forest landscape. They cautioned that more careful study is warranted before setting fuels reduction goals:

> We suggest that restoration of fire as a process is certainly warranted, but quantitative targets for how frequent prescribed fires should be, how much land area should be burned in a particular year, or how much fuel reduction is appropriate (Babbitt 1997; Laverty and Williams 2000) are premature because of large uncertainty about mean fire intervals and fire rotations. More careful study is also warranted before physical restoration of forest structure or fuels is undertaken on a wide scale (Covington 2000; Laverty and Williams 2000). This is particularly true in valuable National Parks, Research Natural Areas, and other protected areas, where a goal is often to maintain natural ecosystems and the species dependent upon them.

iii. Assumption: forests that have missed fire cycles are burning more intensely

Research indicates that California mixed conifer forests that have missed the greatest number of fire cycles due to fire suppression are not burning more intensely than forests that have missed fewer fire cycles (Odion and Hanson 2006, 2008, Odion et al. 2010). For example, Odion et al. (2010) found that mixed conifer forests in the Klamath Mountains of northwestern California became more fire-resistant with increasing time since fire. Specifically, fire intervals greater than 75 years led to a significantly lower probability and maximum size of large high-severity burned patches than where the fire interval was shorter. The researchers hypothesized that forests became less pyrogenic with longer fire intervals and with stand age: the closed canopy produces a microclimate less favorable to fire as surface fuels stay moister; larger trees and fallen logs act as heat sinks during fire; and forest stands begin to self-thin small trees and lower branches of large trees. They concluded that "long fire intervals may increase both the resistance of forests to fire and their resiliency after fire" (p. 102). They questioned current vegetation management practices that thin and construct fuelbreaks based on the assumption that fire exclusion leads to more pyrogenic forests:

Our findings that fire exclusion leads to afforestation and loss of vegetation that is dependent on frequent fire are consistent with global patterns (Bond, Woodward & Midgley 2005). However, our results conflict with assumptions regarding fire-prone forested landscapes of the study region (Spies et al. 2006) and western United States of America that fire exclusion leads to more pyrogenic forests, increasing the probability of high-severity fire. Current management based on these prevailing views, such as thinning forest stands, constructing fuelbreaks and establishing plantations after fire, does not address the rapid decrease in fire-dependent sclerophyll vegetation and changes to forests that are caused by fire exclusion in the study region. (Odion et al. 2009: 103).

> iv. **Assumption: fire is burning at unnaturally high levels, especially high intensity fire**

The Forest fuels reduction program is premised on the assumption that fire in the San Bernardino National Forest is burning at unnaturally high levels, and particularly that high severity fire is occurring at excessive levels. However, this premise is not supported by the best-available science. A comprehensive study to assess the frequency, extent, and magnitude (size and severity) of all large wildland fires in the western U.S. found no consistent trend toward either greater burned area, greater number of fires, or higher burn severity in the Pacific Southwest or Pacific Northwest during 1984-2005 (Figure 18) (Schwind 2008). Instead western conifer forests appear to be dominated by low- and moderate-intensity fire, with high-intensity fire comprising a minor portion of the overall area burned (Odion and Hanson 2008, Schwind 2008).

Figure 18. Percent of acres burned by severity for the Pacific Southwest MTBS mapping zone between 1984 and 2005.
Source: Schwind (2008): Figure 14.
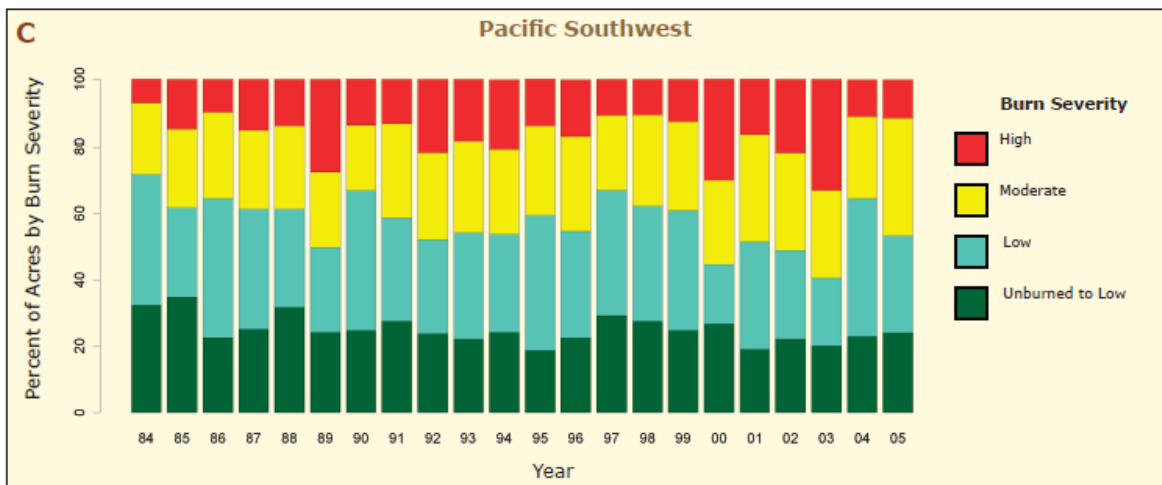
In fact, as a result of fire suppression, fire of all intensities in California is still burning significantly below the historic extent. An estimated 1,800,000 hectares of California wildlands burned each year pre-historically compared with about 2,000,000 hectares burned in the entire U.S. over a decade (1994-2004) (Stephens et al. 2007). First-hand accounts in the late 1800s

indicate that California skies were smoky in the summer and fall before fire suppression (Stephens et al. 2007).

In regard to high intensity fire, reconstructions of historic fire regimes indicate that high intensity fire was common in most conifer forests of the western U.S. prior to fire suppression and logging, even in pine-dominated forests with frequent fire regimes, and high intensity fire patches could be quite large (Beaty and Taylor 2001, Baker et al. 2007, Hessberg et al. 2007, Hanson 2010). For example, a reconstruction of historic fire occurrence in eastern Washington dry mixed conifer forests found that mixed severity (high, moderate, low), rather than low severity, fires were dominant (Hessberg et al. 2007). A reconstruction of historic fire occurrence in a mixed conifer forest in the southern Cascades found mid-elevation slopes to be dominated by moderate-intensity fire (mixed with low and high intensity) while upper-elevation slopes were dominated by high intensity fire (Beaty and Taylor 2001). In addition, data on fire rotation intervals indicate that there was about two to four times more high-intensity fire historically in western U.S. conifer forests than there is today (Hanson 2010). For example, the high-intensity fire rotation interval in the dry ponderosa pine forests of the Southwest was estimated at 300-400 years before fire suppression and logging, and about 625 years today (Rhodes and Baker 2008).

> ### v. Assumption: high intensity fire is ecologically destructive and "unhealthy"

Numerous studies have found that high-intensity fire and the snag forest and early successional habitats it creates are ecologically important and "natural," biodiverse, and under-represented (Hutto 2006, Noss et al. 2006, Hutto 2008, Swanson et al. 2010). Mature forests that burn at high intensity are important for cavity-dependent species that often select large snags for nesting and denning. Early successional ecosystems created by high intensity fire typically have complex food webs and high species diversity comprised of opportunists and habitat specialists that require the distinct conditions created by intense fires (Swanson et al. 2010). As summarized by Hutto (2006), "[t]he dramatic positive response of so many plant and animal species to severe fire and the absence of such responses to low-severity fire in conifer forests throughout the U.S. West argue strongly against the idea that severe fire is unnatural":

> Besides the growing body of evidence that large, infrequent events are ecologically significant and not out of the range of natural variation (Foster et al. 1998, Turner & Dale 1998), an evolutionary perspective also yields some insight into the 'naturalness' of severely burned forests… The dramatic positive response of so many plant and animal species to severe fire and the absence of such responses to low-severity fire in conifer forests throughout the U.S. West argue strongly against the idea that severe fire is unnatural. The biological uniqueness associated with severe fires could emerge only from a long evolutionary history between a severe-fire environment and the organisms that have become relatively restricted in distribution to such fires. The retention of those unique qualities associated with severely burned forest should, therefore, be of highest importance in management circles. (Hutto 2006: 987).

3.   Urban Air Pollution

Numerous studies have documented the impacts of exceptionally high levels of nitrogen deposition and ozone enrichment in the forests of the San Bernardino Mountains (Fenn and Poth 1999, Fenn et al. 2003a, Fenn et al. 2003b, Fenn et al. 2005, Fenn et al. 2008). Ongoing, chronic urban air pollution threatens the San Bernardino flying squirrel by (a) decreasing the abundance of arboreal lichen forage species; (b) reducing the diversity of understory forest cover; (c) decreasing the abundance of mycorrhizae; and (d) potentially increasing the susceptibility of pines to drought.

Nitrogen deposition rates in southern California forests and chaparral in the Los Angeles air basin are the highest in North America (Fenn et al. 2003b). The most exposed areas are the south-facing slopes of the San Gabriel Mountains and the western and southern edges of the San Bernardino Mountains (Fenn et al. 2003b). Nitrogen and ozone pollutants are generated by the greater Los Angeles metropolitan area, primarily from fossil fuel combustion (e.g. vehicle exhaust, residential production, and industry) and secondarily from fertilizer use; these pollutants are transported downwind to the San Bernardino Mountains (Fenn et al. 2003a, Fenn et al. 2005). Fossil fuel combustion emits nitrogen oxide, which is converted to other nitrogen oxides (NOx) and O_3 in the presence of ultraviolet light, while agricultural areas produce NH_3 and NOx emissions from fertilized soils and manure from feedlots (Bobbink et al. 2010).

Nitrogen deposition inputs in the low- and mid-elevation mixed conifer forests of the San Bernardino Mountains range from 20 to 45 kg per ha per year in the most exposed areas (Fenn et al. 2003b). However, deposition rates can double in years with high fog deposition, particularly when fog occurs in late summer with unusually high NO_3^- and NH_4^+ concentrations (Fenn et al. 2003b). Deposition under canopies of large trees can be even higher (Fenn et al. 2003b). Ozone concentrations are also high and average 80 ppb over June, July, and August during daylight hours (Grulke et al. 2005). Nitrogen deposition in the San Bernardino Mountains declines sharply with distance from the source areas, resulting in a pollution gradient in which the western and southern regions are most impacted (Fenn et al. 2003b).

Due to high nitrogen loading, montane forests exposed to air pollution in the San Bernardino Mountains are nitrogen saturated, as indicated by high streamwater NO_3^- export and elevated nitric oxide (NO) emissions from soil (Fenn et al. 2005). The streamwater NO_3^- concentrations from montane watersheds downwind of greater Los Angeles are the highest in North America (Fenn et al. 2003a). Some streams from high-elevation areas in the San Bernardino Mountains export high levels of NO_3^-, with peaks as high as 370 µeq per L (Fenn and Poth 1999). Nitrate concentrations in springs indicate that nitrogen deposition is affecting NO_3^- levels in groundwater (Fenn et al. 2003a). High fluxes of NO from high-deposition forested areas of the San Bernardino Mountains are largely reemissions from soil of atmospherically deposited nitrogen and rival those of fertilized croplands (Fenn et al. 2003a). Nitrogen deposition and ozone enrichment have already had significant ecological impacts in the San Bernardino Mountains that threaten the San Bernardino flying squirrel, as detailed below.

a.   Decreases in the abundance of acidophyte lichens

Nitrogen deposition and ozone enrichment have been linked to dramatic alterations in the epiphytic lichen communities in the San Bernardino Mountains (Fenn et al. 2003a, Fenn et al. 2008). Up to 50% of the lichen species that occurred in the San Bernardino Mountains in the early 1900s have disappeared; the principal species suffering from local extinctions are acidophytes (Fenn et al. 2003a). Lichens appear to be the most sensitive terrestrial species to N enrichment and serve as ''canaries in the coal mine'' for biological change from air pollution (Fenn et al. 2008). Distinct shifts in lichen community composition, from sensitive to more tolerant species, occur at N loading levels as low as 3-5 kg ha^{-1} yr^{-1} in California mixed conifer forests (Fenn et al. 2008). Fenn et al. (2008) predicted that the relative abundance of acidophytes in the lichen community is expected to drop by 50% at a N load level of 5.7 kg N ha^{-1} yr^{-1}, and that complete extirpation of acidophytes from the lichen community will occur at an N load of about 10.2 kg ha^{-1} yr^{-1}. Fenn et al. (2008) recommended a critical load for lichens of 3.1 kg N ha^{-1} yr^{-1}, defined as the deposition level at which unacceptable impacts occur to lichen. However, this level of deposition or greater occurs over most of the forested region of the San Bernardino Mountains (Fenn et al. 2008). Fenn et al. (2008) highlighted the severe ecological consequences of acidophyte lichen loss, including negative impacts on flying squirrels that eat lichen acidophytes like the bearded lichen *Bryoria fremontii*. The researchers concluded that "[t]he maintenance of healthy acidophyte populations is of particular concern because they are an integral part of food webs and are used as nesting material and habitat for insects, mollusks, birds, and animals" (p. 505).

b. Declines in understory plant diversity

Nitrogen deposition and ozone enrichment are associated with a decline in understory plant diversity in the mixed conifer forests of the San Bernardino Mountains (Bobbink et al. 2010). Allen et al. (2007) cited in Bobbink et al. (2010) found significant decreases in understory diversity of forest plants over a 30-year period. The highest declines, estimated at 20-40% of species lost between 1973 and 2003, occurred at the most polluted sites. Although changes in precipitation and local disturbance may have contributed to species' losses, ozone enrichment and N deposition appeared to increase litter depth and encourage the growth of exotic species to the detriment of native species (Bobbick et al. 2010). Flying squirrels are associated with greater understory cover which is thought to provide protection from predators while they are foraging on the ground for fungi. Loss of native understory diversity may negatively affect the San Bernardino flying squirrel by decreasing the cover of important species.

c. Decline in mycorrhizal fungi diversity

Nitrogen enrichment from air pollution has been linked to the decline in the diversity of mycorrhizae in coastal sage scrub in the San Gabriel Mountains, adjacent to the San Bernardino Mountains (Edgerton-Warburton et al. 2001, Fenn et al. 2003a). One study found that the diversity and density of arbuscular mycorrhizal fungal spores declined from 19 to 12 species with increasing soil N in southern California coastal sage scrub along an N deposition gradient (Fenn et al. 2003a). The largest-pored fungi of the genera *Scutellospora, Gigaspora, Acaulospora,* and *Entrophospora* were the primary species to decline or disappear with elevated N, while potentially less mutualistic species of small-spored *Glomus* increased. A similar pattern was found in the San Dimas Experimental Forest where large-spored species declined as soil N

increased from 1937 to the present and soils became N-saturated (Egerton-Warburton et al. 2001). Fungal colonization of native California shrub roots declined with elevated N, although this effect was not observed for exotic grass roots, and nitrogen enrichment enhanced the proliferation of potentially less mutualistic small-pored *Glomus*. Overall, N deposition appeared result in the decline of mycorrhizal diversity and benefit invasive plants and less mutualistic species of mycorrhizae. Although studies on the effects of nitrogen enrichment on hypogeous mycorrhizal fungi, a primary food source for the San Bernardino flying squirrel, are not yet available, the negative effects on arbuscular mycorrhizal fungi raise cause for concern.

d. Higher susceptibility to drought conditions

The combined effects of nitrogen and ozone enrichment on the physiological responses of conifers and black oaks in the San Bernardino Mountains are not yet well-understood (Fenn et al. 2005, Grulke et al. 2005, Nowinski et al. 2009). However, initial studies indicate that nitrogen and ozone enrichment result in a decrease in fine root biomass in ponderosa pines with increasing air pollution exposure across the San Bernardino Mountains (Fenn et al. 2008). Available data suggest that standing fine root biomass is reduced by 26% during the early season root growth flush period with N deposition of 17 kg ha^{-1} yr^{-1} for NO$_3^-$ leaching (Fenn et al. 2008). The loss of fine root biomass is thought to make ponderosa pine more susceptible to drought, which could result in changes in forest structure that are detrimental to the San Bernardino flying squirrel.

4. Urban Development in the San Bernardino and San Jacinto Mountains

The San Bernardino flying squirrel is threatened by the cumulative impacts of habitat loss and fragmentation from the expansion of existing communities and ski resorts in the San Bernardino and San Jacinto Mountains, by development in new areas, and by the construction of Wildland/Urban Interface (WUI) Defense and Threat Zones around communities and human structures to reduce wildfire risk. As detailed above, the northern flying squirrel is particularly sensitive to habitat fragmentation, whereby large openings affect the ability of individuals to forage and disperse. The northern flying squirrel is susceptible to population subdivision caused by deforested swaths as narrow as 30 m wide (Brylski 1998). Due to the proximity to the Los Angeles and San Diego metropolitan areas, human development and recreational uses in the San Bernardino and San Jacinto Mountains have continued to expand and are expected to intensify for the foreseeable future. Approximately 20 million people live within the metropolitan Los Angeles and San Diego areas, and by 2020, the region's population is expected to expand to 35 million people. The two counties inhabited by the San Bernardino flying squirrel, Riverside and San Bernardino, are home to 14 of the 20 fastest-growing cities in California.

The U.S. Forest Service identified the major threat to the San Bernardino flying squirrel as "private land developments and fuels management that change mature forest habitats into more open areas with lower tree densities and less forest floor structure" (emphasis added) (U.S. Forest Service 2005d). As summarized in the U.S. Forest Service, "Populations and habitat for San Bernardino flying squirrels on private land is declining rapidly. Most of the private land habitat is in or adjacent to the mountain communities in the San Bernardino and San Jacinto Mountains. This habitat is being developed at a very rapid pace as home construction and sales

continue to grow. As density and human (and pet) disturbance increase, there is a corresponding loss of flying squirrels" (U.S. Forest Service 2005d).

An additional threat is that increasing urban development will be accompanied by the creation and maintenance of WUI Defense and Threat Zones around human structures on the San Bernardino National Forest, which fragment and degrade flying squirrel habitat—a problem that will only increase with expanding human development. As stated in the San Bernardino National Forest Plan, "[c]ommunity defense zones are needed to protect the communities of Big Bear Lake, Big Bear City, Fawnskin, Moonridge, Sugarloaf, Baldwin Lake, Erwin Lake and Lake Williams" (p. 50) (U.S. Forest Service 2005b). In addition, the Strategy states that WUIs are applicable to national forest land, all structures upon them, and where national forest boundaries are directly adjacent to communities on private lands. In 2005, the annual need for Wildland/Urban Interface (WUI) Defense and Threat Zones in the San Bernardino National Forest was estimated at 6,500 acres (Defense 3,500, Threat 3,000) (U.S. Forest Service 2005b). Habitat treatments in the WUI Defense Zone include thinning of canopy cover, removal of snags and coarse woody debris, and thinning of understory cover, all of which remove essential habitat features for the San Bernardino flying squirrel and fragment its habitat.

The section below details a small sample of the currently proposed development projects in San Bernardino flying squirrel habitat in the San Bernardino Mountains that individually and cumulatively threaten the San Bernardino flying squirrel.

a.   Church of the Woods

The Church of the Woods project is proposed on 38 acres in the community of Rim Forest on the north side of Highway 18, approximately 450 ft. east of Bear Springs Road. The project site is 95% ponderosa pines, Jeffrey pine, white fir, incense cedar, and black oak, with a closed canopy, riparian habitat vegetation, and streams with flowing water. The entire project site is prime breeding habitat for the San Bernardino flying squirrel, including both riparian and upland habitat. The San Bernardino flying squirrel was observed in the project site (PCR Services Corporation 2010). As discussed in the draft EIR, the implementation of the proposed project would involve grading and alteration of 63 percent of the site and the loss of approximately 23 acres of the Westside ponderosa pine plant community. Due to habitat loss, the impacts of the project to the San Bernardino flying squirrel are considered "potentially significant" (PCR Services Corporation 2010).

b.   Moon Camp

The revised Moon Camp Development Project proposes 57 lots (Single Residential homes of 20,000 s.f. minimum lot size) and a marina on 62.43 acres located on State Highway 38 between Canyon Road and Polique Canyon Road, in the Fawnskin area of San Bernardino County. The San Bernardino flying squirrel was trapped in 1998 by the Forest Service approximately 0.5 mile north of the northern boundary of the project site (Michael Brandman Associates 2010). As described in the draft EIR, "the project site provides suitable foraging habitat for this species [the San Bernardino flying squirrel] and the potential for occurrence is considered high. The northeastern portion of the project site provides potential nesting habitat as the forest in this area more dense with some portions having a closed canopy" (p. 4.3-27)

(Michael Brandman Associates 2010). Furthermore, "the loss of tree density could reduce habitat for San Bernardino flying squirrel in the fire break area" (p. 4.5-11) (Michael Brandman Associates 2010).

c. Royal Rangers Adventure Camp and Conference Center

The proposed Royal Rangers campground site is a 50-acre "butterfly"-shaped parcel of land located within the Twin Peaks area of the San Bernardino County National Forest on the east side of State Highway 189 at Pinecrest Road and north of Highway 18 (Rim of the World Highway). The project site is largely undeveloped and covered by montane coniferous forest at elevations of 5,250 to 5,800 feet. As discussed in the EIR, this site contains habitat for the San Bernardino flying squirrel (Vista Community Planners 2010).

d. High Timber Ranch

The High Timber Ranch LLC project proposes 196 single family residential lots and 3 lettered lots on approximately 166 acres located in unincorporated San Bernardino County, community of Moonridge (County of San Bernardino 2008). The proposed project site is located within a Jeffrey pine forest community and in an area known to support the San Bernardino flying squirrel (County of San Bernardino 2007).

B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The northern flying squirrel has been considered a nuisance species because squirrels have been known to nest in the attics of houses, causing minor damage to the house as well as noise irritation to the owner of the house. San Bernardino flying squirrels have been documented suffering injury and mortality by being killed by domestic cats; they may also suffer injury and mortality by being removed from houses and captured by humans as pets. As communities in the San Bernardino and San Jacinto Mountains expand, the threat of house cat predation increases and may be significant in some regions. As summarized by the U.S. Forest Service, "As density and human (and pet) disturbance increase, there is a corresponding loss of flying squirrels" (U.S. Forest Service 2005d).

C. Disease and Predation

Disease has not been well-studied in the San Bernardino flying squirrel. However, recent evidence suggests that disease may pose a threat to this subspecies. Western grey squirrels (*Sciurus griseus*) have been found infected with West Nile virus in the San Bernardino Mountains (www.westnile.ca.gov/); recent declines in grey squirrels in the San Bernardino Mountains may be associated with West Nile virus and may pose a mortality risk to San Bernardino flying squirrels. In addition, climate change may affect the San Bernardino flying squirrels' interactions with pathogens and predators. Of particular concern, projected changes in temperature and humidity may increase disease prevalence and severity in the San Bernardino flying squirrel. Many wildlife and plant pathogens are sensitive to temperature, rainfall, and

humidity (Harvell et al. 2002). As the climate has warmed, these pathogens, in many cases, have expanded their ranges northward and upslope because warmer temperatures (1) have allowed their survival and development in areas that were previously below their temperature threshold, (2) increased their rates of development, (3) increased rates of reproduction and biting of their tick, midge, and mosquito vectors, and (4) lowered the resistance of their hosts (Harvell et al. 2002, Parmesan 2006). Thus, rising temperatures at higher elevations may increase the prevalence of diseases and disease vectors, exposing flying squirrels to new diseases or increasing the transmission of existing diseases.

D. Inadequacy of Existing Regulatory Mechanisms

1. Current Regulatory Mechanisms Addressing Greenhouse Gas Emissions and Climate Change Are Insufficient to Protect the San Bernardino Flying Squirrel

Greenhouse gas emissions pose a primary threat to the continued existence of the San Bernardino flying squirrel, and yet are among the least regulated threats. Regulatory mechanisms at the state, national and international level do not require the greenhouse gas emissions reductions necessary to protect the flying squirrel from extinction.

a. National and international emissions reductions needed to protect the San Bernardino Flying Squirrel

The best-available science indicates that atmospheric CO_2 concentrations must be reduced to at most 350 ppm to protect species and ecosystems, as detailed above. In order to reach a 350 ppm CO_2 target or below, numerous studies indicate that global CO_2 emissions must peak before 2020 followed by rapid annual reductions bringing emissions to or very close to net zero by 2050. The IPCC found that to reach a 450 ppm CO_2eq target, the emissions of the United States and other developed countries should be reduced by 25 to 40% below 1990 levels by 2020 and by 80-95% below 1990 levels by 2050 (Gupta et al. 2007); thus reductions to reach a 350 ppm CO_2 target must be more stringent. Baer and Athanasiou (2009) outlined a trajectory to reach 350 ppm CO_2 target by 2100 that requires 2020 global emissions to reach 42% below 1990 levels, with emissions reaching zero in 2050.They concluded that Annex I (developed country) emissions must be more than 50% below 1990 levels by 2020 and reach zero emissions in 2050 (Baer and Athanasiou 2009).

b. State climate initiatives are insufficient

California is the world's sixth largest economy and the twelfth largest polluter in its own right, and is also a leader in climate change policy, with a number of laws and policies that aim to reduce the state's greenhouse gas emissions. Foremost among these is the Global Warming Solutions Act of 2006 (AB 32) which requires the reduction of greenhouse gas emissions to 1990 levels by the year 2020. (Cal. Health and Safety Code § 38500 et seq.) The Global Warming Solutions Act is supplemented by other laws such as the California Environmental Quality Act, (California Public Resources Code §21000 et seq., "CEQA"), which requires state and local agencies to assess and reduce to the extent feasible all significant environmental impacts from

new project approvals. State and local agencies are not currently fully implementing CEQA with regard to greenhouse gas emissions, but were they to do so this would greatly assist the state in meeting or surpassing the reductions required under the statewide cap by sharply limiting emissions from new development. In addition, Governor Schwarzenegger's Executive Order S-3-05 sets a goal of reducing greenhouse gas emissions as follows: by 2010, reduce emissions to 2000 levels; by 2020, reduce emissions to 1990 levels; and by 2050, reduce GHG emissions to 80 percent below 1990 levels. Executive branch agencies including California EPA and the California Resources Agency have ongoing programs aimed at meeting these targets. Progress to date, however, has been slow under all of these authorities, and even if all legal mandates were fully and successfully implemented, existing California law provides only a fraction of the emissions reductions needed to prevent the extinction of the flying squirrel.

c.   United States climate initiatives are ineffective

The United States is responsible for approximately 20% of worldwide annual carbon dioxide emissions (U.S. Energy Information Administration 2010, http://www.eia.gov), yet does not currently have adequate regulations to reduce greenhouse gas emissions. This was acknowledged by the Department of Interior in the final listing rule for the polar bear, which concluded that regulatory mechanisms in the United States are inadequate to effectively address climate change (73 Fed. Reg. 28287-28288). While existing laws including the Clean Air Act, Energy Policy and Conservation Act, Clean Water Act, Endangered Species Act, and others provide authority to executive branch agencies to require greenhouse gas emissions reductions from virtually all major sources in the U.S., these agencies are either failing to implement or only partially implementing these laws for greenhouse gases. For example, the EPA has recently issued a rulemaking regulating greenhouse gas emissions from automobiles (75 Fed. Reg. 25324, Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule), but has to date failed to implement the majority of other Clean Air Act programs, such as the new source review, the new source pollution standards, or the criteria air pollutant/national ambient air quality standards programs, to address the climate crisis (See, e.g. 75 Fed. Reg. 17004, Reconsideration of Interpretation of Regulations That Determine Pollutants Covered by Clean Air Act Permitting Programs). While full implementation of these flagship environmental laws, particularly the Clean Air Act, would provide an effective and comprehensive greenhouse gas reduction strategy, due to their non-implementation, existing regulatory mechanisms must be considered inadequate to protect the San Bernardino flying squirrel from climate change.

d.   International climate initiatives are ineffective

The primary international regulatory mechanisms addressing greenhouse gas emissions are the United Nations Framework Convention on Climate Change and the Kyoto Protocol. As acknowledged by the Department of Interior in the final listing rule for the polar bear, these international initiatives are inadequate to effectively address climate change (73 Fed. Reg. 28287-28288). The Kyoto Protocol's first commitment period only sets targets for action through 2012. Importantly, there is still no binding international agreement governing greenhouse gas emissions in the years beyond 2012. While the 2009 U.N. Climate Change Conference in Copenhagen called on countries to hold the increase in global temperature below 2°C (an

inadequate target for avoiding dangerous climate change), the *non-binding* "Copenhagen Accord" that emerged from the conference failed to enact binding regulations that limit emissions to reach this goal. Even if countries did meet their pledges, analyses of the Accord found that collective national pledges to cut greenhouse gas emissions are inadequate to achieve the 2°C, and instead suggest emission scenarios leading to a 3 to 3.9°C warming (Pew 2010, Rogelj et al. 2010). Thus international regulatory mechanisms must be considered inadequate to protect the San Bernardino flying squirrel from climate change.

> **2. Regulatory Mechanisms are Inadequate to Prevent Habitat Destruction and Degradation from Other Threats**

Much of the habitat for the San Bernardino flying squirrel is encompassed within the San Bernardino National Forest (Butler et al. 1991). However, the San Bernardino National Forest Land Management Plan (U.S. Forest Service 2005b, a, c) does not provide adequate protection to the San Bernardino flying squirrel or its habitat. The Forest Service's fuels reduction program is degrading flying squirrel habitat in the mixed conifer forests of the San Bernardino and San Jacinto mountains, and the Forest Service is not monitoring the individual and cumulative impacts of fuels reduction projects on the San Bernardino flying squirrel. In addition, San Bernardino and Riverside counties are not adequately evaluating the individual and cumulative impacts of development projects on the San Bernardino flying squirrel despite its status as an "Endangered, Rare, or Threatened Species" under the California Envirnonmental Quality Act (CEQA) pursuant to Guidelines §15380.

CRITICAL HABITAT

The ESA mandates that, when the USFWS lists a species as endangered or threatened, the agency generally must also concurrently designate critical habitat for that species. Section 4(a)(3)(A)(i) of the ESA states that, "to the maximum extent prudent and determinable," the USFWS:

> shall, concurrently with making a determination . . . that a species is an endangered species or threatened species, designate any habitat of such species which is then considered to be critical habitat . . . .

16 U.S.C. § 1533(a)(3)(A)(i); *see also id.* at § 1533(b)(6)(C). The ESA defines the term "critical habitat" to mean:

> i. the specific areas within the geographical area occupied by the species, at the time it is listed . . . , on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and

ii. specific areas outside the geographical area occupied by the species
　　　　at the time it is listed . . . , upon a determination by the Secretary
　　　　that such areas are essential for the conservation of the species.

Id. at § 1532(5)(A).

Petitioner expects that USFWS will comply with this unambiguous mandate and designate critical habitat concurrently with the listing of the San Bernardino flying squirrel. We believe that all current and historic areas utilized by the species for foraging and breeding meet the criteria for designation as critical habitat and must therefore be designated as such. In addition, all areas that will become essential for the survival and recovery of the San Bernardino flying squirrel under changing climate conditions projected for this century must be designated as critical habitat.

Critical habitat for the San Bernardino flying squirrel is needed to ensure that federal actions avoid jeopardizing the species and help promote its conservation. Designation would help inform federal and state governments and private landowners on conservation planning, habitat management, and other actions needed to secure habitat, and help address conflicts that undermine its protection and restoration.

CONCLUSION

The best available science indicates that the San Bernardino flying squirrel is in danger of extinction as a result of anthropogenic climate change that threatens its forest habitat and food supply, forest management practices that are removing essential habitat features, air pollution that is negatively impacting habitat and food sources, urban development that is destroying and fragmenting habitat, and the inadequacy of regulatory mechanisms to mitigate these threats. Petitioner Center for Biological Diversity requests that the U.S. Fish and Wildlife Service list the San Bernardino flying squirrel under the U.S. Endangered Species Act with concurrent designation of critical habitat.

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