APPENDIX O

SPECIES ACCOUNTS FOR SELECT FOCAL SPECIES

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APPENDIX O

SPECIES ACCOUNTS FOR SELECT FOCAL SPECIES

Matthew D. Schlesinger and Erik M. Holst, editors

Vascular Plants

MOUNTAIN BENT GRASS (*Agrostis humilis)*

Susan Urie

Taxonomy

Scientific name: *Agrostis humilis* Vasey
Family: *Poaceae* (grass family*)*
Common names: Mountain bent grass
ADP Taxon Code: AGHU
Synonymy: *Podarostis humilis* Bjorkman. 1960
Type locality: Mt. Adams, Washington
Type collector: Vasey, 1882

Description (after Cronquist et al. 1977)

Agrostis humilis is a small tufted perennial grass. Culms are low, only 3-18 (24) cm (1.2-7 [9.4] in) tall; sheaths smooth; ligules short, obtuse to truncate; blades flat to folded to filiform 0.5 to 1.2 mm (0.02 to 0.05 in) broad, mostly basal; panicles short, 1.5-4 (5) cm (0.6-1.6 [2] in) long, loosely contracted; glumes subequal, narrow-lanceolate to lanceolate, acute, purple; lemma awnless; callus subglabrous; palea present; rachila vestige laking or very short.

Distribution

A. humilis is widespread outside of California from the Cascade Range of southern British Columbia through Washington, Oregon, across to Nevada and northern Utah, to the Rocky Mountains from Montana to New Mexico (Cronquist et al. 1977). It was first documented as occurring in California in 1978 when it was found in Tuolomne County, in a moist alpine meadow at the outflow of Blue Canyon Lake (Neisess 1978). *A. humilis* is currently known to occur in Alpine, Mariposa and Tuolomne counties but is expected to be elsewhere in California (Skinner and Pavlik 1994). This species is more common than previously assumed, and the new occurrences are expected to be found in California (Hickman 1993). No records exist for this species in the Lake Tahoe basin, but the species potentially occurs, based on nearby records (Dennis 1995).

Ecology and Habitat Relationships

A. humilis grows low to the ground, which is characteristic of high elevation plants. It can be found in bogs and alpine meadows (Hitchcock 1971). Near Blue Canyon Lake, *A. humilis* was found growing in a mixed community including *Carex nigricans* (sedge), *Pedicularis groenlandica* (bull elephant heads), *Potentilla breweri* (Brewer's cinquefoil*)*, *Dodecatheon alpinum* (alpine shooting star), *Caltha leptosepala* var. *biflora* (marsh marigold), *Aster alpigenus* var. *andersonii* (alpine aster), *Salix arctica* (arctic willow), *Castelleja lemmonii* (Lemmon's paintbrush), *Trisetum spicatum* var. *molle*, *Juncus longistylis*, and *Claytonia nevadensis* (Neisess 1978). The area was probably fairly densely covered with vegetation. *A. humilis* habitat and range suggest that it is relictual in Sierran alpine tundra (Neisess 1978).

A. humilis intergrades with *A. thurberiana* at the upper elevations of the range of *A. thurberiana* (Hickman 1993). *A. humilis* is restricted to subalpine or alpine meadows and slopes. Little detailed information concerning the reproductive biology of *A. humilis* is available. However, most grasses are wind pollinated. The longevity and germinative capabilities of *A. humilis* seed are unknown.

Effects of Human Activities

Human activities that alter the hydrology of an area directly above or within a population or that would uproot plants through displacement of the soil surface could reduce the viability of *A. humilis*. The primary threats to *A. humilis* in high mountain meadows are camping, hiking, and sheep grazing. Currently there are no known occurrences of *A. humilis* in the Lake Tahoe Basin Management Unit;

therefore, it is unknown if trails directly or indirectly affect *A. humilis*. Generally, humans do not spend extended periods in the high subalpine meadows and bogs. However, these ecosystems are fragile, and because the growing season is short and climatic conditions are harsh, impacts are likely to be severe.

Because *A. humilis* is restricted to subalpine or alpine meadows and slopes, sheep grazing would probably have the most potential to affect this species negatively. Trailing and bedding by sheep may cause mechanical damage by trampling, and grazing would damage individual plants. *A. humilis* would most likely be a palatable species.

Conservation

Locating areas with *A. humilis* could help in identifying relict Sierran tundra plant communities. Surveys are needed to discover if *A. humilis* occurs in the Lake Tahoe Basin Management Unit. The need for and degree of protection for this species could then be evaluated. Interim conservation measures could include grazing limitations in habitats where *A. humilis* is likely to occur. One fundamental prerequisite of maintaining species viability is through genetic diversity that is enhanced by the wide geographical distribution of a species. Additionally, conservation of *A. humilis* and its associated ecosystems is important because high country meadows are a source for clean water.

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GALENA ROCKCRESS (*Arabis rigidissima* var. *demota*)

Robin Barron and Erik M. Holst

Taxonomy

Scientific Name: *Arabis rigidissima var. demota*
Family: Brassicaceae (mustard family)
Common Name: Galena rockcress or Galena Creek rockcress
ADP Taxon code: ARRID
Type Locality:
Type Collector: Rollins (Dennis 1999)

This species is not listed in the Jepson Manual of Higher Plants (Hickman 1993); however, it is recognized by the California Native Plant Society (Skinner and Pavlik 1994). The Nevada Natural Heritage Program Global Rank indicates that the "taxonomic status is uncertain" (NNHP 1999).

Description (after Rollins 1983)

Rollins (1983) describes *Arabis rigidissima* var. *demota* as follows: perennial, glaucous; stems to 7.5 cm (29.5 in) tall, one or few from branched or simple, ligneous or subligneous base. Usually branched, stiff, with branches rigidly ascending, leaves narrowly petiolate; blade oblanceolate, pubescent with 3 or 4 branched dendritic trichomes, tufted; cauline leaves clasping; pedicels and siliques divaricately ascending glabrous; siliques few, remote, straight to slightly curved, 4-6 cm (1.6-2.4 in) by approximately 3 mm (0.12 in) obtuse at apex, the valves veiny, strongly 1-nerved nearly to apex, margins slightly uneven, the style absent or very short; petals light to deep pink; seeds in a single row, flattened, winged, broadly oblong to nearly orbicular, 2.5-3 mm (0.1-0.12 in) long or in diameter, wing ca. 0.5 mm (0.02 in) wide; cotyledons accumbent.

Distribution

A. rigidissima var. *demota* is a geographically restricted regional endemic that has been identified only in the Carson Range of the Sierra Nevada in Placer County, California, and in Washoe County, Nevada (USDA 1990, Skinner and Pavlik 1994). All of the five locations noted for this species in the CalFlora Occurrence Database are in Placer County (Dennis 1999); Skinner and Pavlik (1994) note 11 occurrences from the Carson Range in Nevada. It has not been detected in the Lake Tahoe basin but may occur there. The initial collection of *A. rigidissima* var. *demota* is unknown, but it may be Teihm (1989).

Ecology

Dennis (1999) notes this plant as generally occurring in rocky areas in or at the edge of lodgepole pine (*Pinus contorta*), red fir (*Abies magnifica*), and mixed evergreen forests. Skinner and Pavlik (1994) describe *A. rigidissima* var. *demota* as occurring in rocky areas associated with broad-leaved upland and upper montane conifer forests. Data from CalFlora indicate that *A. rigidissima* var. *demota* occurs at elevations between 2,286 and 2,560 m (7,500 and 8,400 ft) (Dennis 1999); the Northern Nevada Native Plant Society cites this species as occurring at elevations between 2,140 m and 3,055 m (7,020 and 10,020 ft) (NNHP 1999).

Data regarding the reproductive biology of *A. rigidissima* var. *demota* are lacking (Tiehm 1989); however, findings indicate it flowers from June through July, fruiting in September (Gibson 1992).

Effects of Human Activities

The California Native Plant Society's Inventory of Rare and Endangered Vascular Plants notes that *A. rigidissima* var. *demota* is "threatened by logging" (Skinner and Pavlik 1994, p. 61). Gibson (1992), on his field survey form, lists off-highway vehicle use and logging as threats to *A. rigidissima* var. *demota*. Other human activities that could adversely affect population viability by habitat destruction and trampling include grazing and recreational activities, such as hiking, camping, mountain biking, and equestrian use.

Conservation

As Forest Service sensitive, *A. rigidissima* var. *demota* "will be managed to ensure that [it does] not become threatened or endangered because of Forest Service actions" (USDA 1988).

The US Fish and Wildlife Service considers *A. rigidissima* var. *demota* a "Species of Concern" because it "…may be endangered or threatened. Not enough biological information has been gathered to support listing at this time" (Goulde 1999). The Nevada Natural Heritage Program has ranked assigned a Global Rank of G3T2Q[1] and a State Rank of S2 to *A. rigidissima var. demota* (NNHR 1999). The Global Rank indicates that based on a worldwide distribution at the species level, this species is "Rare and local throughout its range, or with very restricted range, or otherwise vulnerable to extinction" and at the infraspecific level, it is imperiled. The State Rank indicates that based on its distribution in Nevada at the lowest taxonomic level, *A. rigidissima* var. *demota* is imperiled. These rankings indicate that future conservation and monitoring efforts should be focused at determining population size and frequency of occurrence of this species. After additional information has been gathered, the need for further protection can be evaluated. Due to the limited numbers and size of occurrences, interim conservation measures would be most effective if they provide for complete protection to all occurrences.

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[1] Q indicates that the "taxonomic status is uncertain" (NNHP 1999).

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AUSTIN'S MILKVETCH (*Astragalus austiniae*)

Robin Barron and Erik M. Holst

Taxonomy

Scientific Name: *Astragalus austiniae* A. Gray (ex) Brewer & S. Watson
Family: Fabaceae (pea family)
Common Name: Austin's milkvetch, or Austin's locoweed
ADP Code: ASAU
Type Locality: Mt. Stanford (Castle Peak), Nevada County, California
Type Collector: J. G. Lemmon 1875

Description (from Hickman 1993)

Astragalus austiniae is a dwarfed, cespitose perennial, with dense, wavy, silvery hairs. The stems of this species are less than 11 cm (4.3 in) in length. The leaves of *A. austiniae* are 1-5 cm (0.4-2 in) in length with lower stipules fused around the stem into often overlapping sheaths; leaflets number 5-13 and are 107 mm (4.2 in), being more or less elliptic to oblanceolate and keeled on lower surface. The inflorescence is head-like with 4-14 flowers that are erect to ascending. Flower petals are whitish to lilac-tinged; the banner is 8.4-11.3 mm (0.33-0.44 in) in length and recurved at approximately 35°. Banner and wings finely hairy on outside; the keel is 6.2-8.1 mm (0.24-0.32 in). The fruit of *A. austiniae* is ascending or spreading and more or less included in calyx. It is 5-7 mm (0.12-0.26 in) in length, 3-4 mm (0.12-0.16 in) wide, oblong-ovoid, and covered with densely interwoven fine hairs; chambers usually number 2 and are in the lower two-thirds of the fruit.

Distribution

This narrowly distributed Sierra Nevada endemic has been found only in the northern Sierra Nevada in El Dorado, Nevada, and Placer counties. Eighteen occurrences have been listed from Castle Peak, Echo Peak, Mt. Rose, Mt. Tallac, Tinker Knob and Mt. Stanford (Dennis 1999). The initial collection of *A. austiniae* was made by J. G. Lemmon in 1873 (Dennis 1999). Of the documented occurrences, nine specimens were collected before 1900, one was collected in 1943, and eight were collected between 1960 and 1983. On the second summit plateau of Mt. Rose at 3,050 m (10,000 ft) in July of 1978, Gladys Smith photographed a population of *A. austiniae* and collected a single specimen (Smith 1984). The 1970 Echo Peak collection by Smith represents an extension in the range of this species (Smith 1984); it is the southern most collection of *A. austiniae* noted in Dennis (1999). It is only the second known locality in El

Dorado County, Mt. Tallac being the other (Smith 1984). The most recent collection noted in the CalFlora database was in 1983; however, the exact location of this Placer County collection is not noted in the database (Dennis 1999).

Ecology

A. austiniae grows at high elevations in exposed harsh climates with thin soils, often in decomposed granite. Typically this species grows on dry and exposed ridges and slopes near or above timberline at elevations of 2,700 to 3,200 m (8,858 to 10,500 ft) (Hickman 1993, Smith 1984). Generally, alpine and subalpine perennials that grow on exposed gravelly or talus slopes are low growing. This growth form protects the plant from the drying winds and enables it to take advantage of the warmer temperatures near the ground (Taylor 1999). The reflective character of the dense, long, silky hairs of the leaves gives protection from sunlight in these exposed situations by intercepting and diverting the strong alpine sunlight (Taylor 1999). While these hairs reflect visible light rays they also trap heat rays, which warm the surface of the plant in a greenhouse-like effect; they are also thought to help reduce water loss through the leaf surface (Zwinger and Willard 1972, Hall 1991).

Because the growing season at high elevations is very short, alpine plants tend to have well-developed root systems; food reserves from the root are used in early spring to initiate vegetative growth (Smith 1999). Such root systems enable them to hold fast through the erosional forces of the slopes they inhabit (Smith 1999).

Hummingbirds are known to be pollinators for some species of *Astragalus* that have large showy flowers. However, the dull whitish to pale lavender flowers of *A. austiniae* are unlikely to attract hummingbirds. Bees commonly are the pollinators of plants with zygomorphic flowers (Holmberg 1999). *Astragalus* species do contain several toxic glycosides and may concentrate selenium if growing in selenium rich soils. Some species are known to be poisonous to bees (McKee and Pieters 1937).

Species of *Astragalus*, like other members of the Fabaceae, have dehiscent fruit. As the seedpods dry, the fruit is propelled away from the parent plant. Other methods of dispersal may include gravity and wind. Birds or small mammals, such as ground squirrels, chipmunks, pikas, or voles, may aid in dispersal; however, because information on *A. austiniae* is generally lacking, such dispersal methods have not been documented.

Effects of Human Activities

A. austiniae typically occurs in high elevation exposed rocky terrain, a relatively inaccessible habitat in which few human visitors would be expected. However, in such locations as Mt. Tallac, recreational uses such as hikers and campers can adversely affect this species by trampling it. Additionally, hikers on steep gravelly slopes may exacerbate erosional forces, thereby contributing to plant mortality (Smith 1996).

Conservation

As previously noted, *A. austiniae* is a regional endemic with only 18 records in the CalFlora database (Dennis 1995). Because of this limited distribution, anyone considering conservation or monitoring efforts should first determine the frequency of occurrence of *A. austiniae* in the Lake Tahoe basin. If new occurrences are discovered, the need for and degree of protection of the species then could be evaluated. Conservation efforts for existing occurrences should provide for total protection, due to the limited number and size of these occurrences.

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MARIPOSA SEDGE (*Carex mariposana*)

Susan Urie

Taxonomy

Scientific name: *Carex mariposana* Bailey ex Mackenzie
Family: *Cyperaceae* (sedge family*)*
Common names: Mariposa sedge
ADP Taxon Code: CAMA-?
Synonymy: *Carex paucifructus* Mackenzie
Type locality: Devils Basin (Desolation Wilderness), El Dorado County, California
Type collector: Ezra Brainerd, 1897

Description (from Janeway 1992)

Carex mariposana is a low densely tufted or clumped perennial sedge. Culms are 4.3-10.3 dm (16.9-40.5 in) tall and longer than leaves; leaf blades are flat, 3-6 mm (0.12-0.24 in) wide and glabrous. The inflorescence is simple: 24-40 mm (0.95- 1.6 in) long, rhomboid to elliptic-ovate, the spikelets numerous, densely clustered but still distinguishable. The spikelet has both staminate and pistillate flowers; the staminate flowers are few and basal. The pistillate flowers are numerous and terminal; the lowest bract is shorter than inflorescence, non-sheathing. The scale is shorter than perigynium, narrower, acute. Perigynia are ascending, ovate, (3.8) 4.5-5.9 mm ([0.15] 0.18-0.23 in) long, 1.3-2.1 mm (0.05-0.08 in) wide, and more or less flat on front and rounded on back with thin flat wings 0.2-0.3 mm (0.008-0.012 in) wide. Achene is two sided, 1.5-2.1 mm (0.06-0.08 in) long.

Distribution

Some authors contend that *C. mariposana* is endemic to the Sierra Nevada (Cronquist et al. 1977), while others give its limitation as northwestern California, the high Cascade Range, the Sierra Nevada, and Washoe County, Nevada (Hickman 1993). Dennis (1999) indicates that in California the distribution of *C. mariposana* extends south into portions of Riverside, San Bernadino, San Diego, and Ventura counties. Locally this plant has been collected from a few locations in Nevada along the east side of Lake Tahoe on Genoa Peak road in red fir forest and the rocky ridge south of Spooner Summit in a Jeffrey pine forest (Smith 1983). Janeway (1999) found *C. mariposana* to be living in a dry portion of the meadow above Meeks Bay in 1998. Potter (1983) identified *C. mariposana* at Heather Lake in Desolation Wilderness.

Ecology

C. mariposana is an uncommon species that is a member of the "*C. pachystachya* complex" of section *Ovales* (Whitkus 1988). *C. mariposana* has been maintained as a separate species in the Jepson Manual (Hickman 1993). This plant occurs in the drier portions of meadows at elevations between 1,200-3,200 m (3,937-10,500 ft). Specific information regarding the life history of *C. mariposana* is not well documented; all *Carex* species are wind pollinated.

Effects of Human Activities

In mountain meadows, recreational activities such as camping, mountain biking, hiking, and equestrian use can uproot plants through soil displacement and could reduce the viability of *C. mariposana* populations. Similarly grazing can adversely affect *C. mariposana* because of the mechanical damage done to the soil by trailing and bedding. Because there is only one known occurrence of species in the Lake Tahoe Basin Management Unit, specific direct or indirect impacts to this species by such human activities have not been documented. Thus, viable measures to mitigate adverse impacts have not been established.

Conservation

The TRPA has established that a minimum of one population site be maintained for *C. mariposana* (TRPA 1986) and that "Projects and activities…shall be regulated to preserve sensitive plants and their habitat" (TRPA 1987).

Surveys are needed to discover the extent of *C. mariposana* populations in the Lake Tahoe basin. The need for protection of this species in the basin then could be evaluated. Interim conservation measures could include grazing limitations in habitats where *C. mariposana* is likely to occur. One fundamental prerequisite of maintaining species viability is through genetic diversity that is enhanced by the wide geographical distribution of the species. Conservation of *C. mariposana* ecosystems is important because high country meadows filter out sediments and contribute to good water quality.

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BULLTHISTLE (*Cirsium vulgare*)

Robin Barron and Erik M. Holst

Taxonomy

Scientific Name: *Cirsium vulgare (*Savi.) Ten.
Family: Asteraceae (sunflower family)
Common Name: Bullthistle
ADP Taxon code: CIVU
Type Locality: Unknown
Type Collector: Unknown

Description

Cirsium vulgare is an exotic invasive biennial that stands 3-20 dm (1- 5.6 ft) tall; it generally has one stem that is openly branched above the middle and is often glandular and hairy (Hickman 1993). Leaves are harshly bristly above, sometimes with densely interwoven hairs; lower leaves are 10-40 cm (3.9-15.7 in) long (Hickman 1993). The upper leaves become smaller with spiny wings; main leaf lobes generally rigidly spreading, spine-margined, with main spines less than 15 mm (0.59 in) long (Hickman 1993). Blooms are one to several flowers and clustered with bract-like uppermost leaves beneath; flower heads are 1 to 2 inches in diameter, hemispheric or bell-shaped, and petals are purple (USDI 1999). Stems are furrowed, cottony-hairy, with spiny irregular wings along the furrows; leaves are lobed and sharply spiny. The involucral bracts subtending the globular compact flower heads are also sharply spiny and from the heads emerge a deep purple or rosy purple flower cluster (Whitson 1991).

Distribution

A native of Europe, Asia Minor, Turkish Armenia, Kurdistan, Iran and Chinese Turkestan, *C. vulgare* probably arrived in North America during colonial times and is widely established in North America, having been spread as a seed contaminant (Whitson 1999). Disturbed areas, such as pastures, fields, and roadsides, offer potential habitats for this species (McClintock no date). It is uncertain when *C. vulgare* reached California (McClintock no date); however, according to Hickman (1993), *C. vulgare* is presently found throughout the California Floristic Province at elevations less than 2,300 m (7,545 ft) and in the Great Basin. Smith (1984) notes this species occurs sporadically around Lake Tahoe. The date of the initial collection in California is unknown; however, the earliest record in the CalFlora database is from Alameda County in 1894 (Dennis 1999). The elevational record for *C. vulgare* in California is represented by two collections, both at 2,255 m (7,400 ft). One of these specimens, as noted by Smith (1984) was collected in El Dorado County, along US Highway 50, near Little Norway (west of Echo Summit); it is not noted in the CalFlora database. The other specimen was collected in Alpine County near Sonora Pass Road in 1944 (Dennis 1999).

Ecology

C. vulgare is a biennial plant that grows from a fleshy taproot. The first-year plants consist only of a basal rosette of leaves, but in the second year erect stems emerge, growing from one to five feet in height (Allan 1978, in McClintock no date). *C. vulgare* flowers from July through September and reproduces only by seeds that are blown about by means of the plumed pappus bristles (Whitson 1991).

Effects of Human Activities

As previously noted, the seeds of *C. vulgare* are wind dispersed and readily invade disturbed loosened soils. Human activities and management scenarios, such as logging, road building, highway maintenance, recreational facility development, mountain biking, equestrian use and grazing, that result in bare loosened soils can increase the risk for the introduction of this thistle (Taylor 1999).

Conservation

Monitoring efforts should be targeted at determining the frequency of occurrence of *C. vulgare* in the Lake Tahoe basin. A secondary objective of such a monitoring effort might be to determine the relative abundance of this species. Once the extent of occurrences is determined, the type and extent of various control and/or eradication methods can be evaluated.

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TAHOE DRABA (*Draba asterophora* var. *asterophora*)

Mike Taylor

Taxonomy

Scientific name: *Draba asterophora* Payson var. *asterophora*
Family: Brassicaceae (mustard family)
Common name: Tahoe draba
ADP Taxon Code: DRASA
Type locality: Sierra Nevada, Mt. Rose (Washoe County, Nevada)
Type collector: P.B. Kennedy, 1905

Description (Baad 1979)

Draba asterophora var. *asterophora* is a small alpine cushion perennial with numerous flowering stalks that are 3–8 cm (1.2–3.1 in) tall. The leaves are in basal rosettes and on short sterile branches. They are obovate, 5–12 mm (0.2–0.5 in) long, and 2–7 mm (0.1–0.3 in) broad. The leaves of *D. asterophora* var. *asterophora* are pubescent; the pubescence is rather sparse and consists mostly of long-stalked, cruciform or stellate hairs. The flower is yellow and has 4 petals 4–6 mm (0.15–0.23 in) long. The style is 0.5-2.0 mm (0.02-0.07 in) long. The seed pods (silicles) of *D. asterophora* var. *asterophora* are nearly oval, flat, and 5–13 mm (0.2–0.5 in) long by 3–6 mm (0.1–0.2 in) wide. They are glabrous or minutely pubescent with soft star-like hairs; the seeds are winged.

Distribution

Draba asterophora var. *asterophora* has a discontinuous distribution from Mt. Rose in Washoe County, Nevada, to Mt. Gibbs near Tioga Pass in Yosemite, California (USDA 1998). Two occurrences are known from Mt. Rose at elevations of 2,710–3,290 m (8,900–10,800 ft); a cluster of four occurrences is known from the Freel Peak/Jobs Sister area located near the El Dorado and Alpine county lines at elevations above 2,860 m (9,400 ft) (USDA 1998). Three occurrences are known from Monument Peak at elevations above 2,990 m (9,800 ft) (Heavenly Ski Resort) (USDA 1994). New occurrences of *D. asterophora* var. *asterophora* were discovered at Heavenly Ski Resort in 1997 during surveys pursuant to ski area improvements (Strain 1999). Two occurrences are known from the Desolation Valley Wilderness at elevations above 2,620 m (8,600 ft), one of which has not been re-located since 1974 despite several attempts to do so (Smith 1999). The second Desolation Wilderness occurrence was discovered in 1976 near the boundary between the Lake Tahoe Basin Management Unit and the Eldorado National Forest (USDA 1994). The occurrence located near Tioga Pass on Mt. Gibbs at an elevation of 3,505 m (11,500 ft) has not been re-located since it was discovered in 1916; "This pop[ulation] has been overlooked and the plant has been called a narrow Tahoe basin endemic" (CDFG 1985).

Population size of occurrences vary. The Desolation Wilderness and Freel Peak occurrences contain thousands of individuals, although the Mt. Rose occurrences totaled less than two dozen plants in 1979 (USDA 1994). The total number of individuals at the four known locations, Mount Rose, Freel Peak/Jobs Sister/Star Lake, Monument Peak (Heavenly) and Desolation Valley, is estimated to be between 7,500 and 10,000 (USDA 1994).

Ecology

Draba asterophora var. *asterophora* and other alpine perennials that grow on exposed talus slopes are known as cushion plants. They are generally long-lived and develop fairly extensive root systems. All the foliage grows close to the ground in a small mound about the size of a pincushion; this growth form serves to minimize the effects of wind while taking advantage of warmer temperatures near the ground (Zwinger and Willard 1972). Another benefit of low cushion-like growth is that the plant traps its own soil and organic matter; as wind blows over the cushion of foliage, friction causes the wind to lose some of its energy, and fine dust particles, bits of leaf debris, and other matter fall directly into the cushion (Zwinger and Willard 1972).

The stems and leaves of *Draba asterophora* var. *asterophora* are covered with silver/white hairs. These stellate (star-shaped) hairs serve a variety of functions, such as protecting the stems and leaves by intercepting and diverting the strong alpine sunlight (Zwinger and Willard 1972). While the hairs reflect visible light rays they also trap heat rays, which warm the surface of the plant in a greenhouse-like effect; these hairs also help reduce water loss from the surface of the leaves (Zwinger and Willard 1972).

Flowering habits of alpine plants generally follow one of two strategies to attract pollinators. Species such as those growing on the lee side of large boulders or in rocky crevices are protected from harsh winds and often rely on large showy flowers to attract pollinators (Zwinger and Willard 1972). Species such as *D. asterophora* var. *asterophora* grow on exposed talus slopes and rely on many small flowers; the entire upper surface of the plant becomes covered with blooms in order to attract pollinators by sheer abundance rather than by size (Zwinger and Willard 1972).

D. asterophora var. *asterophora* is found in alpine habitats, characterized by scree or talus substrates, with the exception of one occurrence in Desolation Wilderness, where the habitat was characterized by Smith (1984, p. Supp-21) as "moist ledges of metamorphic rock." The Jepson Manual lists the species' habitat as "rock crevices and alpine barrens" at elevations above 2,500 m (8,125 ft) (Hickman 1993). This species is often observed in association with *Tsuga mertensiana* (mountain hemlock), *Pinus albicaulis* (white bark pine), *Calyptridium umbellatum* (pussy-paws), *Penstemon* sp., *Erysimun capitatum* ssp. *perenne* (western wallflower), *Phlox* sp., and *Eriogonum* sp. (buckwheat) (Baad 1979).

Effects of Human Activities

The ability of *D. asterophora* var. *asterophora* to tolerate disturbances from recreation is not known. Due to its high elevation habitat, primary threats to this species would include trampling, due to hiking and equestrian use, grazing, ski area development, and horticultural collection. It is typically most susceptible to damage from trampling during and after snowmelt until the plant sets seed and becomes relatively dormant in late August.

Conservation

D. asterophora var. *asterophora* is a Forest Service sensitive species, as well as a TRPA sensitive species. As Forest Service sensitive, *D. asterophora* var. *asterophora* "will be managed to ensure that [it does] not become threatened or endangered because of Forest Service actions" (USDA 1988). The TRPA has established that a minimum of five population sites be maintained for *D. asterophora* var. *asterophora* (TRPA 1986) and that "Projects and activities…shall be regulated to preserve sensitive plants and their habitat" (TRPA 1987).

The USDA Forest Service has not developed a species management guide for this species, nor have specific management objectives been identified. The lack of specific management objectives is largely due to a lack of data concerning the viability of this species. The absence of data concerning trends in population numbers, plant vigor, and reproductive success necessitates a conservative approach to the determination of effects to this taxon. Although *D. asterophora* var. *asterophora* monitoring is limited, no evidence exists to indicate that the overall abundance of this species is decreasing (USDA 1998). Given the discovery of new occurrences as recently as 1997, it appears that other populations of *D. asterophora* var. *asterophora* may exist. Heavenly Ski Resort is monitoring a 1997 restoration project involving Tahoe draba on Monument Peak. This project is being monitored annually for five years, and results may affect mitigation recommendations for future projects that might threaten *D. asterophora* var. *asterophora* populations.

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CUP LAKE DRABA (*Draba asterophora* var. *macrocarpa*)

Mike Taylor

Taxonomy

Scientific name: *Draba asterophora* Payson var. *macrocarpa* C. L. Hitchcock
Family: Brassicaceae (mustard family)
Common name: Cup Lake draba
ADP Taxon Code: DRASM
Type locality: Sierra Nevada, Cup Lake (Desolation Wilderness)
Type collector: H. M. Evans, 1918

Description (Baad 1979)

Draba asterophora var. *macrocarpa* is a diminutive alpine cushion perennial with numerous flowering stalks that are 3-8 cm (1.2-3.1 in) tall. The leaves are in basal rosettes and on short, sterile branches. They are obovate, 5-12 mm (0.2-0.5 in) long, and 2-7 mm (0.08-2.8 in) broad. The leaves of *D. asterophora* var. *macrocarpa* are pubescent; the pubescence is rather sparse and consists mostly of long-stalked, cruciform or stellate hairs. The flower has yellow petals 6 mm (0.24 in) long. The sepals are 3 mm (1.2 in) long and the styles are 1-2 mm (0.04-0.08 in) long. Fruits are silicles (seed pods) broadly lanceolate and 10-15 mm (0.4-0.6 in) long; seeds are winged.

Distribution

D. asterophora var. *macrocarpa* is known from only two locations, both within Desolation Wilderness. One population occurs on the Eldorado National Forest (ENF) at Cup Lake, and the other occurs on the Lake Tahoe Basin Management Unit (LTBMU) at Saucer Lake. Multiple clusters or groups of *D. asterophora* var. *macrocarpa* have been located at both sites. Detailed information from the Eldorado National Forest Sensitive Plant Habitat and Occurrence Maps on each occurrence is listed below (USDA 1994).

Occurrence 03-01 (southeast side of Ralston Peak at Cup Lake, ENF)

- Initial collection by H. M. Evans, July 1918, identified and determined taxonomically unique by C. L. Hitchcock (1941).

- In August 1978, Baad located 20 individuals scattered about 15 m (50 ft) from the east shore of Cup Lake.
- In July 1990, Andrew Kundert located 1,000 plants growing from the south edge of the Cup Lake to well up the (north-facing) slope.
- In August 1993, Allessio, Foster, and others located approximately 1,000 plants growing along the south shoreline to 30 m (100 ft) upslope in open conditions.

Occurrence 03-02 (west slope of Talking Mountain at Saucer Lake, LTBMU)

- Initial discovery by B. Potter, 1981 in two distinct loci. The first, on the talus slope south of Saucer Lake (abundant), and another, smaller, more scattered occurrence north of Saucer Lake along the trail leading to Upper Echo Lake.
- In July 1990, A. Kundert located approximately 1,000 plants on the talus slopes south of the Lake and near the lakes outlet (west side of lake).

Ecology

D. asterophora var. *macrocarpa* and other alpine perennials that grow on exposed, talus slopes are known as cushion plants. They are generally long-lived and develop fairly extensive root systems. All the foliage grows close to the ground in a small mound about the size of a pincushion. This growth form serves to minimize the effects of wind while taking advantage of the warmer temperatures near the ground (Zwinger and Willard 1972). Another benefit of low, cushion-like growth is that the plant traps its own soil and organic matter; as wind blows over the cushion of foliage, friction causes the wind to lose some of its energy, and fine dust particles, bits of leaf debris, and other matter fall directly into the cushion (Zwinger and Willard 1972).

The stems and leaves of *D. asterophora* var. *macrocarpa* are covered with silver/white hairs. These stellate (star-shaped) hairs serve a variety of functions. They protect stems and leaves by intercepting and diverting the strong alpine sunlight (Zwinger and Willard 1972). While the hairs reflect visible light rays they also trap heat rays that warm the surface of the plant in a greenhouse-like effect; these hairs also help reduce water loss from the surface of the leaves (Zwinger and Willard 1972).

Flowering habits of alpine plants generally follow one of two strategies. Plants that are protected from harsh winds, such as those growing on the lee side of large boulders or in rocky crevices, often rely on large showy flowers to attract pollinators (Zwinger and Willard 1972). Plants that grow on exposed talus slopes such as *D. asterophora* var. *macrocarpa*, rely on many, small flowers. The entire upper surface of the plant become covered with blooms, the strategy being to attract pollinators by sheer abundance rather than by size (Zwinger and Willard 1972).

Habitat for this alpine cushion plant consists of "steep, gravelly or rocky slopes" (Potter 1983) at elevations of 2,560 to 2,815 m (8,400 to 9,235 ft) Baad (1979) described the habitat as "relatively deep soil in the shade of granitic rocks. The Jepson Manual (Hickman 1993) lists the habitat of *D. asterophora* var. *macrocarpa* as "rock crevices and alpine barrens" at elevations above 2,500 m (8,125 ft).

D. asterophora var. *macrocarpa* is often found in association with *Phyllodoce breweri* (red mountain heather), *Penstemon newberryi* (mountain pride), *Sambucus caerulea* (elderberry), and *Tsuga mertensiana* (mountain hemlock) (Baad 1979). Other observers (Barron 1992) have also noted the following associates: *Luzula divaricata, Chaenactis alpigena,* and *Saxifraga tolmiei.*

Effects of Human Activities

D. asterophora var. *macrocarpa* occurs in relatively remote areas where accessibility and human disturbance are limited. Impacts to these species are primarily a result of recreational use that typically is infrequent in the inaccessible sites where this taxon is known to occur.

In the Desolation Wilderness Management Guidelines (USDA 1998, p.3-35), Lesky finds: "The ability of the Cup Lake draba to tolerate disturbances related to wilderness uses and impacts is not known. Pincushion plants such as Cup Lake draba are typically most susceptible to damage from trampling during and after snowmelt until the plant sets seed and becomes relatively dormant in late August.

Existing occurrences of Cup Lake draba show no evidence of decreased vigor due to wilderness use. A user-created trail forms a transect across one large cluster of plants, and the abundance of individual plants does not appear to be affected by infrequent use of the trail. The majority of occupied habitat is unlikely to be traversed by wilderness users."

Mining, ski area development, grazing, and horticultural collection are factors which could cause future impacts to this species.

Conservation

D. asterophora var. *macrocarpa* is a federal species of special concern, a Forest Service sensitive species, and a TRPA sensitive species. As Forest Service sensitive, *D. asterophora* var. *macrocarpa* "will be managed to ensure that [it does] not become threatened or endangered because of Forest Service actions" (USDA 1988). The TRPA has established that a minimum of two population sites be maintained for *D. asterophora* var. *macrocarpa* (TRPA 1986) and that "Projects and activities…shall be regulated to preserve sensitive plants and their habitat" (TRPA 1987).

A species management guide has not been prepared for *D. asterophora* var. *macrocarpa* nor have specific management objectives been identified for this sensitive species. The lack of specific management objectives is largely due to a lack of data concerning the viability of this species. The absence of data concerning trends in population numbers, plant vigor, and reproductive success necessitates a conservative approach to the determination of effects to this taxon. If future projects are proposed that would impose a threat to *D. asterophora* var. *macrocarpa* populations, recommendations might consider total protection, due to the limited number and size of these occurrences.

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Zwinger, A. H., and B. E. Willard. 1972. Land Above the Trees. Harper and Row. San Francisco, California.

SUBALPINE FIREWEED (*Epilobium howellii*)

Mike Taylor

Taxonomy

Scientific name: *Epilobium howellii* P. Hoch
Family: *Onagraceae* Evening Primrose Family
Common names: subalpine fireweed
ADP Taxon Code: EPHO
Type locality: Yuba Pass, Sierra County, California.
Type collector: Hoch, 1975

Description (from Hoch 1992)

Epilobium howellii is a delicate perennial herb, forming short, threadlike stolons with scattered minute leaves. The stems are 8 - 20 cm (3.1-7.8 in) tall, densely glandular, terete (rounded), loosely clumped. The leaves of *E. howellii* are sessile; the blades are 4-20 mm (0.16-7.8 in) long, round to lanceolate or narrower above, tip obtuse to subacute above. The margins are finely toothed and stigillose, mainly on veins or all over on upper leaves. The inflorescence is erect. Flowers are small, subcleistogamous; floral tube 0.4 to 0.8 mm (0.02-0.03 in) deep; sepals 1.5 to 2.0 mm (0.06-0.08 in) long; petals 2 to 3 mm (0.08-0.1 in) long, white; stamens in two unequal sets, the longer ones shedding pollen onto capitate stigma prior to petal expansion. Capsules are 3 to 45 mm (0.12-1.77 in) long, subglabrous, on pedicels 25 to 40 mm (0.98-1.57 in) long. Seeds of *E. howellii* are 0.8 to 1.1 mm (0.03-0.04 in) long. The surface is low papillate; coma dingy, easily detached.

Distribution

E. howellii is ranked by the California Native Plant Society as "rare throughout its range"; it meets the criteria for listing under the California Endangered Species Act (Skinner and Pavlik 1994, p. 14). This species was first found in 1975 at Yuba Pass, Sierra County, California. *E. howellii* was recollected in 1981 to obtain seeds for cultivation experiments, which proved it was a new, previously undescribed species (Hoch 1992). The plants collected from Yuba Pass were compared against 80,000 herbarium specimens of *Epilobium* spp., resulting in only three matches; a collection from Fresno County, 4.8 km (3 mi) east of Huntington Lake; one from Mono County, 1.6 km (1 m) southwest of Portal Forebay; and, a third in Sierra County, on the south shore of Twin Lakes (Hoch 1992). There are no known occurrences in the Lake Tahoe Basin.

Given the wide range of the known occurrences, and no apparent reason for its rarity, it is possible that this small plant has been overlooked in the past. Because morphological distinctions among many members of this genus are both fine and sometimes variable, and clear taxonomic keys are few, identification of *E. howellii* may have been overlooked or disregarded (Hoch, pers. comm.).

Ecology

E. howellii flowers from July to early August with fruiting occurring August to October; the flowers are consistently small (petals not more than 3 mm [0.12 in]) and most are cleistogamous (Hoch 1992). Stems and other parts of this small perennial plant are covered with glandular pubescence (Hoch 1992). This adaptation, not common in this genus, serves an unknown purpose, but is valuable in identification of *E. howellii* (Hoch 1992). Little else is known of the ecology of this species.

Habitat Relationships

This species seems to be restricted to wet, boggy areas of the Sierra Nevada between 2,000 and 2,700 m (6,560 and 8,860 ft) in elevation (Hoch 1992, Hickman 1993). It has been found in meadows and swales, scattered among grasses and moss, often in the presence of willows (Hoch 1992).

Effects of Human Activities

The factors that could potentially reduce the viability *E. howellii* are activities that disturb the soil. In mountain meadows where recreational activities such as camping, mountain biking, hiking and equestrian use are likely to occur, these activities may uproot plants and adversely affect this species. Grazing may negatively affect *E. howellii* populations through mechanical damage done to the soil by trailing and bedding. Similarly, timber harvest activities that encroach into meadow habitats could disrupt soil characteristics and adversely impact populations. Because information is lacking on this species, and since there are no known occurrences of *E. howellii* in the Lake Tahoe Basin, specific management scenarios that have the potential to directly or indirectly affect population viability have not been identified.

Conservation

As Forest Service sensitive, *E. howellii* "will be managed to ensure that [it does] not become threatened or endangered because of Forest Service actions" (USDA 1988).

As previously noted, there are no known occurrences of *E. howellii* in the Lake Tahoe Basin. Thus, initial conservation and monitoring efforts should focus on determining if *E. howellii* is present in the Lake Tahoe basin. If populations are discovered, the need and the degree of protection could then be evaluated. Interim conservation measures could focus on the conservation of meadow ecosystems that provide habitat for this species.

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TORREY'S BUCKWHEAT (*Eroigonum umbellatum* var. *torreyanum*)

Susan Urie

Taxonomy

Scientific name: *Eroigonum umbellatum* Torr. var. *torreyanum* (A. Gray) Jones (*E. torreyanum* Gray)
Family: *Polygonaceae* (Buckwheat Family)
Common names: Donner Pass buckwheat or Torrey's buckwheat.
ADP Taxon Code: ERUMT
Synonymy: *Eriogonum torreyanum* considered by J. T. Howell
Type locality: "California, on a high mountain of the Sierra Nevada near Donner's Pass" (Torrey and Gray 1870)
Type collector: John Torrey, 1865

The taxonomic status of this species is somewhat controversial. Until the taxonomy of the entire *E. umbellatum* complex is thoroughly investigated, the status of the rare taxon will remain as a variety of *E. umbellatum.*

The following species account is based on information condensed from the Interim Management Guide for *Eroigonum umbellatum* var. *torreyanum* written by Kan (1992).

Description (Reveal 1989)

Eroigonum umbellatum var. *torreyanum* is a perennial shrub with vegetative growth. Plants form large prostrate mats 1-3 dm (4-12 in) high and 4-20 dm (1-6 ft) across. Leaves growing in basal rosettes are elliptic to broadly elliptic, 1-3(4) cm (0.5-1.5 in) long, green and glabrous (non-hairy) on both surfaces. Flowering stems are erect, 1-2 dm (4-8 in) long, glabrous; inflorescences are umbellate with a whorl of bracts in the middle of the branches, 0.3-1 dm (1-4in) long. The branches are glabrous; involucres with tubes 5-7 mm (0.2-0.3 in) long. The lobes are 2-5 mm (0.08-0.2 in) long and glabrous. The flowers are bright yellow, often turning a burnt orange color upon aging; stipe 1.3-2 mm (0.05-0.08 in) long, glabrous; sepals monomorphic , obovate, 7-10 mm (0.3-0.4 in) long; stamens yellow, mostly exerted. A single long tap root anchors the plant on loose steep slopes; *E. umbellatum* var. *torreyanum* blooms from July to mid August.

Distribution

All populations of *E. umbellatum* var. *torreyanum* are located within a narrow band, about 34 kilometers (21 mi) long and only 2 to 6 km (1.2 to 3.7 mi) wide, along the east side of the Sierra Crest at an elevation of 2,200 to 2,500 m (7,200 to 8,200 ft). The occurrences range from the east slopes of Webber Mountain in the north to Silver Peak, just north of Squaw Valley, in the south. The populations all lie within the boundaries of the Tahoe National Forest although some occur on private land. Most occurrences lie within Nevada and Placer counties, with three of the populations occurring just over the border in Sierra County.

Together, the populations consist of an estimated 7,215 plants. The size of the populations varies widely, from approximately 3,000 individuals on the east slope of Silver Peak to only one individual on an unnamed slope northwest of Silver Peak. Twelve of the sixteen populations contain fewer than 200 plants. Over 90 percent of the plants occur in four of the populations, with the remaining 10 percent spread out among the other twelve populations.

All historical locations of *E. umbellatum* var. *torreyanum* were revisited by Tamara Kan. A listing of these sites was provided by the *Tahoe National Forest Sensitive Plant Program Standards and Guidelines* (USDA 1992). Once this initial survey was completed, it became clear that the extant populations occurred exclusively on meiss soils with sparse vegetation. Potential habitat was then mapped based on soil type and vegetation type within the boundaries of Tahoe National Forest. No surveys were preformed within the Lake Tahoe Basin. There are currently no known population locations within the Lake Tahoe Basin, but potential habitat does exist there.

Ecology

E. umbellatum var. *torreyanum* is self-compatible (Kan 1993) and self-pollination among flowers within and umbel or among umbels on a single plant probably occurs. Though the largest plants normally produce thousands of flowers in a given season, very few seeds are produced, indicating that the variety has a barrier to successful sexual reproduction. One reason for the low seed set may be herbivory. Two known herbivores are seed-eating Lyceanid butterfly larvae and a pollen-eating flower beetle (*Trichochrous* or *Amecocerus*). Little is known about seed dispersal; seeds are relatively small and drop in close proximity to the plants that shed them.

The insects that potentially pollinate *E. umbellatum var. torreyanum* flowers include *Apis mellifera* (honey bee), *Bombus bifarius* and *B. vosnesenskii* (bumble bees), *Andrena sp.* (solitary bee), *Trichodes* (checkered flower beetle), Miridae (plant bug), Pompilidae (spider wasp), Staphylinidae (rove beetle) and various ants.

The plant species most commonly co-occurring with *E. umbellatum* var. *torreyanum* are *Eriogonum umbellatum* var. *Nevadans* (Sulphur Buckwheat), *Monardella odoritissima* (Coyote Mint), *Phlox diffusa* (Spreading Phlox), *Wyethia mollis* (Mountain Mule-ears), *Artemisia arbuscula* (Dwarf Sagebrush), *Collomia tinctoria* (Yellow-staining Collomia), *Purshia tridentata* (Antelope Brush) and *Sitanion hysterix* (Bottlebrush Squirreltail). These are all quite common species in this region of the Sierra Nevada.

Habitat Relationships

The restriction of *E. umbellatum* var. *torreyanum* populations to a narrow band of subalpine habitat on the east side of the Sierran Crest near Donner Pass suggests that the variety has rather specific environmental requirements. *E. umbellatum* var. *torreyanum* occurs where the overall vegetation cover is patchy with open areas of scattered herbs and grasses, patches of dense shrubs, and small groves of trees or sentinel trees. Soils are shallow meiss soils with sparse vegetation; however, this species may thrive in deeper soils as long as the shrub cover is not too dense or tall. Meiss soils are formed from andesitic rock of volcanic origin, having a rather coarse texture and low available water holding capacity and have a high to moderate erosion potential. *E. umbellatum* var. *torreyanum* occurs mainly on east facing slopes. The populations are never centered on open exposed ridges, though a few fringe individuals may be on or close to the ridgeline. Though the average slope for the sites is about 30 degrees, steep slopes do not seem to be a requirement for *E. umbellatum* var. *torreyanum*, since the largest and most vigorous plants occur on a relatively level area at Silver Peak. However, proximity to the ridge and thus increased exposure to wind seems to deter the species from much of the flat habitat available. The populations occur at elevations ranging from 2,200 to 2,500 m (7,200 to 8,200 ft).

Effects of Human Activities

The historical elevational range of *E. umbellatum* var. *torreyanum* was apparently broader, with some populations situated at elevations as low as 1,830 m (6,000 ft). It seems likely that human disturbance has caused the local extinction of *E. umbellatum* var. *torreyanum* at the lower elevation sites, relegating the variety to less accessible montane habitats. One historical occurrence was located near the Squaw Valley and Highway 89 interchange. Development in that area has apparently eliminated that occurrence.

There is potential for grazing activities to be detrimental to occurrences of *E. umbellatum* var. *torreyanum* for two reasons: 1) trailing and bedding of sheep within these populations and habitats may cause mechanical damage from trampling and frequent uprooting of individuals, and 2) allowing grazing during the short grazing season may reduce inflorescence and hence seed production. Cattle grazing has a much reduced chance of affecting this species because most habitat is located high on rocky terrain.

Management activities such as prescribed burning and timber harvesting would probably not affect *E. umbellatum* var. *torreyanum* because the species occurs on high rocky ridges where vegetation is naturally sparse.

Conservation

E. umbellatum var. *torreyanum* is a federal species of concern and a Forest Service sensitive species. As Forest Service sensitive, *E. umbellatum* var. *torreyanum* "will be managed to ensure that [it does] not become threatened or endangered because of Forest Service actions" (USDA 1988).

If future projects are proposed that would threaten *E. umbellatum* var. *torreyanum* habitat, surveys should take place to determine if this variety is present. Due to the limited number of occurrences of this species, any new population discoveries should be documented, and management scenarios should be coordinated so as to avoid adversely affecting populations. In those instances where *E. umbellatum* var. *torreyanum* occurs in existing or proposed grazing allotments, consideration should be given to modifying management prescriptions to avoid or limit effects to populations. Other conservation efforts might include federal acquisition of parcels on private land where populations of *E. umbellatum* var. *torreyanum* are threatened by proposed logging, mining, ski area expansion/development, or other disturbance. Consideration could also be given to withdrawing National Forest Lands from the land exchange base when parcels encompass occurrences of *E. umbellatum* var. *torreyanum.*

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TALL WHITETOP (*Lepidium latifolium*)

Robin Barron

Taxonomy

Scientific Name: *Lepidium latifolium L.*
Family: Brassicaceae (Mustard Family)
Common Name: Tall whitetop or perennial peppergrass.
ADP Taxon code: LELA-2
Type Locality: Unknown
Type Collector: Unknown

Description (Hickman 1993)

Lepidium latifolium is a perennial Eurasian weed that is one to three feet tall. In wet areas it may reach eight feet in height. *L. latifolium* is glabrous, grayish, and rhizomed. The basal lanceolate leaves are bright to gray-green. These leaves are toothed and long-petioled; there are many reduced cauline leaves 1-4 cm (0.4-1.6 in) wide. The lower leaves are petioled and the upper leaves are sessile. Leaf margins of *L. latifolium* are smooth to toothed. The inflorescence is a panicle, with sparse hairs. Sepals are less than 1 mm (0.04 in); the margins are wide. The petals are white and stamens number 6. The white flowers develop in dense clusters near the ends of branches. Individual flowers are very small, but the entire top of the plant blooms in early summer through fall. A two-seeded fruit capsule is formed. The reddish-brown seeds are round, flat, slightly hairy, and about 1 mm (0.04 in) long.

Distribution

L. latifolium is a native of southern Europe and western Asia that is now naturalized in many parts of the United States and declared 'Noxious' in numerous western states. It favors disturbed areas, beaches, tidal shores, saline soils, roadsides, wet areas, croplands and waste places, below 1,900 m (6,230 ft) (Hickman 1993). An early collection in the Calflora database references Jack Major as the collector in Sacramento County in 1963 (Dennis 1995).

L. latifolium occurs in El Dorado County and has long been established in the Highway 50 corridor with a large occurrence at Riverton (pers. observ.). It has also been observed along Highway 50 east of Little Norway and slightly west of Echo Summit and at the Nevada Department of Transportation yards on Logging Road Land off Kingsbury Grade (pers. observ.). In the Lake Tahoe Basin *L. latifolium* has been noted at Incline Village (Benoit 1997), South Shore (Donaldson 1999), Meyer's Landfill (Taylor pers. comm.), and at Tahoe City (Taylor pers. comm., Urie pers. comm.).

Ecology

Over six billion seeds are produced by one acre of *L. latifolium*; most are shed in the fall, but some persist until the next season (Donaldson 1999). This exotic invasive species favors disturbed areas and spreads by underground stems (rhizomes) that may grow 1 to 3 m (3 to 10 ft) from the main colony; new plants may also grow from fragments of rhizomes as small as 2.5 mm (0.1 in) thick (Donaldson 1999). Herbicide treatments are often ineffective because the leaves and stems of *L. latifolium* are covered with a waxy layer (Whitson 1991).

Effects of Human Activities

L. latifolium is believed to have been introduced into the United States as a contaminant of sugar beet seed in the late 1800s or early 1900s (Donaldson 1999). This species is now frequently spread by human activities such as construction projects and recreational activities. Seeds and rhizomes can be spread through contaminated fill dirt during road construction or repairs. Straw used for erosion control may also aid in plant dispersal. Seeds and rhizomes may also be carried on construction equipment, especially tires, to previously uninfested areas (Benoit 1997, Taylor pers. comm). Likewise, rhizome fragments may be transported by off-highway recreational vehicles. Since *L. latifolium* commonly infests streambanks and wetlands, and because seeds float, they can be transported by water flows in streams and irrigation ditches (Donaldson 1999). Livestock and waterfowl may also serve as dispersal vectors (Donaldson 1999).

Conservation

No biological control agents are currently available for *L. latifolium* (Callihan 1999) and large mature plants can have a 3 m (10 ft) root (Urie pers. comm.); thus, manual pulling of this species in the seedling stage is advised. To avoid reintroduction and further dispersal, all plant parts should be disposed of by burning or composting. Because new plants can sprout from very small sections of rhizomes, mechanical control measures such as mowing, disking or tilling are generally ineffective and are not recommended (Donaldson 1999). If herbicides are used to assist in control of *L. latifolium*, treatments must be properly timed to avoid wasting effort. Specifically, applications should be coordinated with the plant's growth cycle in order to achieve maximum effectiveness and may need to include two seasonal applications (Donaldson 1999).

Additionally, because the semi-woody growth of older plants often makes it difficult to apply herbicide to younger plants, effective herbicide treatments may need to incorporate removal of previous years' growth. Herbicide treatments may not be appropriate in instances where *L. latifolium* is associated with waterways or other wet areas.

In as much as the discovery of *L. latifolium* in the Lake Tahoe basin was relatively recent, initial monitoring scenarios could focus on determining its relative abundance or population size in the basin. As part of this monitoring strategy, efforts could be placed on encouraging public reporting of occurrences to the appropriate agencies and encouraging prompt removal of *L. latifolium* on private lands. Additionally, the benefits of education and awareness should not be overlooked. Such efforts could include information on dispersal mechanisms and the potential invasiveness of this species.

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LONG-PETALED LEWISIA (*Lewisia longipetala)*

Susan Urie

Taxonomy

Scientific name: *Lewisia longipetala* (Piper) Clay
Family: *Portulacaceae* (Purslane Family)
Common names: Long-petaled or large-flowered lewisia.
ADP Taxon Code: LELO
Synonymy: *Oreobroma longipetalum* (Piper), *Lewisia pygmaea* (A. Gray) Robinson in Gray spp. *longipetala* (Piper) Ferris, *Lewisia longipetala* (Piper) Clay.
Type locality: Sierra Nevada, mountains west of Truckee, California
Type collector: J.G. Lemmon, 1875

The following species account is based on information from the Interim Management Guide for *Lewisia longipetala* written by Anne Halford (1992a).

Description

Lewisia longipetala is a low, deciduous perennial less than 10 cm (3.9 in) in height when in flower, with a tuft of basal leaves produced from a short caudex with long fleshy branched roots. Basal leaves are many, mid-green and not glaucous. They are narrowly linear or linear-oblanceolate, 2-5 cm (0.9-2 in) long, 2-5 mm (0.9-2 in) wide, acute, scarious at the base, fleshy, flat and slightly channelled on the upper surface, convex beneath, forming loose tufts rather than well defined rosettes. Inflorescences consist of several scapes 3-6 cm (1.2-2.4 in) long, each bearing 1-3 flowers. Bracts are lanceolate, 5 mm (0.2) long with conspicuous purplish glandular teeth. The lower two are opposite; the upper alternate, subtending the branches the branches (if more than 1 flower) of the inflorescence. The pedicel is rather stout, 1-2.5 cm (0.4-1 in) long. Flowers are 2.5-3.5 (-4) cm (1-1.4 (-1.6) in) in diameter. Sepals are 2, dark purple, broadly obovate, 4-10 mm (0.16-3.9 in) long, and truncate or rounded at the apex conspicuously glandular-dentate. Petals numbering 5-10 are very pale pink, white with more senescent flowers, narrowly elliptic-oblong, 11-20 mm (0.43-0.79 in) long, acute or apiculate, often with a reddish gland at the apex; stamens 7-9. The style is deeply divided into 5 or 6 branches. Capsules are broadly ellipsoid, c. 8 mm (0.31 in) long. Seeds numerous, brown, ovoid 1.5 mm long, shiny.

Distribution

L. longipetala, a high altitude endemic, is found in alpine snowbank communities that occur along the crest of the Sierra Nevada. Its current distribution is restricted to an approximately 200 km (125 mi) section of the northern Sierra that includes portions of the Tahoe and Eldorado National Forests and the Lake Tahoe Basin Management Unit. *L. longipetala* occurs in several locations within Desolation Wilderness. The species was historically known from only nine locations before 1990. Since then three additional populations have been documented, which were located when approximately 100 km (62 mi) of suitable *L. longipetala* habitat was surveyed beyond the previously located populations during 1990 and 1991. In addition, historical populations of *L. longipetala* at Castle Peak on the Tahoe National Forest and Wahoo Lakes on the Sierra National Forest were revisited and found to be no longer present or originally misidentified. The 2 occurrences in the Lake Tahoe basin exist near Triangle Lake and Dick's Lake in Desolation Wilderness.

Ecology

L. longipetala is a perennial plant that is most often found growing within gravelly snowmelt rivulets directly below persistent snowbanks. The leaves regrow every year as the snowbanks start to recede. Depending on the amount of snowfall, the plants emerge and flower sometime between July and September (Van Zuuk 1999).

Little detailed information concerning the reproductive biology of *Lewisia* taxa is available; however, floral traits and nectar production are suggestive of insect mediated pollination systems (Hohn 1975). During the study of *L. longipetala* conducted on the Tahoe National Forest, observations of bumblebees (*Bombus edwardsii* Cresson) and *Chloralictus* bee species were documented, but only ants were observed visiting *Lewisia pygmaea*. Although no detailed experiments were undertaken to examine the importance of pollinator associations in *L. longipetala* and *L. pygmaea,* 5 plants that were bagged to exclude pollinators did not produce seed, whereas unbagged plants did (Halford 1992a, 1992b). Cross-pollination within the *Lewisia* genus is encouraged due to the delayed maturation of the stigma in relation to the anthers.

Seeds are numerous, small and probably drop down, establishing in close proximity to the plant which shed them. Seeds could also be dispersed by the water from the melting snowbanks. Other methods of seed dispersal are unknown, but probably exist since separate occurrences are located on high ridge tops, often many miles apart.

Carex paysonis, Antennaria media, Juncus mertensianus and *Lewisia pygmaea* were the plants most commonly associated with *L. longipetala.* Competition between these species was not analyzed in the Interim Management Guide (Halford 1992a).

Habitat Relationships

L. longipetala is a highly restricted species due to its habitat specialization. Occurrences of *L. longipetala* are most commonly associated with high elevation leeward facing slopes or basins that receive high snow accumulations. Soils are derived from basaltic and granitic parent materials (specific soil types are concurrent with existing soil types listed in Van Zuuk [1999]). Within these level slopes and basins, *L. longipetala* is most often found growing within gravelly snowmelt rivulets below persistent snowbanks. In addition, some of the most robust plants are found growing directly in the meltwater from these snowbanks. Smaller populations (fewer than 50 individuals) have also been documented in cracks of steep (greater than 30 percent) granitic slabs. All populations receive snowmelt runoff; the amount and duration depends on the year's snowpack. *L. longipetala* and other associate *Lewisia* species *(L. pygmaea, L. nevadensis,* and *L. triphylla)* quickly senesce following a decrease in water availability.

Currently there is little information regarding the response of *L. longipetala* to disturbance. However, recent data (Halford 1992a) suggest that several environmental factors may exist as limitations to overall plant population vigor. These physical and biotic factors include water limitations in sites where topography does not provide for continuous snowmelt runoff and elements of potential competitive exclusion of *L. longipetala* by other herbaceous species in those areas capable of sustaining more vegetation. Naturally occurring variations in weather patterns tend to affect the life cycle of *L. longipetala* from year to year. In heavy snow years some plants may remain buried until snowfield melts, lying dormant below a larger than usual snowfield. In exceptionally dry years, *L. longipetala* may experience a very short season and senesces when snowmelt water supply runs out.

Effects of Human Activities

Human activities that alter the hydrology of an area directly above or within a population of this species, or activities that would uproot plants through displacement of the soil surface could potentially reduce the viability of *L. longipetala*. In Desolation Wilderness recreational activities such as camping, hiking and equestrian use have the potential to cause such disturbances. Additionally, because trails tend to channel water and may alter surface water flow, trail placement may affect *L. longipetala* populations; currently, no trails appear to affect known populations of this species. New trail locations and camping areas should be planned to avoid negatively affecting known population locations.

Populations of *L. longipetala* could also potentially be adversely affected by grazing activities because trailing and bedding within plant populations could cause mechanical damage and uproot individuals. Additionally, allowing grazing during the short growing season of this species could reduce inflorescence and hence seed production. Because *L. longipetala* is found in high elevations and in rocky terrain, sheep grazing would be expected to have more potential to adversely affect populations than cattle grazing.

Management activities such as prescribed burning and timber harvesting would not likely affect the occurrences of *L. longipetala* because all known locations are on high rocky ridges where vegetation is naturally sparse.

Conservation

L. longipetala is a federal species of special concern, a Forest Service sensitive species, and a TRPA sensitive species. As Forest Service sensitive, *D. asterophora* var. *asterophora* "will be managed to ensure that [it does] not become threatened or endangered because of Forest Service actions" (USDA 1988). The TRPA has established that a minimum of two population sites be maintained for *D. asterophora* var. *asterophora* (TRPA 1986) and that "Projects and activities…shall be regulated to preserve sensitive plants and their habitat" (TRPA 1987).

If future projects are proposed that would pose a treat to *L. longipetala* populations, conservation efforts should provide for total protection, due to the limited number and size of these occurrences. Through monitoring and protection of *L. longipetala* populations, genetic diversity, a prerequisite to maintaining species viability, may be enhanced.

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EURASIAN WATERMILFOIL (*Myriophyllum spicatum)*

Robin Barron

Taxonomy

Scientific Name: *Myriophyllum spicatum L.*
Family: Haloragaceae (Watermilfoil Family)
Common Name: Eurasian watermilfoil or Eurasian milfoil
ADP Taxon Code: MYSP
Type locality: Unknown.
Type collector: Willoughby, John W. 1814.

Description (from Hickman 1993)

Myriophyllum spicatum is a rooted aquatic perennial with smooth stems that branch near the water's surface. The stem can be more than 2 m (6.6 ft) long. It is reddish or olive-green when dry. It grows from six to nine feet long with long, vine-like stems. The feather-like leaves are up to 3.8 cm (1.5 in) long, and are whorled about the stem in groups of 4. The leaflets grow in pairs of more than 12 on each leaf. This characteristic helps to distinguish *M. spicatum* from native species, but it is not consistent (Donaldson and Johnson 1999). Inflorescence is a spike, 4–8 cm (1.6–3.1 in) tall and is emergent. This species is commonly found in lakes and marshes at less than 1,500 m (4,920 ft). *M. spicatum* is native to Eurasia and North Africa.

Distribution

M. spicatum is a "one of the most widely distributed of all non-indigenous aquatic plants" (Jacono 1999, p. 1). *M. spicatum* is confirmed in 43 of the United States and 3 Canadian provinces; it is continuing to expand to new locations (Jacono 1999). Most plants are found in water up to 3 m (10 ft) deep, although they can be found in water as deep as 6 m (20 ft) (Donaldson and Johnson 1999). The first documented occurrence of *M. spicatum* in the United States was in Washington, D. C. in 1942 (Jacono 1999). The species spread westward into inland lakes primarily by boats and water birds and reached Midwestern States between the 1950s and 1980s (MDNR 1995). The Calflora database has only 8 entries for *M. spicatum*, the earliest being 29 July 1976; none of the specimens were collected in counties adjacent to Lake Tahoe (Dennis 1995).

Although generally found at elevations below 1,500 m (4,920 ft), *M. spicatum* is found in Lake Tahoe at Tahoe Keys Marina, Emerald Bay, Crystal Bay, Elk Point Marina, Ski Run Marina, and the Upper Truckee River (Donaldson and Johnson 1999).

Ecology and Habitat Relationships

M. spicatum is spread primarily by plant fragments, although it does produce seeds (Jacono 1999, Hickman 1993). Fragments of the stem that have nodes are capable of growing roots, stems, and leaves as they float in water; rooted plants can be spread by rhizomes (MDNR 1995, Hickman 1993). This species occurs in ponds, reservoirs, lakes, irrigation canals, and slow moving areas of rivers and streams; *M. spicatum* can also found in brackish water of estuaries (Jacono 1999). This species becomes "particularly troublesome in waterbodies that have experienced disturbances such as nutrient loading, intense plant management, or abundant motorboat use" (Jacono 1999, p. 1).

M. spicatum is an aggressive exotic invasive that has the potential to displace native aquatic plants in a variety of ecosystems. Because it is tolerant of low water temperatures, this species is able to begin growing in early spring from shoots that were formed the previous fall; it then forms thick mats that reduce solar penetration and shade other plants (Jacono 1999). As *M. spicatum* becomes established, "…canopy formation and light reduction, are significant factors in the decline of native plant abundance and diversity" (Jacono 1999, p.1).

Although recreational watercraft are the most common transportation mechanism for new introductions of *M. spicatum*, waterbirds also play a role in its spread in some areas (MDNR 1995). A single fragment on a boat propeller can spread the plant from lake to lake (Donaldson and Johnson 1999).

Effects of Human Activities

As previously noted, *M. spicatum* may spread by several vectors including waterbirds; however, it is thought to have been introduced into Lake Tahoe by watercraft brought in by recreational visitors. Because this species can easily reproduce from stem fragments, watercraft may also aid in its distribution within inhabited waters by fragmenting plants. In areas where *M. spicatum* is present, other human activities such as the mechanical clearing of aquatic vegetation for marinas or docking facilities have the potential to aid in reproduction by creating thousands of new fragments (MDNR 1995).

Investigations are presently being conducted to identify insects that may aid in the biological control of *M. spicatum*. Studies have indicated that *Euhrychiopsis lecontei*, a North American native milfoil weevil, can cause significant damage to *M. spicatum* while having little impact on native species (Newman 1999). This suggests the insect may be useful as a potential biocontrol agent. The milfoil weevil is native to North America and is a specialist herbivore of watermilfoils. Once exposed to the exotic *M. spicatum*, the weevil prefers *M. spicatum* to its native host *M. sibericum* (Donaldson and Johnson 1999). Adult weevils live submersed and lay eggs on milfoil meristems. The larvae eat the meristem and bore down through the stem, consuming the cortex, and then pupate lower on the stem. The consumption of meristem and stem mining by larvae are the two main effects of weevils on the plant and this damage can suppress plant growth, reduce root biomass and carbohydrate stores and cause the plant to sink from the water column. Although the weevil has been quite effective at some sites, it has not been effective at other sites; thus, site specific predictions regarding a degree of effectiveness can not be made (Solarz and Newman 1996, Sheldon and O'Bryan 1996, Creed and Sheldon 1993, 1995, Newman et al. 1996, Creed and Sheldon 1992, cited in Newman 1999).

Other potential biological control agents for *M. spicatum* include *Acentria ephemerella*, a naturalized pyralid moth, and *Cricotopus myriophylli,* a native chironomid midge. The caterpillar of *Acentria* has been associated with milfoil declines in New England and Ontario; studies show it has a "high preference" for *M. spicatum*, but it also eats many other species of aquatic macrophytes. It is unknown how these potential biological controls would affect the indigenous species of Lake Tahoe, so, as noted in discussions of invertebrates such as *Capnia lacustra* (see Focal Species Account for *Capnia lacustra*), caution should be exercised before introducing nonnative invertebrates into the lake.

Mechanical harvesting to reduce the mass of plant growth during the summer only removes plant matter down to about six feet, and it promptly regrows (Donaldson and Johnson 1999). Additionally, as previously noted, mechanical clearing has the potential to aid in reproduction by creating thousands of new fragments (MDNR 1995).

Conservation

Monitoring efforts could focus on determining the relative abundance of *M. spicatum* at different sites in the Lake Tahoe basin. Once this is determined, the type and extent of control and/or eradication efforts can be evaluated. Other actions could include implementation of prevention programs to stop the spread of *M. spicatum* into bodies of water in the basin that are currently weed-free (Donaldson and Johnson 1999). Interim conservation efforts might focus on reducing the mass of plant growth of known populations of *M. spicatum*.

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SUGAR PINE (*Pinus lambertiana*)

Mike Taylor

Taxonomy

Scientific Name: *Pinus lambertiana* Douglas
Family: Pinaceae
Common Name: Sugar pine
ADP Taxon Code: PILA
Type locality:
Type collector:

Description (from Sudworth 1967)

Pinus lambertiana is the tallest and largest of the pines. Mature trees can be 50 to 55 m (160 to 180 ft) tall with a diameter at breast height (DBH) of 1.2 to 2.1 m (4 to 7 ft). Occasionally taller and larger trees are found. Mature trees are known for straight trunks with only a slight taper. Crowns are flattened with long horizontal branches. Old bark is deeply furrowed longitudinally and is a gray- brown to deep red- brown. Bark of young trees is smooth, thin and dull gray. Foliage is blue-green. The needles in bundles (fascicles) of five are from 6.4 to over 10 cm (2.5 to 4 in) in length. Cones are from 30.5 to 61 cm (12 to 24 in) in length, the longest of the genus, and about 7.6 to 10 cm (3 to 4 in) in diameter. The brownish cones ripen during August of the second year. The seeds are smooth and vary from dark chocolate to a blackish brown. The wood is light and soft with heartwood that is pale reddish brown and is of great commercial value.

Distribution (Sudworth 1967)

P. lambertiana extends from the mountains of Western Oregon to Southern California; it is also found in Baja California. In Oregon, *P. lambertiana* inhabits mixed conifer and mixed evergreen forests from the west side of the Cascade Mountains in north-central Oregon south into the Siskiyou and Klamath ranges at elevations between 518 and 1,524 m (1,700 and 5,000 ft) . In California, *P. lambertiana* ranges throughout the Sierra Nevada to Southern California. It is abundant in the northern two-thirds of the state at elevations between 915 m and 1,830 m (3,000 and 6,000 ft) with the exception of the Modoc Plateau (northeastern California), where it does not occur. It ranges westward to within 32—48 km (20—30 mi.) of the Pacific Ocean (the inland margin of the fog-belt) and is reported to extend nearly to sea level on the flats of the Smith River (Del Norte County). In the northern Sierra it is mainly on the west slope at elevations between 1,070 to 1,980 m (3,500 and 6,500 ft), occasionally to 610 and 2290 m (2,000 and 7,500 ft). In the Lake Tahoe basin *P. lambertiana* extends onto the east slope and along the shore of the lake at an elevation of 1,905 m (6,250 ft); it follows the Truckee River into Nevada to a point opposite Reno, Nevada where it is scattered at elevations above 1,830 m (6,000 ft).

Ecology and Habitat Relationships

In the Sierra Nevada, *P. lambertiana* grows mainly on loose, deep, moist, well-drained, sandy or gravelly loams where the humidity is fairly high (Collingwood and Brush 1947). Optimum rainfall is over 102 cm (40 in) per year. Mature trees stand on a broad, shallow root system (Collingwood and Brush 1947).

Kinloch and Scheuner (1990) note that peak reproduction occurs late in *P. lambertiana*; often trees as large as 51 cm (20 in) DBH produce as few as 15 cones per crop, but mature trees can produce crops of up to 400 cones. The seeds are large with an average of 2,100 seeds/lb. The seed is also heavy with a relatively small wing; therefore, seed is rarely dispersed beyond 45 m (150 ft) from the parent tree. The species also has a relatively small investment in foliage as a proportion of total biomass. Early growth of *P. lambertiana* is slow compared with *P. ponderosa* (ponderosa pine); most of the energy is devoted to roots and stem. However, the growth rate accelerates during the pole stage and is sustained for longer periods of time than those of common associates (Kinloch and Scheuner 1990).

P. lambertiana is more tolerant of shade than *P. ponderosa* or *P. jeffereyi* (Jeffrey pine), but less tolerant than *Abies concolor* (white fir) or *Calocedrus decurrens* (incense cedar) (Baker 1949). Young trees are easily damaged by fire, but the thick bark of older trees protects them (USDA 1971). However in proportion to the diameter, *P. lambertiana* has thinner, denser bark, with poorer insulating capacity than the bark of associated conifers (USDA 1971). Because of their height, old trees are frequent targets of lightning. *P. lambertiana* is intermediate in sensitivity to sulfur dioxide injury, being less sensitive than true firs, *Pseudotsuga menziesii* (Douglas-fir), and hemlock (*Tsuga* spp.), but more sensitive than the hard pines, *Larix occidentalis* (western larch) and *Picea engelmanii* (Engelmann spruce) (Scheffer and Hedgcock 1955).

P. lambertiana is a component of the mixed conifer zone. In the northern Sierra Nevada and southern Cascades the mixed conifer zone is composed of a diverse mixture of montane trees, dominated by conifers including *A. concolor*, *P. menziesii, C. decurrens*, *P. ponderosa* and *P. lambertiana* (Fites 1993). The hardwoods *Quercus kelloggii* (black oak) and *Quercus chrysolepis* (canyon live oak) are common as well (Fites 1993). The mixed conifer zone is further divided into three separate series—Douglas-fir-mixed conifer, ponderosa pine-mixed conifer and white fir-mixed conifer (Fites 1993). *P. lambertiana* is a species common to all three series. It ranges from relatively low elevations, 640 m (2,100 ft), in the Douglas fir-mixed conifer series, to middle high elevations, 1,920 m (6,300 ft), in the white fir-mixed conifer series (Fites 1993). Rarely a site dominant, *P. lambertiana* and *C. decurrens* are nearly constant minor components (canopy cover estimates for *P. lambertiana* across all three mixed conifer series range from 4 percent to 38 percent) (Fites 1993).

Effects of Human Activities

P. lambertiana has great ecological value and contributes to the biodiversity of the mixed conifer ecosystem. It provides structural and functional diversity including food and habitat for many wildlife species. However, the arrival of *Cronartium ribicola* (white pine blister rust) into the Klamath and Siskiyou mountains in 1930 has sharply reduced the abundance of *P. lambertiana* (Mielke 1943). *C. ribicola* was accidentally introduced into British Columbia in 1910 on white pine nursery stock imported from France (Kimmey and Wagner 1961). *C. ribicola* is predominantly a moist, cool weather disease, and conditions for its spread to pines become less frequent and of shorter duration from north to south (Kimmey and Wagner 1961). The gradient of increasing temperature and aridity from north to south has apparently retarded the spread of the disease in the Sierra; however, these conditions have not stabilized the epidemic. Every decade the disease extends into new areas and intensifies in areas previously invaded (Kimmey and Wagner 1961). A small percentage of *P. lambertiana* have shown major gene resistance (MGR) to *C. ribicola*.

It is likely that historic logging practices have had an effect on the relative abundance of *P. lambertiana* in mixed conifer forests. Comparison of historic (1935) and recent (1992) data from studies of forested stands in the northern and central Sierra show a dramatic decline in basal area of *P. lambertiana* (as well as a significant decrease in stand basal area overall) in mixed conifer type forests in the Sierra Nevada (Bouldin 1999). The 1935 surveys of 413 plots measured the average basal area of *P. lambertiana* at 48 square meters per hectare (210 square feet per acre), which was 43 percent of the average total basal area of 111 square meters per hectare (482 square feet per acre) (Bouldin 1999). Data taken in 1992 from 635 mixed conifer plots show *P. lambertiana* basal area averaging 12 square meters per hectare (53 square feet per acre), or 26 percent of the average overall basal area of 48 square meters per hectare (207 square feet per acre) (Bouldin 1999). This represents a 57 percent reduction of overall basal area and a 75 percent reduction in basal area of *P. lambertiana*.

Conservation

The Pacific Southwest Region of the USDA Forest Service initiated a breeding program for rust resistant sugar pine in 1957. A Region-wide screening program has located more than a thousand MGR trees scattered throughout the Sierra Nevada and northern California. The breeding program is not only focused on MGR resistance; additional mechanisms termed slow rust resistance are being evaluated and incorporated into the program. The goal is to meet reforestation requirements with seed from both proven MGR and slow rust seed parents (Kitzmiller 1976, Stover pers. comm.).

Other strategies for protecting the genetic diversity of *P. lambertiana* include timber sale marking prescriptions that favor the retention of *P. lambertiana* over other species during thinning projects. Reforestation projects on mixed conifer sites require that 10 percent of the replanted trees are *P. lambertiana*, specifically MGR seedlings, if available (Dabney pers. comm.).

Envirogram of the Sugar Pine

The envirogram of the sugar pine (Figure O-1) depicts important habitat elements, food resources, interspecific interactions, and reproductive requirements of the species.

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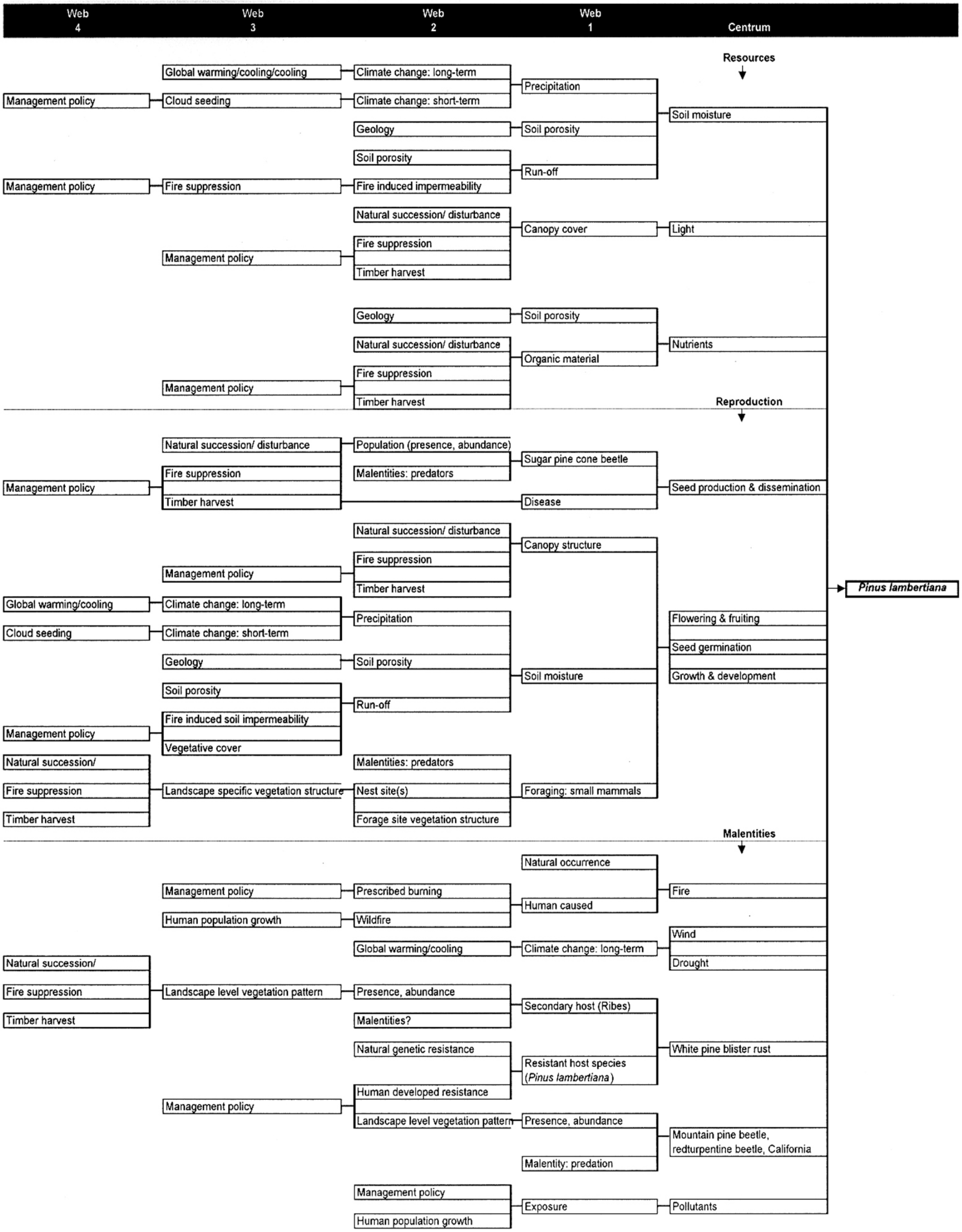

Figure O-1—Envirogram for the sugar pine (*Pinus lambertiana*).

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TAHOE YELLOWCRESS (*Rorippa subumbellata*)

Susan Urie

Taxonomy

Scientific name: *Rorippa subumbellata* Rollins
Family: *Brassicaceae (Mustard Family)*
Common names: Tahoe Water Cress, Tahoe Yellowcress, Tahoe Yellow Cress.
ADP Taxon Code: ROSU-2
Synonymy: None.
Type locality: Meeks Bay, Eldorado County
Type collector: Reed C. Rollins, 1941

Description (from Hickman 1993)

Rorippa subumbellata is a low, decumbent perennial with several branched stems 5–15 (20) cm (2–5.9 (7.9 in) long with hairs crinkled. Leaves are sessile to short-petioled, clasping stems or not, 1–3 cm (0.04–1.2 in), oblong to widely oblanceolate, wavy-margined to deeply pinnately lobed; hairs lacking or sparse. The inflorescence ranges from umbell-like to elongate. Flowers have sepals 2–3 mm (0.08-0.12 in), yellowish, glabrous, persistent in fruit; petals 2.5–3.5 mm (0.1–0.14 in), oblong-oblanceolate to spoon-shaped, yellow. Fruits are 3–5 mm (0.12–0.2 in), widely oblong to more or less round, more or less glabrous; pedicel erect to ascending, 3–6 mm (0.12–.24 in), straight; style 1–1.5 mm (0.04–0.06 in), glabrous, stigma unexpanded. The seed of *R. subumbellata* is about 1 mm (0.04 in), plump and more or less angled.

Distribution

Rorippa subumbellata is endemic to beaches on the shores of Lake Tahoe. The distribution around the Lake Tahoe's edge is patchy, with most occurrences found on the west and south shores in California, where the greatest expanses of beach occur (CSLC 1998).

Ecology

R. subumbellata is a perennial plant which is capable of re-sprouting each season from dormant rootstalks, though it is unknown if rootstalks could survive being inundated by water for long periods of time. The dominant mechanism of site recolonization, whether by seed, re-sprouting, or the deposition of vegetative plant material, has not been determined (CSLC 1998). The species grows in sandy substrate with little or no soil formation and generally good drainage. *R. subumbellata* grows in full sunlight and has a low to moderate dependency on seasonal precipitation (Kundert 1990). The plants are found where the beach is wide enough to offer a back beach area, out of wave action and behind the highest debris deposit line (Ferreira 1987).

Little detailed information concerning the reproductive biology of *R. subumbellata* is available. The longevity and germinative capabilities of the seed of *R. subumbellata* are unknown. Pollinators have not been identified. Seeds are small (less than 1 mm [0.04 in]) and probably drop down, establishing in close proximity to the plant that shed them. Seeds could also be dispersed by lake water.

R. subumbellata usually grows in areas which are either sparsely vegetated by other species or in areas with no other vegetation. It grows in three beach habitat sites: high elevation, wetland and disturbed beaches. The high elevation beach associated species are *Phacelia hastata* var. *hastata* (Phacelia), *Lupine* sp. (lupine), *Lepidium virginicum* var. *pubescens* (peppergrass), and others. Wetland beach associates are *Juncus balticus* (rush) *Carex douglassii* (sedge), *Salix* sp. (Willow), *Alder incana* var. *tenufolia* (alder), *Mimulus guttatus* (monkeyflower) and others.

R. subumbellata grows among *Bromus mollis* (brome), *Verbascum thapsus* (mullien), and *Rumex crispus* (curly dock) on disturbed beaches (CSLC 1998).

Habitat Relationships

Natural conditions such as changing lake surface elevations, sand movement by water erosion, and competition with wetland plant species can all eliminate or create suitable substrates for plant growth (CSLC 1998). It is not yet known how these conditions specifically affect *R. subumbellata.*

According to the CSLC Biological Assessment (CSLC 1998), the number of *R. subumbellata* occurrences in any particular year is strongly related to the cyclic lake elevations. During periods of low water, additional habitat for *R. subumbellata* is exposed and becomes available for colonization, such as the 1992–1993 season. When the lake level is high, much of the habitat for *R. subumbellata* is inundated and unavailable for plant growth. While high lake levels may cause mortality in some *R. subumbellata* sites and pose an immediate threat to existing individuals, it is likely beneficial to the species in the long term because high lake levels remove other plant species and open new habitat. Kundert (1990) noted that Lake Tahoe experienced a "…drought cycle during 1977, 1978, and 1980 that was followed by high water levels in years 1981, 1982, 1983, and 1985… During this period, populations [of *R. subumbellata*] have increased during low lake levels and correspondingly decreased during high lake levels. This seems to indicate only a temporal effect on the population size of this plant and may not be a long term one." Presently, dam operations are altering the historical seasonal fluctuation of the lake; the impacts of these operations on *R. subumbellata* populations have not been well documented.

Beaches at the mouths of streams are completely reformed during periods of high spring runoff, such as in 1982, 1983, 1986, and 1997 (CSLC 1998). During such events, aerial stems and rootstocks of *R. subumbellata* are removed. This material may be deposited around the lake, providing a mechanism for *R. subumbellata* to distribute propagules to other lake shore locations. At this time there are not data to support or refute this idea.

Fluctuating water levels also influence the competitive interaction of *R. subumbellata* with other wetland plant species (CSLC 1998). During high water years, wetland species such as rushes (*Juncus* spp.) and willows (*Salix* spp.) colonize much of the available beach. Depending on the duration of the high water over a number of seasons, wetland species may completely displace *R. subumbellata* in some locations. If higher ground is available at the site of colonization, *R. subumbellata* will often become established in those areas. This mechanism of growing across a range of elevations has allowed *R. subumbellata* to track changing water tables, avoiding inundation and competition from other plants.

Effects of Human Activities

Substrate disturbance, construction, other development and recreation are the primary anthropogenic disturbances to *R. subumbellata* and its habitat (CSLC 1998). Obviously, much of the sandy beach habitat of Lake Tahoe is very popular for human activities. Substrate disturbance results from heavy foot traffic and other disturbances. Substrate disturbance mixes the normal sand layering and breaks up the soil armor layer that are often associated with *R. subumbellata* sites. Construction and development reduce the available habitat. Constructing piers requires the use of heavy machinery, which poses immediate risk to the individual plants and churns the sand, breaking up natural layering and surface armor. One of the most detrimental development activities is beach raking and clearing by home owners. Localized recreation is generally considered the greatest risk to *R. subumbellata* and its habitat. Recreation activity may account for the loss of the plant at various sites around the Lake including El Dorado Beach, one of the most heavily used beaches in the basin (TRPA 1995).

Conservation

The California State Lands Commission (CSLC) has been developing a Biological Assessment for *R. subumbellata*. CSLC has collected information from surveys of 44 potential sites over the past twenty years. *R. subumbellata* was found to occur on 9 of those sites in 1997 when the Draft report was released. Seven of the original 43 sites were not surveyed in 1997 (CSLC 1998). Known occurrences lie within Nevada and California on public and private property. The Biological Assessment and the development of a Tahoe yellowcress stewardship plan are being carried out under the auspices of a multi-agency and private interest group task force. The California State Lands Commission is the lead agency coordinating this program. Other involved agencies include the USDA Forest Service (USFS), Tahoe Regional Planning Agency (TRPA), USDI Fish and Wildlife Service (USFWS), California Department of Parks and Recreation (CDPR), California Fish and Game (CDFG), California Tahoe Conservancy (CTC), Nevada Natural Heritage Division, and Nevada Division of Forestry. Private interests, including private shore owners, developers, local environmental groups, and consultants are also encouraged to participate in the *R. subumbellata* conservation effort.

Several agencies including the USFS, CDPR, Kingsbury General Improvement District, USFWS and the TRPA have transplanted seedlings and installed exclosures or supported inventories and studies. All of these efforts have contributed towards the conservation of the species to some degree. Some projects were successful at first, but lost ground because the installed structures either were not maintained or were disregarded by the public. The population trend data indicate that occurrences and habitat are being reduced.

Suggestions for species conservation include yearly monitoring and research projects to fill in knowledge gaps. Many studies have been performed to investigate habitat relationships and historical distribution, but several aspects of this species life history, population demographics and ecology are still unknown. The Biological Assessment (CSLC 1998) has outlined the objectives for a research plan: 1) to derive basic population parameters such as rates of seed set, germination, recruitment, growth, and mortality in order to project the future population status under current conditions; 2) to examine important aspects of the life history characteristics of *R. subumbellata* (e.g., preferred environmental conditions for germination and establishment, impacts of inundation and soil disturbance); and 3) to quantify environmental features at sites with *R. subumbellata*.

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WATER BULRUSH (*Scirpus subterminalis*)

Susan Urie and Erik M. Holst

Taxonomy

Scientific name: *Scirpus subterminalis* Torr.
Family: *Cyperaceae* (Sedge Family*)*
Common names: Water Bulrush, Water Club-rush.
ADP Taxon Code: SCSU_?
Synonymy: None
Type locality:
Type collector: John Torrey, 1984

Description (from Hickman 1993)

Scirpus subterminalis is a perennial sedge that grows submersed in water up to the inflorescence.

Culms are 20–140 cm. (8–55 in); leaf tips generally floating; rhizome is long, delicate. Stems are generally erect, and less than 1 mm (0.4 in) wide and cylindric. Leaves are basal and cauline with sheaths to one-half the stem. Blades much greater than sheaths, weak, and slender. Inflorescence is a spikelet 1, 6–13 mm (0.2–0.5 in) long and 4–7 mm (0.15–0.27 in) wide; bract 1, 1–6 cm (0.4–2.4 in), erect, stiff, and more or less stem-like. The floral bract is 4–6 mm (0.15–0.24 in), glabrous, green, pale brown in age, and the tip abruptly pointed. Flower perianth bristles are generally 6, less than to equal fruit, more or less straight to contorted. Fruit 2.5–4 mm (0.09–0.16 in), sharply three-angled, and smooth.

Distribution

S. subterminalis occurs from southern Alaska to southern Oregon, chiefly west of the Cascade summits, but also extending inland to northern Idaho, and northwest Montana; Newfoundland to Ontario, south to South Carolina, Georgia and Missouri with an isolated station in Utah (Cronquist et al. 1977). *S. subterminalis* is rare in California. The Jepson Manual lists this plant as occurring in the Klamath Range and northern Sierra Nevada high country (Hickman 1993). In the Lake Tahoe basin, Dennis (1999) notes 2 collections at Grass Lake and 2 collections at Upper Angora Lake; all 4 of these collections were made in 1972.

Ecology and Habitat Relationships

S. subterminalis is a rhizomatous perennial herb that grows submersed in margins of lakes, ponds and marshes at elevations between 1,750–2,250 m (5,741–7,382 ft) (Skinner and Pavlick 1994, Hickman 1993). Data from collections of this species in the Lake Tahoe basin indicate that it needs a constant source of water. The Species Management System for California Herbaria 'Detail Query Results' noted both Upper Angora Lake collections were made by Smith in water near the lake shore (SMASCH 1999). Smith's (1973) collection records indicate that in Upper Angora Lake this species was found in water to 30 cm. (11.8 in) deep. One of the SMASCH (1999) queries for *S. subterminalis* at Grass Lake noted this species growing on floating *Sphagnum* mats. (For further information on Grass Lake, see the Ecologically Significant Area account of bogs and fens in this chapter, Appendix X.)

Effects of Human Activities

Since *S. subterminalis* is dependent on a constant source of water, recreational activities such as camping, swimming and wading have the potential to reduce species population viability by disturbing sediment, uprooting plants, or polluting ponds, lakes, marshes and bogs where this species occurs. Similarly, sheep and cattle grazing may negatively affect population viability.

Conservation

Because of the age and small number of documented occurrences of *S. subterminalis* in the Lake Tahoe basin, the initial step in a conservation and/or monitoring strategy would be to determine the extent of the population of this species within the basin. The need for and degree of protection could then be evaluated. Interim strategies to avoid adverse impacts to *S. subterminalis* population viability could include conservation of the pond, lake, marsh, and bog ecosystems.

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Birds

BALD EAGLE (*Haliaeetus leucocephalus*)

J. Shane Romsos

Distribution

Bald Eagles occur throughout North America and are permanent residents and winter migrants in California (Detrich 1986). Breeding Bald Eagles in California are restricted primarily to northern counties, are typically found at lower elevations, and rarely occur in the high Sierra Nevada. In Nevada, a pair of Bald Eagles has bred at Lahontan Reservoir in the north central part of the state, at Topaz Lake (state line between California and Nevada), and nests were established near the mouth of the Carson River and at Marlette Lake in the Lake Tahoe Basin (L. Neel, pers. comm.). In the Lake Tahoe basin the occurrence of Bald Eagles has been recorded as far back as 1874 (Orr and Moffit 1971) with at least two nest sites known to exist today (one at Emerald Bay and the other at Marlette Lake). Sighting records indicate that the basin is used year-round by Bald Eagles; however, use occurs primarily during fall and winter months in correspondence with kokanee salmon (Oncorhynchus nerka) spawning activity. Most Bald Eagle sightings in the basin have been along undeveloped shorelines (east and west shores of Lake Tahoe and at Fallen Leaf and Marlette Lakes) and south shore marshes (Laves and Romsos 1998, USFS – LTBMU unpub. data).

Ecology

Population Biology/Demographics

Bald Eagles produce 1 to 3 eggs (usually 2) and typically only fledge 1 chick per nest (Bent 1961, Ehrlich et al. 1988). Mabie et al. (1994) reported that 33% (46 of 138) of nestlings banded in Texas survived to breeding age. Gerrard et al. (1978) estimated a 37% first-year survival rate for 43 tagged birds in Canada. Others have reported survival rates of immature birds ranging from 10 to 100% (Sherrod et al. 1976, Buehler et al. 1991, McClelland et al. 1996). Sherrod et al. (1976) estimated adult Bald Eagle mortality rates in Alaska at 5.4% per year. Harmata et al. (1999) estimated an 87% first year survival rate, a 60 to 71 % survival rate during the 3- to 4-year age class, and a 34% survival rate through age 7 for eagles tagged in the Greater Yellowstone Ecosystem (GYE). Bald Eagles have been reported to live up to 36 years in captivity (Johnsgard 1990). Causes of mortality include starvation, shooting, trapping, disease, accidents and collisions, poisoning, conspecific encounters, and electrocution (Newton 1979, Wiemeyer et al. 1993, Garcelon and Thomas 1997, Harmata et al. 1999).

Life History

The Bald Eagle mating season is dependent on latitude. In the central states of North America (at a similar latitude to Lake Tahoe's), Bald Eagles initiate pair bonding and mate between January and July. Eagles form long term pair bonds, but if one of the birds dies, the survivor will soon form a new bond (Bent 1961). Thus, eagles are usually monogamous; however, polygyny (one male concurrently tending to two females in the same nest) has been observed in a population in the southern Channel Islands of California (D. Garcelon, pers. comm.).

Bald Eagles' investment in producing chicks can be significant. Eggs are incubated for approximately 35 days (Bent 1961, Ehrlich et al. 1988) and chicks are semialtricial at hatching (immobile, downy, eyes open, and fed by parents). Both parents provide for chicks for 10 to 12 weeks, at which time young will fledge. Wood et al. (1998) reported that fledgling eagles showed nest site dependency from 4 to 11 weeks after first flight with 80% of the fledgling observations occurring within 229 m of the nests. In the Lake Tahoe basin in 1998, egg laying was estimated to occur in early May and young fledged in late August (USFS - LTBMU unpub. data). Bald Eagles reach sexual maturity at age 4 to 5. Harmata et al. (1999) reported an average age of 6.2 years for eagle first reproduction (n = 6) at GYE. At sexual maturity, the typical Bald Eagle plumage becomes obvious.

Reproductive Behavior

Bald Eagle courtship displays can be spectacular. Eagles engage in aerial displays that include locking talons and descending in a series of somersaults, rapid chasing, and circling (Bent 1961, Ehrlich et al. 1988). Bent (1961) reported that adults sometimes mated with immature eagles, but that two immature eagles mating was unlikely.

Foraging

Although eagles will eat a variety of prey items, they are specialized to consume only flesh. Bald Eagles require large bodies of water (i.e., lakes, reservoirs, large rivers, oceans) with abundant prey resources (mostly fish and waterfowl). Typical foraging behavior includes swooping from hunting perches or from soaring flight to glean fish or waterfowl from the water surface. In shallow water, eagles will wade and pursue fish (Bennetts and McClelland 1997). In flooded fields, eagles will pounce on displaced small mammals. Eagles are also known to scavenge on carcasses of a variety of taxa. During spawning runs, eagles will occasionally congregate into large groups to take advantage of abundant fish. Grubb and Lopez (1997) observed Bald Eagles "ice fishing" during winter, in which eagles punched a hole in the ice and waited for fish to come within striking distance. Eagles will also scavenge fish frozen in lake ice (Grubb and Lopez 1997). Eagles have been known to pounce on or chase injured or ice-bound waterfowl. Bennetts and McClelland (1997) observed that Bald Eagle foraging ability becomes more efficient with age due in large part to experience in using different foraging methods.

Dispersal/Movement

Breeding Bald Eagles in North America include a combination of resident and migratory populations, in that some birds in a population will migrate and others will remain at breeding areas (Jenkins et al. 1999). When food supplies are consistent year-round and a mild winter climate is predominant, eagles are more likely to remain on breeding territories throughout the year (Newton 1979).

The direction and distance of Bald Eagles dispersal and seasonal movements can be unpredictable. In general, eagles fledged in Alaska, Canada, and Montana migrate south (Sherrod et al. 1976, Gerrard et al. 1978, McClelland et al. 1994, Harmata et al 1999), while birds reared in Texas and California tend to migrate north during autumn (Hunt et al. 1992, Mabie et al. 1994, D. Garcelon, pers. comm.). Jenkins et al. (1999) recorded movements of immature Bald Eagles radio-tagged in northern California that ranged from 50 to 190 km from the study area in both northerly and southerly directions. By September of the year they fledged, all radio-tagged immature birds (n =13) departed from the study area and 7 (54%) returned to the study area the following year (Jenkins et al. 1999). Others have reported much greater dispersal distances from natal areas. For example, Harmata et al. (1999) reported that >90% of juveniles produced in the GYE left the area by autumn and that 95% of dispersal movements from the natal nests were £ 889 km in a south and west direction. McClelland et al. (1994) reported that eagle movement distances between winter and summer areas measured up to 2,756 km. Interesting, McClelland et al. (1994) recorded a juvenile Bald Eagle movement from Glacier National Park to just east of the Lake Tahoe basin in the Carson River Valley. Harmata et al. (1999) observed that once eagles selected a wintering area, fidelity to that area was strong. They also observed that homing back to natal sites was strong following Bald Eagles' first winter migration, although wandering was common during the following summer. Similar to female Ospreys, female Bald Eagles tend to disperse farther than males (Harmata et al. 1999). Shorter male dispersal distance is presumed to be reproductively advantageous because males are more familiar with the area in which they were fledged and thus are more able to acquire prey and avoid predators (Greenwood and Harvey 1982). Likewise, a greater dispersal distance by females probably avoids inbreeding (Pusey 1987).

Home Range

Bald Eagles are active throughout the year and are diurnal. Johnsgard (1990) estimated breeding territories for eagles in Oregon at 660 ha (1,650 acres), with an average of 0.5 km of shoreline per pair, and an average distance between nest territories of 3.2 km. In Arizona, home ranges were estimated at 64 sq. km, with 15 to 18 km of shoreline per pair. Breeding territories in Alaska varied from 11 to 45 ha and averaged 23 ha, with a minimum distance between nests of 1 km (Hansel and Troyer 1964).

Habitat Relationships

Bald Eagles are habitat specialists in that open water with juxtaposed mature trees or steep cliffs is a requirement for nesting, perching, hunting, and roosting (Bent 1961).

Perch sites are important to Bald Eagles because such sites provide eagles locations to rest, preen, and feed, and positions from which to hunt. Bald Eagles typically perch in large, robustly limbed trees, on snags, on broken topped trees, or on rocks near water (Peterson 1986, Laves and Romsos 1998). Laves and Romsos (1998) found that wintering Bald Eagles in the Lake Tahoe basin used only dominant trees (mostly snags) within the shorezone to perch. Wintering Bald Eagles in the basin most frequently perched in the late successional Jeffrey pine vegetation type while the montane chaparral vegetation type was used least. The wetland/wet meadow vegetation type and open water were the most frequently encountered habitat types immediately adjacent to perch sites during winter months (Laves and Romsos 1998). Opportunistic observations of Bald Eagles have been recorded basin-wide during all seasons for several years and most sightings have been located along the undeveloped shorelines of regional lakes (USFS – LTBMU unpub. data). These observations suggest that Bald Eagles use the basin year round and that undeveloped shorelines are important habitat elements.

Roost trees are also an import habitat element for Bald Eagles (Dellasala et al. 1998). A roost is a perch where one or more birds rest at night. In the Pacific Northwest, Bald Eagles congregate and roost up to 19 km from open water. Communal roosting by Bald Eagles is thought to improve thermal regulation (especial during winter months), increase chances of finding food (the greater the number of birds, the greater the opportunity to find food), and establish a social hierarchy (Anthony et al. 1982). Bald Eagle roost sites vary by tree species and use is related to roost tree availability. Roost sites are similar in character to perch sites: located in dominant trees that have open and robust branches, are sometimes defoliated (i.e., snags), are protected from prevailing winds, and are typically far from human development (Anthony et al. 1982). Mature, late-successional tree stands reduce heat loss. Roost locations in the Lake Tahoe basin are thought to occur in the Glen Alpine, Marlette Creek, and Bliss Creek watersheds, but this conclusion has not been verified (L. Neel, pers. comm., Laves and Romsos 1998).

Nest sites are perhaps the most important habitat element for promoting the reproductive success of Bald Eagles. Nests are typically established in large, dominant live trees with open branch work and are often located within 1.6 km of open water. Nest trees and branches of nest trees must be sturdy in order to support the massive stick platform nests that are commonly constructed and added to annually. Nests are usually situated at or just below the tree canopy in forested areas. Call (1978) reported that nests were most frequently found in stands with less than 40% tree canopy cover. In Maine, eagles selected nest sites away from human disturbance and near lakes with abundant warm-water fishes (Livingston et al. 1990). Known nest sites (n = 2) in the Lake Tahoe basin are situated in dominant live coniferous trees in close proximity to open water (< 200m) and at a considerable distance from developed shoreline (> 4.5 km). In treeless areas, eagles will establish nests on cliff faces or pinnacles.

Bald Eagles may be negatively affected by natural disturbance if such disturbance significantly affects required habitat elements such as perch, roost and nest trees or interrupts a constant food supply. Natural disturbance, such as drought, may initially improve availability of food in the form of carcasses, but in the long term may force eagles to migrate out of an area.

Effects of Human Activities

There is considerable pressure to increase recreational access to shorelines of Lake Tahoe regional lakes (TRPA 1986, TRPA 1996). This demand and current recreational access to shorelines may jeopardize opportunities to provide undisturbed perching, nesting, foraging, and roosting habitat for Bald Eagles (Knight and Gutzwiller 1995, Laves and Romsos 1998). Boyle and Sampson (1985) listed 536 references that identified effects of non-consumptive outdoor recreation on terrestrial vertebrates in North America. Greater than 81% of these articles reported negative effects on wildlife. Several researchers have documented negative impacts of recreational activities on Bald Eagles (reviewed in Knight and Gutzwiller 1995). Negative impacts to Bald Eagles from recreationists, such as beach visitors with unleashed dogs, include reduced fitness, altered behavior, changes in demographics, changes in distribution (both temporal and spatial), changes in community composition and interactions, and even death (summarized by Knight and Gutzwiller 1995). Management efforts that minimize recreational disturbance at key Bald Eagle use areas in the Lake Tahoe basin may significantly improve the quality of habitat at those areas. For example, Laves and Romsos (1998) reported that 90% of wintering Bald Eagle foraging attempts were made during the day when no recreational activities were present. Skagen et al. (1991) reported similar findings in which eagles fed more at a site when no human disturbance was recorded. Visual screening at Bald Eagle foraging areas, in the form of native vegetation and obscured observation decks may aid in reducing the effect of human disturbance in some places (e.g., Taylor Creek Marsh, South Lake Tahoe).

Conservation

On a localized scale, habitat elements, such as perch, nest and roost trees, should be important management considerations. Maintenance of mature, late-successional trees, younger replacement trees, and snags in the shorezone and marshes will perpetuate quality habitat features necessary for Bald Eagles. Additionally, improving and maintaining habitat for waterfowl and fish will contribute to improving habitat conditions for Bald Eagles in the Lake Tahoe region.

On a continental scale, it is important to recognize that Bald Eagles are not tied to a breeding locations but will move considerable distances to wintering areas. Recent research has been able to decipher large-scale Bald Eagle movement patterns (e.g., McClelland et al. 1994, Jenkins et al. 1999, Harmata et al. 1999). Awareness of seasonal long-range Bald Eagle movements warrants a landscape level habitat management strategy. Such a strategy would acknowledge cumulative impacts of changes in use sites along an eagle's migratory landscape.

At the writing of this species account the Bald Eagle was federally listed as a threatened species in the lower 48 states. However, July 2, 1999, the U. S. Fish and Wildlife Service proposed for the Bald Eagle to be down-listed from threatened status. After a 90 day comment period, the status of the Bald Eagle was to be determined. Nevertheless, the Bald Eagle is still protected under the Bald Eagle Protection Act (1940), and the Migratory Bird Treaty Act (1918), and is listed by California and Nevada as an Endangered Species.

The TRPA considers the Bald Eagle a "Special Interest Species" and has established a policy for preserving the breeding and wintering population in the Lake Tahoe basin (TRPA 1982). According to the TRPA's Goals and Policies (1986), a minimum of 1 nest site must be maintained for Bald Eagles and two areas have been identified for the protection of wintering habitat. In addition to this policy, the TRPA (1987) protects all historic and current nest sites with a ½ mile disturbance radius delineated around each nest. Consequently, since the adoption of the environmental threshold carrying capacities (TRPA 1982), two nest sites have been provided protection from human-caused disturbance. Within the disturbance zone for Bald Eagles, all perch and nesting trees are protected from being physically disturbed, and the habitat within disturbance zones cannot be manipulated unless such manipulation enhances Bald Eagle habitat. Thus, according to the TRPA Code of Ordinances (1987), only projects or activities that are beneficial to the species (i.e., habitat enhancement projects) are allowed to occur within disturbance zones unless Bald Eagles select a nest location in close proximity to development (TRPA 1987). Additional conservation measures have been established by the USFS – LTBMU, given the Bald Eagle's status as a USFS sensitive species; signs have been posted around the perimeter of Bald Eagle wintering areas that warn the public not to enter or disturb the wintering area. Although the TRPA and USFS - LTBMU policies attempt to reduce adverse activities within disturbance zones for Bald Eagle, little enforcement or education is promoted to reduce shoreline access via boats or hikers/skiers into disturbance zones or wintering areas. Consequently, the effectiveness of ½ mile disturbance zones and wintering areas in terms of promoting the reproductive viability of Tahoe's Bald Eagle population is unknown.

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BROWN-HEADED COWBIRD (*Molothrus ater*)

Matthew D. Schlesinger and J. Shane Romsos

Distribution

The Brown-headed Cowbird has expanded its original range from the plains and prairies west of the Mississippi River prior to 1800 to include most of North America (Brittingham and Temple 1983, Ehrlich et al. 1988). As North America was settled, lands were cleared for agriculture and forests were fragmented for human settlement. On a continental scale, these land use practices likely promoted the range expansion of cowbirds because the open habitats created were conducive to the feeding habits and social behavior of cowbirds (Brittingham and Temple 1983). Records indicate that Brown-headed Cowbirds have only recently (since 1960) expanded their range into the Lake Tahoe Basin (Orr and Moffitt 1971). Recent surveys by Manley and Schlesinger (in prep) documented the cowbird throughout the basin, at over 75 percent of lotic riparian study sites and over 28 percent of lentic riparian study sites. A map in Lowther (1993) based on Breeding Bird Survey data indicates that cowbirds are more abundant in the Lake Tahoe area than in the rest of the Sierra Nevada; this pattern is most likely due to increased human settlement in the basin.

Ecology

Population Biology/Demographics

Estimates of adult survival range from approximately 40 percent to 63 percent, while estimates of survival to fledging range from less than 5 percent to 32 percent (Lowther 1993). Lowther (1993) estimated that overall survival from egg to adulthood is about 3 percent and a lifetime fecundity of 80 eggs per female is necessary to sustain a population.

Brown-headed Cowbirds are susceptible to a variety of internal parasites (Lowther 1993). Predation on cowbirds apparently occurs mostly on eggs and young; because Brown-headed Cowbirds are brood parasites, predation on cowbird eggs and young primarily reflects predation rates on host nests. However, egg loss can also be attributed to rejection of cowbird eggs by host parents (Ehrlich et al. 1988).

Reproductive Behavior

The Brown-headed Cowbird is a generalist parasite; it lays its eggs in the nests of other species and allows the host species to hatch and rear the cowbird's young (Brittingham and Temple 1983, Ehrlich et al. 1988). Thus, the cowbird does not build a nest of its own. Cowbirds find nests to parasitize by looking for signs of nesting or by flushing nesting birds to locate their nests (Norman and Robertson 1975). Cowbirds may parasitize several nests of several species in a single season, laying 1-7 eggs in each nest over the course of the breeding season (Lowther 1993).

Life History

Brown-headed Cowbirds migrate to locations in southern North America in the fall, often as part of mixed-species blackbird flocks. Cowbirds migrate north in the spring, probably returning to the Lake Tahoe Basin in mid-May, which is approximately when they return to Inyo County, California (Yokel 1986). Cowbirds form pair bonds that may last a single season or many years, and cowbirds have been shown to be both monogamous and polygamous (Lowther 1993). Females may lay about 40 eggs per season in the nests of various host species. Cowbird eggs generally hatch before those of the host brood, allowing cowbird chicks to dominate food provided by host parents. Cowbird young are altricial like the young of host species and leave nests in 8-13 days (Lowther 1993). Both males and females can breed at 1 yr, but yearling males in California rarely mate (Lowther 1993).

Foraging (behavior/needs)

Cowbirds are ground-feeders, taking mainly seeds with the addition of invertebrates in spring and summer (Granholm 1990). Cowbirds are often found near grazing mammals such as cattle, gleaning disturbed invertebrates, foraging in manure, and picking invertebrates off the animals themselves (Granholm 1990).

Home Range

Cowbird home ranges vary from less than 1 ha to over 30 ha (Granholm 1990), although no data from birds in California are available.

Interactions with Other Species

Cowbird parasitism may adversely affect many passerine species in the Lake Tahoe Basin. Because cowbird eggs usually hatch one day prior to the host brood, chicks develop rapidly and are able to dominate food provisions at the expense of the host brood. Furthermore, cowbirds often eject eggs of host species when they lay their own (Robinson et al. 1993). Ehrlich et al. (1988) reported that as many as 144 North American bird species are vulnerable to reduced reproductive success as a result of brown-headed cowbird brood parasitism. Flycatchers, vireos, warblers, tanagers, and thrushes are especially susceptible to parasitism (Brittingham and Temple 1983). The effect of cowbird parasitism is not equal among passerine species because many host species have developed the ability to recognize and reject cowbird eggs. The ability to recognize and reject cowbird eggs is most likely dependent on the amount of time that cowbird and host species have co-occurred (Ehrlich et al. 1988). Thus, because cowbirds have only recently expanded into the Lake Tahoe Basin, passerine species in the basin are probably extremely vulnerable to reproductive failure due to nest parasitism.

Research Needs

Impacts of cowbirds on passerines in the Lake Tahoe Basin have not been studied, although some studies of cowbirds have been conducted in other parts of the Sierra Nevada (e.g., Verner and Ritter 1983, Airola 1986, Rothstein et al. 1980). Whether the basin's passerines have been significantly affected by cowbirds is unclear. Ehrlich et al. (1988) speculated that passerines that have not co-occurred with cowbirds have not evolved anti-cowbird defenses, but this hypothesis has not been tested.

Habitat Relationships

Cowbird habitat relationships have been well studied, and suitable cowbird habitat exists in the basin. Wilcove et al. (1986) noted that cowbirds historically were associated with grazing mammals of grasslands because insects were readily available. In the Lake Tahoe Basin, grazing mammals occur in open habitats adjacent to forest habitats. Additionally, forest habitats in the Lake Tahoe Basin have been artificially "opened" up to for human settlement and recreation (e.g., golf courses, playing fields). Such artificial edge habitats, or ecotones, tend to be more abrupt and extensive than naturally occurring edge habitat and can increase cowbird parasitism. Gates and Gysel (1978) found that cowbird parasitism was one of the most important causes of mortality in passerine species along the ecotone between field and forest habitats in Michigan. The creation of artificial edge habitats can facilitate parasitism by cowbirds and therefore cause increased songbird mortality (Brittingham and Temple 1983).

Effects of Human Activities

Cowbirds have benefited from land clearing across the United States. The increase of edge habitat in comparison to forest interiors has exposed species previously free from parasitism to the effects of cowbirds (Brittingham and Temple 1983).

The effects of prescribed burning on cowbirds are unknown. Results of surveys before and after burns in other regions have been mixed; cowbirds were occasionally more abundant in burned areas, occasionally equally abundant, and occasionally less abundant (Sullivan 1995).

Conservation

Conservation concerns regarding cowbirds mainly involve minimization of impacts to nesting passerines. Several of the Lake Tahoe Basin's focal species have the potential to be negatively affected by cowbird parasitism: American Robin (*Turdus migratorius*), Cassin's Finch (*Carpodacus cassinii*), Chipping Sparrow (*Spizella passerina*), Evening Grosbeak (*Coccothraustes vespertinus*), Hammond's Flycatcher (*Empidonax hammondii*), Hermit Warbler (*Dendroica occidentalis*), House Finch (*Carpodacus mexicanus*), Lesser Goldfinch (*Carduelis psaltria*), MacGillivray's Warbler (*Oporornis tolmiei*), Olive-sided Flycatcher (*Contopus cooperi*), Pine Grosbeak (*Pinicola enucleator*), Purple Finch (*Carpodacus purpureus*), Red Crossbill (*Loxia curvirostra*), Red-winged Blackbird (*Agelaius phoeniceus*), Swainson's Thrush (*Catharus ustulatus*), White-crowned Sparrow (*Zonotrichia leucophrys*), Willow Flycatcher (*Empidonax traillii*), and Yellow Warbler (*Dendroica petechia*). These species are all cup nesters (Ehrlich et al. 1988) of small to medium body size, the group most commonly targeted by cowbirds (Friedman 1929, Lowther

1993). Several non-focal species, as well as some cavity- and ground-nesting focal species, may also be susceptible to parasitism.

There is no current management of cowbirds in the Lake Tahoe Basin. Cowbird management can be politically complex and expensive (and even ethically questionable), with the potential for public opposition. Cowbird management may be warranted in the basin, but only if it can be shown that the basin's passerines are seriously affected by parasitism. Robinson et al. (1993) outline a series of steps in cowbird management when parasitism is suspected to occur: 1) establishment of cowbird presence and density, particularly for females; 2) elucidation of patterns of cowbird occurrence, e.g., interior forests vs. meadows; 3) determination of whether parasitism is occurring for species of concern (in general, the presence of cowbirds suggests that parasitism occurs, but presence or density information cannot yield species-specific parasitism estimates); and 4) determination of the potential impacts of parasitism, including its frequency, the frequency of nest predation, and the reproductive success of hosts. It is possible that information from analogous regions (i.e., areas in the Sierra Nevada at similar elevations) may be used in place of additional data collection in the basin. These guidelines have been simplified from Robinson et al. (1993); interested parties are referred to that document for specifics.

If cowbird parasitism is shown to affect species of concern significantly, then cowbird management may be justified. Methods that have been used to control cowbirds include trapping, shooting, landscape and habitat management, and livestock management (Robinson et al. 1993). Cowbird trapping programs have been somewhat successful in reducing parasitism on certain listed species in other regions (Lowther 1993, Robinson et al. 1993). Trapping is probably the most efficient and politically feasible methods of cowbird control; trapping specifics are given in Robinson et al. (1993). Shooting is also likely effective, especially along with trapping (Robinson et al. 1993) but may not be supported by the public as readily. Landscape and habitat management are probably the most effective long-term methods of cowbird management; the primary objective is to maintain large areas of contiguous habitat while maximizing the habitat-to-edge ratio (Robinson et al. 1993). Finally, management of livestock and pack stations to reduce feeding opportunities for cowbirds may also reduce cowbird populations in the long term (Robinson et al. 1993).

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NORTHERN GOSHAWK (*Accipiter gentilis*)

John J. Keane

Distribution

The Northern Goshawk is distributed throughout forest and woodlands of the Holarctic (Brown and Amadon 1968). Within North America, Northern Goshawks are found in a variety of forested vegetation types, ranging across the boreal forest and extending south through the western mountains into Mexico and, in the East, south through the mixed conifer-hardwood forest to approximately New York/New Jersey at the present (Palmer 1988, Squires and Reynolds 1997). Northern Goshawks are distributed throughout conifer forests of northern California and extend south in the Coast Range to approximately Lake/Mendocino County and south in the Sierra Nevada to approximately the Tehachapis (Bloom et al. 1986, Keane and Woodbridge, in prep.). In Nevada, Northern Goshawks are distributed in the eastern Sierra Nevada and throughout the mountain ranges of the Great Basin, with over 85% of observed nests in aspen (*Populus tremuloides*) stands (Herron et al. 1985). Within the Sierra Nevada, Northern Goshawks breed from approximately 750 m in the ponderosa pine (*Pinus ponderosa*) vegetation type through approximately 3050 m in the red fir (*Abies magnifica*) and lodgepole pine (*Pinus contorta*) vegetation types, and throughout eastside pine (*P. jeffreyi* /*P. ponderosa*) forests on the east slope. Additionally, Northern Goshawks nest in aspen stands occurring within shrub vegetation types on the eastern slope of the Sierra Nevada and throughout the Great Basin (Keane and Woodbridge, in prep.). Northern Goshawks are year-round residents distributed throughout the Lake Tahoe Basin and breed from approximately lake-level to treeline (Keane 1999).

Ecology

Population Biology/Demographics

Little published information is available on Northern Goshawk survivorship estimates for North American populations (DeStefano et al. 1994, Squires and Reynolds 1997, Reynolds and Joy 1998). No population trend data are available. Most work has focused on reproduction (Squires and Reynolds 1997, Keane 1999). Herron et al. (1985) reported 152 known territories in Nevada and estimated a total of 300 for Nevada. Bloom et al. (1986) estimated a total of approximately 1300 territories for California. Keane and Woodbridge (in prep.) have documented approximately 350-400 known territories for the Sierra Nevada (Lassen NF through Sequoia NF). Approximately 12-15 territories are known to exist currently in the Lake Tahoe Basin and an additional 5-10 territories likely exist based on the distribution of known territories and habitat (Keane 1999, pers. obsv.). Densities reported in the literature range from 3-11 pairs per 100 km^2 (Kennedy 1997).

However, density estimates must be interpreted with caution because they are affected by the size the of the study area and by variability in survey effort between studies (Smallwood 1998).

Life History

The following fife history information is summarized from Squires and Reynolds (1997). The Northern Goshawk's clutch size is usually 2-4 eggs, and rarely 1 or 5. Only one clutch is produced per year although replacement clutches can be produced following early nest failure. The incubation period is approximately 32-34 days with some variation between 28-38 days reported. Hatchlings are semialtricial and nidicolous. The nestling period ranges from 35-42 days. The fledgling dependency period can extend to 90 days. Keane (unpubl. data) observed that the post-fledgling dependency period lasted approximately 5-6 weeks after fledging in the Lake Tahoe region. The young are still fed by the adults during this period as they learn to hunt. Post-fledgling movements in the nest area gradually increase as the young gain independence (Kennedy et al. 1994). Dispersal movements can be abrupt (Kenward et al. 1993, Keane unpubl. data). No information is available for the immature stage of Northern Goshawk life history.

Nesting birds can be assigned to age categories based on plumage: subadult (1-2 yr old, juvenile plumage); young adult (2-3 yr old, retaining some juvenile plumage); and adult (>3 yr old, all adult plumage). Females occasionally breed as subadults and young adults. The proportion of young females in the population appears to be higher in depressed or increasing populations (Reynolds and Wight 1978, Kenward et al. 1991) and lower in stable populations. Research is needed to determine if a greater proportion of young females would also be observed in a declining population. Young females may also exhibit lower productivity than older females. It is extremely rare for subadult or young adult males to breed successfully. Given that males supply all food during the pre-laying and incubation periods and the majority of the food during the nestling and post-fledging dependency period, they must possess a high degree of hunting prowess that may require years of experience. Lifetime reproductive success is unknown (Squires and Reynolds 1997). The maximum life span of wild birds is reported as at least 11 years (Fowler 1985).

Reproductive Behavior

Courtship and nest-building is initiated in February. Egg-laying in the Lake Tahoe region varies over an approximately 3-4 week period from mid-April through mid-May and the young disperse from the nest territory from mid-August through mid-September (Keane 1999). Northern Goshawks exhibit high rates of annual variation in reproduction associated with abiotic and biotic environmental factors (Bloom et al. 1986, Squires and Reynolds 1997, Keane 1999). In the Lake Tahoe region, the proportion of territories with successful nests (ranging from 37 to 82%), the number of young produced per successful nest (ranging from 1.6 to 2.4), and the timing of egg-laying (ranging from mid-April through mid-May) varied between years. Annual variation in reproduction was associated with variation in both weather and prey. Reproduction was greatest during a year with warm and mild late winter and early spring and high numbers of Douglas' squirrels (*Tamiasciurus douglasii*) resulting from high cone crop production the previous autumn (Keane 1999).

Foraging Behavior

Northern Goshawks forage primarily by exhibiting short-duration sit-and-wait predatory movements, moving through the forest in a series of short flights that are punctuated by brief periods of prey searching from elevated perches (Squires and Reynolds 1997). They will also use flush-chase techniques, moving through the forest and attempting to surprise and flush prey (Squires and Reynolds 1997). Males generally deliver prey to nests 2-5 times per day during the nestling period. Most perches used for plucking are <1 m in height, often are stumps or bent-over trees or saplings, and some perches near nests are used repeatedly during the nesting period. Kenward (1979) reported that Northern Goshawks in Europe made a prey capture approximately once every 1-2 days during winter.

Northern Goshawks forage on medium- and large-bodied birds and mammals throughout their range (Palmer 1988, Squires and Reynolds 1997). Of a total 1058 prey items identified in Northern Goshawk breeding period diets collected between 1992-1995 in the Lake Tahoe region, 48.6% were mammals (12 species) and 51.4% were birds (22 species) (Keane 1999). Primary prey species were Douglas' squirrels (23% of total prey individuals/32.9% of total biomass), Steller's Jay (Cyanocitta stelleri) (18.9%/11.3%), Northern Flicker (Colaptes auratus) (14.9%/13.0%), ground squirrels (Spermophilus lateralis, S. beldingi, and S. beecheyi) (14.3%/17.9%), American Robin (Turdus migratorius) (9.1%/4.1%), and chipmunks (Tamias spp.) (8.9%/3.3%). Douglas' squirrels are a key prey species that influence annual variation in Northern Goshawk reproduction (Keane 1999). Snowshoe hares (Lepus americanus) may be relatively more important during winter. Further work on winter diet and foraging habitat use is needed.

Dispersal Behavior

Fledgling birds remain in nest territory for 4-6 weeks post-fledging in Lake Tahoe region (Keane, unpubl. data). Little published information exists on natal dispersal; however, distances from natal site to breeding site from 10 banded individuals ranged from 6.4-100 km. Some adults move to different territories between breeding periods (Detrich and Woodbridge 1994), an occurrence hypothesized to be related to differences in habitat quality between territories, as demonstrated for European Sparrowhawks (Accipiter nisus) (Newton 1992).

Home Range

Northern Goshawks are year-round residents in the Lake Tahoe region. Adult breeding period home ranges (95% Adaptive Kernels) estimated using radio-telemetry averaged 2698 ha for males (sd = 1043) and 2016 ha for females (sd = 1690) (Keane 1999). Both sexes increased the size of their home ranges during the nonbreeding period, with males averaging 8193 ha (sd = 4990) and females 5555 ha (sd = 3289). Although individuals expanded their home range during the nonbreeding period, both sexes continued to return to their nest stands throughout this period and spent considerable amounts of time there (Keane 1999).

Interactions with Other Species

The Northern Goshawk has few natural predators. Great Horned Owls (Bubo virginianus), wolverines (Gulo gulo), and fishers (Martes pennanti) have killed nestlings (Erdman et al. 1997). Great Horned Owls, Golden Eagles (Aquila chrysaetos), and martens (Martes americana) have killed adults (Squires and Reynolds 1997). Siblicide and cannibalism have been recorded among nestlings (Squires and Reynolds 1997).

Starvation, particularly during winter, is an important cause of mortality (Kenward et al. 1993). Prey availability is an important limiting ecological factor for Northern Goshawk populations, affecting both survival and reproduction. Douglas' squirrels are key prey for Northern Goshawks in the Lake Tahoe region in the breeding season and may also be key prey in the winter because of the hibernation and migration patterns of other prey species (Keane 1999). See discussion under Foraging Behavior for list of other important prey species during the breeding period.

Research Needs

More work is required to determine winter prey requirements and winter foraging habitat use patterns and requirements. Further work also is needed to document breeding period foraging habitat use patterns and requirements. Additionally, research is needed to investigate habitat quality issues to address relationships between Northern Goshawk fitness (survival and fecundity) and habitat structure and composition (Keane and Morrison 1994, DeStefano 1998). Even more specific to the Lake Tahoe Basin, work is required to assess the impacts of human presence, intervention, and recreation on Northern Goshawk behavior and fitness. Research is required to determine the efficacy of current inventory and monitoring protocols and the effects of annual variation in reproduction and observer variability on survey results.

Habitat Relationships

Habitat Types and Structural Stages Used

Northern Goshawks are distributed throughout all conifer forest types in the Sierra Nevada and also breed in aspen stands within shrub vegetation types on the eastern slope. Nest site habitat structure and composition are the best studied aspect of Northern Goshawk habitat relationships (Squires and Reynolds 1997). Although absolute differences in structural characteristics may differ between vegetation types and geographical regions, relative habitat use patterns are consistent: nest sites with high canopy cover, large numbers of large diameter trees, low shrub/sapling cover, and low numbers of small diameter trees. In the Lake Tahoe region, Keane (1999) found that Northern Goshawk nest sites had significantly greater numbers of live trees >100 cm dbh (mean = 39.0/ha, sd = 5.54), >60-100 cm dbh (54.7/ha, sd = 8.02) and canopy cover (mean = 70.4%, sd = 3.14), and significantly lower shrub/sapling cover (mean = 9.9%, sd = 2.04) and number of live trees >5-30 cm dbh (mean = 299.8/ha, sd = 30.49) than random plots based on 36 m diameter plots centered on nest trees and random points. High canopy cover is the most consistent structural feature across studies of Northern Goshawk nesting habitat (Siders and Kennedy 1996). Hargis et al. (1994) reported average canopy covers of only approximately 30% at Northern Goshawk nest sites in eastside pine vegetation in the eastern Sierra Nevada. However, canopy cover was still significantly greater than in random sites.

Less information is available on the structure and composition of foraging habitat used by North American Northern Goshawks, in part due to the difficulty of obtaining these data for such a mobile species that forages over large areas in relatively inaccessible country. Northern Goshawks have evolved morphological features for capturing prey in forested environments, but are also capable of ambushing prey in open habitats (Squires and Reynolds 1997). In Nevada, aspen-nesting Northern Goshawks forage in open shrub-steppe habitats (Younk and Bechard 1994). The limited information from studies in conifer forests indicates that Northern Goshawks seem to prefer to forage in mature forests (summarized in Squires and Reynolds 1997). More work is needed on this aspect of Northern Goshawk ecology. It should be noted that the key prey species used by Northern Goshawks in the Lake Tahoe region are primarily ground dwellers and/or spend a large proportion of their time near or on the ground. These characteristics, along with the size of each species, likely renders them particularly vulnerable to goshawk predation. Open shrub and lower canopy layers within forested stands may facilitate prey detection and capture by Northern Goshawks. This hypothesis requires further research. Habitat for Douglas' squirrels, a key prey species, consists of mature conifer stands containing large trees capable of sufficient cone production and providing other important food such as fungi and lichens.

Response to Natural Disturbance

Not much published information is available. Goshawks are known to nest in stands that have experienced understory fires that did not reduce canopy cover or numbers of large trees below suitable levels. Stand replacing fire events have eliminated nesting territories. Goshawks have continued to use nest stands with 100% insect kill for at least 4-5 years after tree mortality in some instances, although the long-term suitability of these sites has been eliminated (pers. observ.).

Effects of Human Activities

Habitat Impacts

Large-scale effects of historic timber harvest and fire suppression have likely reduced the overall amount of Northern Goshawk nesting habitat due to a reduction in the number of large trees and an increase in tree density and foliage volume in the lower canopy levels. These same factors may also have negatively affected Northern Goshawk foraging habitat. No data exist that document Northern Goshawk population trends in relation to forest structural and compositional changes in the Sierra Nevada or anywhere else in North America.

There is a paucity of published information available to predict Northern Goshawks' response prescribed fire. Anecdotal observations suggest Northern Goshawks will nest in stands that have been mechanically treated and/or have experienced fire provided that the activities do not lower canopy cover and large tree numbers below suitable levels. These observations suggest that it may be possible to selectively treat individual Northern Goshawk territories to reduce excessive fuel loading with methods that will generate suitable stand structural characteristics. However, uncertainty still exists and any planned activities should be closely coordinated with Northern Goshawk biologists and accompanied by guaranteed implementation and effectiveness monitoring to assess the outcome of the treatment in terms of habitat structure and nesting use by Northern Goshawks. Less information is available to predict effects of prescribed burning on foraging habitat. From a conceptual perspective, management activities that restore vegetation structure, composition, and disturbance dynamics within what is thought to be the pre-European settlement range of natural variation should result in a suitable range of conditions that will support populations of most species. Monitoring is needed to determine the abundance of Northern Goshawk prey species under different management scenarios. An increase in the number of large trees and amount of mature and late-seral/old-growth would be predicted to have a positive effect on Douglas' squirrel populations.

Individual Impacts

Limited published information is available to address impacts on individual birds or territories. Falconry harvest is thought to be of limited impact to populations but could be a problem for individual territories if these sites are continually visited and/or all young are harvested. Human disturbance is a potentially serious problem in the Lake Tahoe Basin. Keane (unpubl. data) found evidence of human disturbance conflicts at 3 territories in the Basin during 1991-1995. Northern Goshawks can be ferocious nest defenders if humans or other threatening animals venture near active nests. Northern Goshawks initiate breeding when the ground is still covered with snow and have multiple nests within a single territory that are used in different years. Nests are sometimes directly located along roads and trails that provide flight access. Following meltout these sites can be prime candidates for conflict as humans begin using these roads and trails. In Angora Creek, residents reported that a local person threatened to return and shoot an aggressive pair of Northern Goshawks that was nesting along a trail in the drainage. In Burke Creek, a local resident reported that the last documented year (1989) that a pair of goshawks has been known to nest in that drainage that the local children continually harassed the birds throughout the breeding period by banging on the active nest tree with sticks to elicit aggressive responses from the adults. This behavior increases physiological stress on the individual birds, reduces the amount of time the adults can expend foraging, and increases the potential to attract nest predators. While surveying this site in 1992 using broadcast calls of Northern Goshawks, the author was approached by a local resident carrying a stick, who commented that he heard the calls and thought the birds had returned. In Saxon Creek, empty rifle shells and adult goshawk feathers were found at the base of a failed Northern Goshawk nest tree situated along a hiking trail. In summary, these observations indicate that human disturbance is a potentially serious problem in the Basin and efforts should be taken to reduce existing impacts and preclude future potential conflicts given the small number of Northern Goshawk territories in the Basin. For example, a planned bike path along the North Shore through an existing Northern Goshawk breeding territory has the potential to cause negative impacts on this pair. Further, the female at this site was among the most aggressive nest defenders observed in the Basin and thus is a threat to people who venture near her nest (pers. observ.).

Limited information is available to predict how individual Northern Goshawk pairs will respond to forest management practices that modify the structure and composition of nesting and foraging habitat.

Population Impacts

Little published information available on population level impacts from human activities due to lack of research about these topics. However, relative to the Lake Tahoe Basin, given the small number of Northern Goshawk territories in the Basin, uncertainty about how goshawks respond to forest management practices, and the high potential for direct human disturbance because of the large number of human residents and recreationists, any human activities that may negatively affect any breeding territory should be avoided. Potential impacts to any one territory should be assessed within the context of cumulative effects across all territories. That is, some territories may be affected by direct human disturbance while others may be affected by forest management practices, natural insect kills, or fire. When all of these potential effects are considered together, a majority of the Northern Goshawk territories in the Basin may be affected by anthropogenic disturbance that could result in population level impacts.

Conservation

The Northern Goshawk is listed as a Species of Special Concern by the State of California, as a Sensitive Species by Region 5 USDA Forest Service, a Special Status Species by the Nevada Division of Wildlife, and as a Special Interest Species by the TRPA. The species has been petitioned three times for federal threatened status either throughout western North America or within subsections of its range (southeastern Alaska, southwestern North America). All listing petitions to date have been denied by the USFWS. Current litigation is pending in regards to the last petition denial to list the species as threatened throughout western North America. A conservation strategy has been created and implemented in the Southwest (Reynolds et al. 1992) and a conservation assessment has been completed for southeastern Alaska (Iverson et al. 1996). Alternative management guidelines that will change Northern Goshawk management across the Sierra Nevada Bioregion are being drafted as a component of the USDA Forest Service's Sierra Nevada Framework Project. Because high quality individual territories have been occupied for up to 75 years (Keane, unpubl. data), conservation efforts are needed to identify and conserve high quality territories that are source habitats for Northern Goshawk populations and research is needed to identify the habitat factors associated with high quality habitat. Northern Goshawks are still distributed throughout their historic range in the Sierra Nevada (Keane and Woodbridge, in prep.). Neither population trend nor demographic data are available to ascertain Northern Goshawk population trends in the Sierra Nevada. Given scientific uncertainty about population trends and the number and distribution of Northern Goshawk pairs required to maintain a viable population, all known and newly discovered territories should receive conservation focus.

Three land management agencies, the US Forest Service, California Department of Parks and Recreation, and Nevada State Parks Division, and a regulatory agency, the Tahoe Regional Planning Agency (TRPA), are responsible for the management of goshawks in the Lake Tahoe basin. Because the TRPA has ultimate permitting authority and the strictest management standards, their policy is perhaps the most appropriate to discuss in terms of current goshawk management in the basin. The TRPA has established threshold standards to maintain at a minimum twelve population sites for goshawks (TRPA 1982). According to the TRPA Code of Ordinances (1987), any element of the overall habitat for any species of concern, which, if diminished, could reduce the existing population or impair the stability or viability of the population, shall be considered critical habitat. The TRPA Code of Ordinances (1987) provides a 0.5 mile radius disturbance zone around each goshawks nest (an area equivalent to approximately 500 acres). Perching sites and nesting trees of goshawks are not to be physically disturbed in any manner nor is habitat within disturbance zones to be manipulated in any manner unless such manipulation is necessary to enhance the quality of goshawk habitat. This policy applies to known goshawk nest sites and nest sites found in the future. Since 1993, the TRPA has interpreted the goshawk disturbance zone as consisting of the most suitable goshawk habitat within 500 acres around each nest. Consequently, an occasionally odd-shaped polygon is used to define the boundaries of a goshawk disturbance zone in order to incorporate critical habitat elements. Current and available literature on goshawk habitat requirements is used to define critical habitat elements. An additional safeguard for goshawk nest stands has required permit applicants to delineate a 253 meter (773 ft) radius (equal to 50 acres) around each nest in which no activities are allowed.

Envirogram of the Northern Goshawk

The envirogram of the Northern Goshawk (Figure O-2) depicts important habitat elements, food resources, interspecific interactions, and reproductive requirements of the species.

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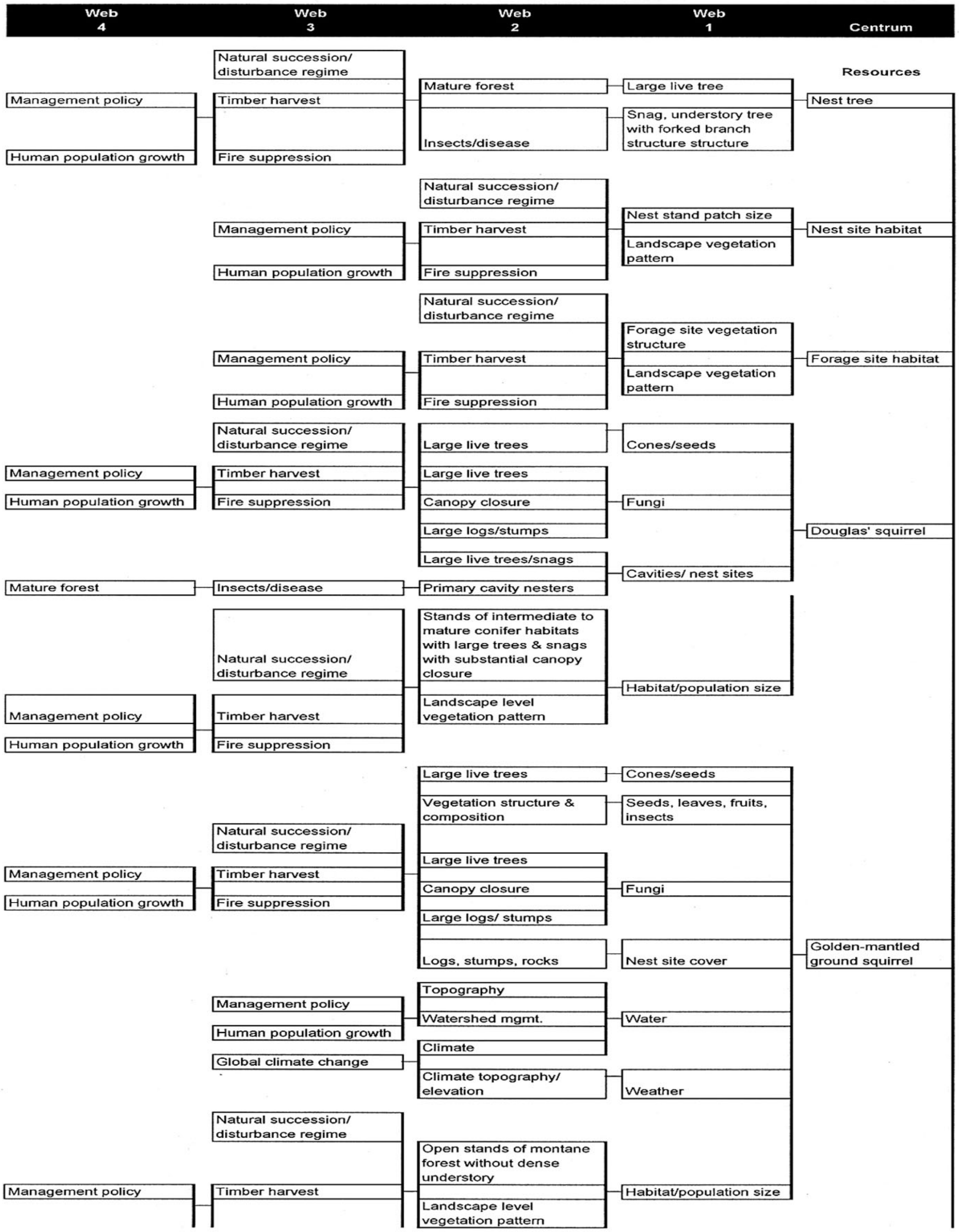


Figure O-2—Envirogram for the Northern Goshawk (*Accipiter gentilis*) (page 1 of 4).

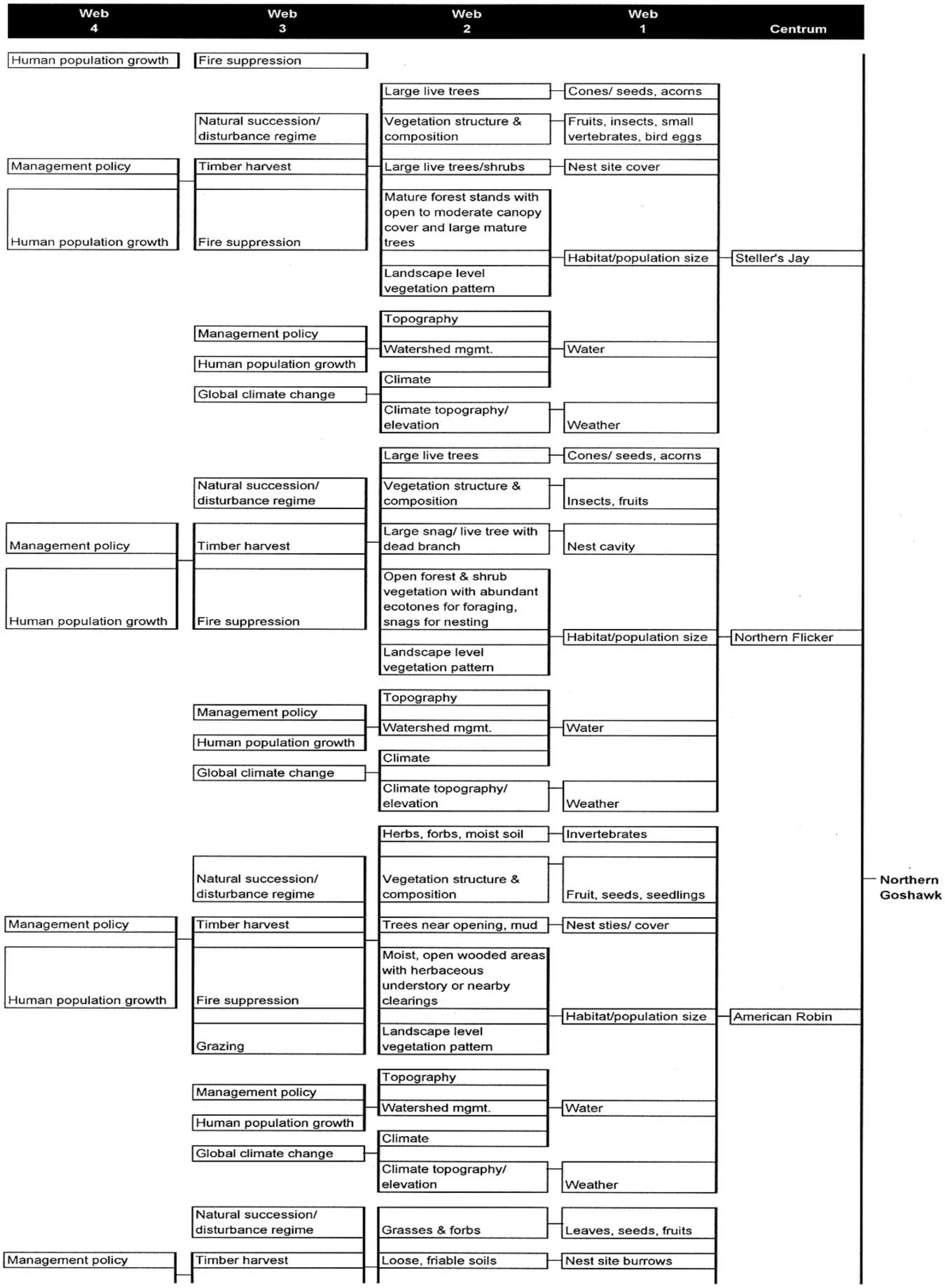


Figure O-2—Envirogram for the Northern Goshawk (*Accipiter gentilis*) (page 2 of 4).

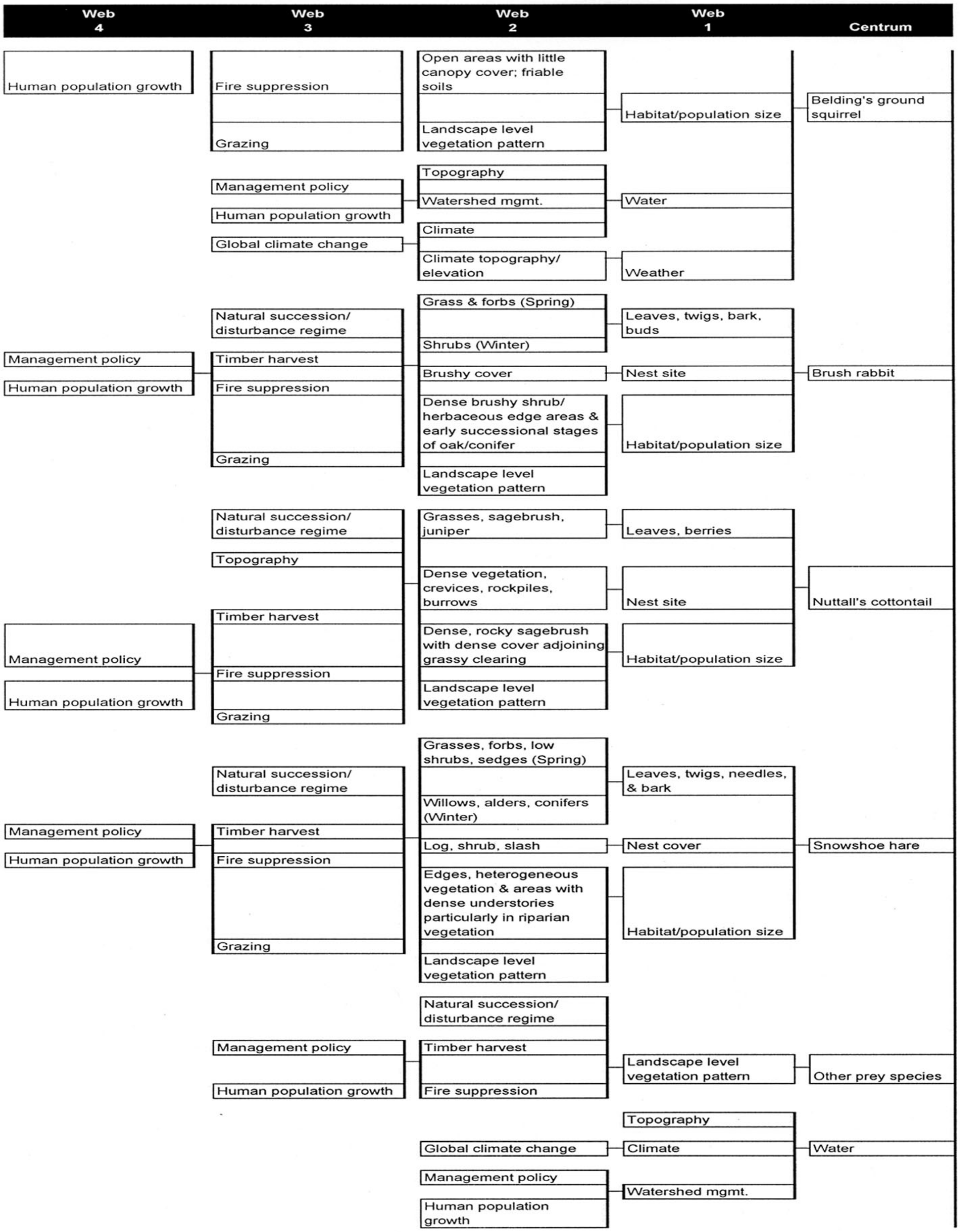
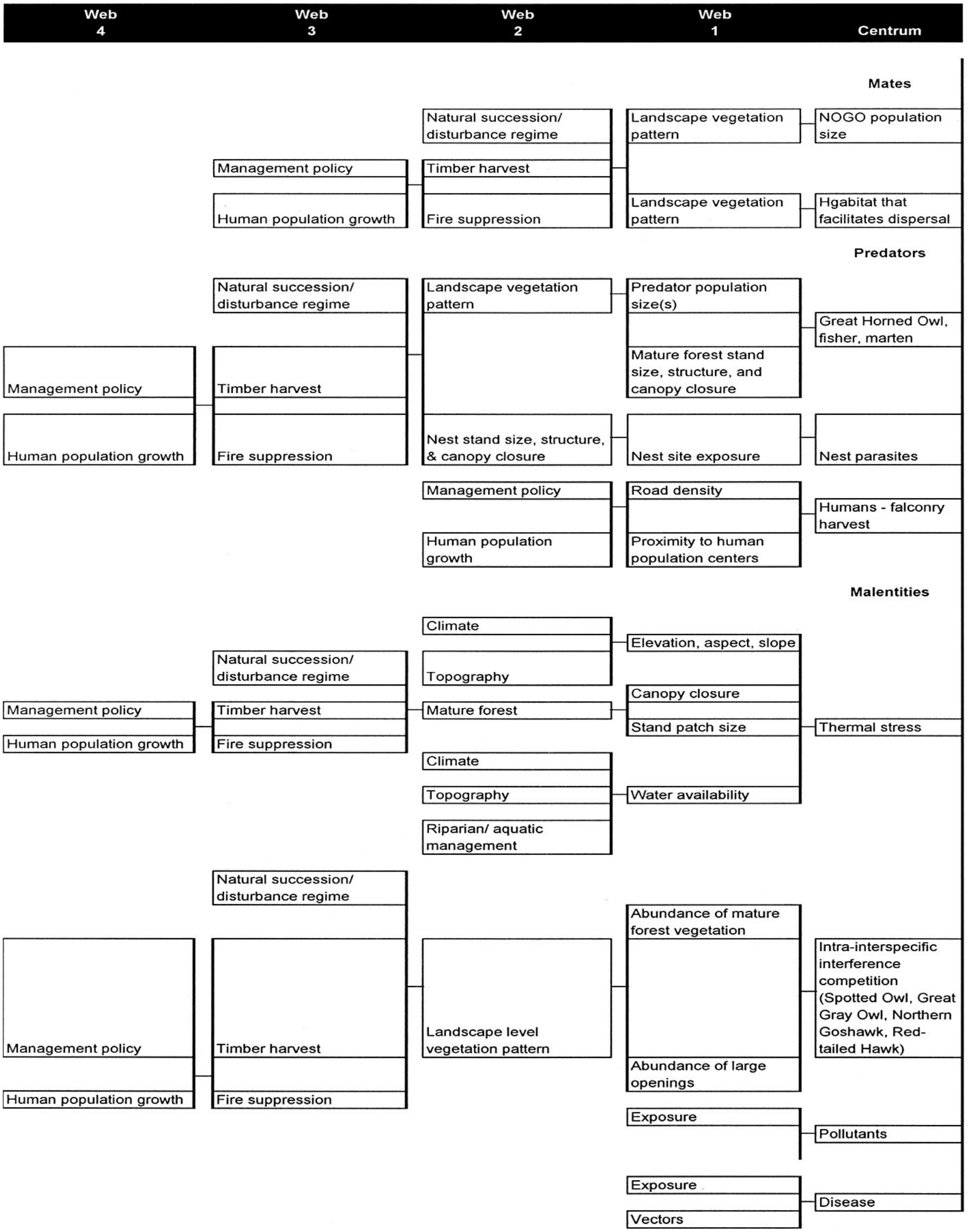


Figure O-2—Envirogram for the Northern Goshawk (*Accipiter gentilis*) (page 3 of 4).



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OSPREY (*Pandion haliaetus*)

J. Shane Romsos

Distribution

The Osprey is widely distributed throughout the world, inhabiting cool temperate to subtropical regions (Poole 1989). In California, Ospreys breed primarily along the Pacific Northwest coast (Poole 1989) and at large rivers, reservoirs and lakes throughout the state (principally northern California). In Nevada, Ospreys occur at Lake Tahoe and probably at other large bodies of water. In the Lake Tahoe basin, nests are distributed primarily along the shoreline at the northern portion of the east shore and southern portion of the west shore of Lake Tahoe (USFS unpub. data). Other Osprey nest sites in the basin are situated upland from lakes up to 2.5 km and occasionally are located along the shorelines of smaller regional lakes (e.g., Fallen Leaf Lake). The US Forest Service's Lake Tahoe Basin Management Unit (LTBMU) and Tahoe Regional Planning Agency (TRPA) annually monitor breeding Ospreys using walk-in and shoreline boat survey methods.

Ecology

Population Biology

On average 1.1 to 1.3 chicks fledge per year from active nests. Poole (1989) reported an Osprey surviving to year 25 and that out of 100 fledged young, 37 were alive at 4 years, 17 after 8 years, and 6 after 12 years. Thus, within a cohort of Osprey, a 63% mortality rate can be expected by year 4 and a 94% mortality rate by year 12.

Life History

Ospreys generally arrive on breeding grounds in late March to early April (Poole 1989), a pattern evident in the Lake Tahoe basin (pers. observ.). Ospreys breeding at Lake Tahoe are presumed to migrate from middle and southern latitudes of South and Central America according to Poole's (1989) accounts (no data exist to support this for Lake Tahoe's population). Ospreys form new pair bonds every year; that is, they may or may not mate with the same individual as in previous years (Ryser 1985). Most Ospreys are monogamous, but polygyny has been reported (usually one male concurrently breeding with two females) (Poole 1989). Ospreys lay 2 to 4 eggs (usually 3) from late April to early May and incubate them from 35 to 42 days (Ehrlich et al. 1988). Chicks hatch asynchronously and are semialtricial (i.e., not hatched simultaneously and are immobile, downy, with eyes open, and fed by parents). Young fledge approximately 56 days after hatching and frequently return to the nest for food (Ehrlich et al. 1988). Age of first reproduction is 3 to 4 years, but can vary between individuals and among populations. Juveniles spend approximately 17 months on wintering grounds. At 2 years old, Ospreys migrate north to temperate latitudes; they usually do not breed until the following year (Poole 1989).

Reproductive Behavior

During pair formation, the male provides food to the female, presumably to display its ability to provide for offspring and to establish mate fidelity (Poole 1989). Courting displays include swift pursuit flight, circling, soaring and dodging with rapid turns and swoops. The female fulfills greater than 70% of incubation and brooding responsibilities, while the male provides most of the food to the female and brood during nesting season (Ehrlich et al. 1988). Nests are constructed by both the male and female and consist of large sticks, sod, dung, seaweed, lichen and moss, cedar bark, garbage (plastic bags, rags, rope, fishing line), and other materials. Nests are large and conspicuous, and are usually established atop snags, large trees, or broken-top trees but also on man-made objects, dirt pinnacles, cacti, utility poles and rocks (Poole 1989). Nests are added to perennially by returning birds.

Foraging (Behavior/Needs)

The Osprey's diet consists primarily of fish, but also rodents, amphibians, reptiles, birds, and invertebrates (Van Deale and Van Deale 1982, Ehrlich et al. 1988, Poole 1989). Ospreys typically take fish near the water's surface and the breadth of their diet depends on the variety of fish found in surface water (Poole 1989). In the Lake Tahoe region, fish such as Lahontan redside (*Richardsonius egregius*), tui chub (*Gila bicolor*) and rainbow trout (*Onchorhynchus mykiss*) probably comprise the Osprey population's diet, considering those species' associations with shallow waters during the breeding season (Beauchamp et al. 1994).

Ospreys are over-water hunters that hover, dive from 30–100 feet, and then strike prey with talons. Ospreys may also swoop down to water's surface from a perch site or opportunistically dive while in flight. Adaptations have allowed Osprey to take advantage of fish as a primary prey resource. Their footpads are spiny to enable them to grip fish, the outer toe is flexible allowing it to be articulated completely backwards, and their legs are long allowing them to reach deep below the water surface (as much as 1 m) to acquire prey (Poole 1989). Because Ospreys use visual cues to detect and capture prey, they require open, clear waters for foraging; piers and buoys with attached boats may obscure fish and impede Ospreys' ability to capture prey efficiently.

Dispersal Behavior

Poole (1989) reviewed studies from Sweden and New England and reported dispersal information on 180 individuals. The studies found that after juveniles migrated to subtropical wintering grounds, males returned very close (< 50 km) to their natal site while females showed less natal site fidelity (Poole 1989).

Home Range

Garber (1972), French and Koplin (1977) and Poole (1989) reported that Osprey will travel up to 14 km to foraging locations.

Interactions with Other Species

Predators of adult Ospreys include Great Horned Owls (*Bubo virginianus*), while raccoons (*Procyon lotor*) and Common Ravens (*Corvus corax*) may raid nests (Poole 1989). Nest predators can take a heavy toll on the reproductive success of Osprey. Bald Eagles (*Haliaeetus luecocephalus*) and gulls (*Larus sp.*) will "kleptoparasitize" prey (steal food in flight) from Ospreys. Some birds, such as House Wrens (*Troglodytes aedon*) and swallows (family Hirundinidae), have been documented to establish nests underneath Osprey nests, presumably as a protective measure from predators (Ryser 1985).

Research Needs

There is a considerable desire to develop recreational access to lakes in the Lake Tahoe basin (TRPA 1986). Studies have documented that human encroachment can impact the reproductive success of Ospreys (Swenson 1979, Levinson and Koplin 1984); however, the degree to which humans disturb Ospreys in unknown in the Tahoe region. Other research that will aid in the conservation of the species in the Tahoe region includes 1) the identification of wintering grounds and patterns of natal site fidelity, 2) identification of Osprey prey species, and 3) a landscape level analysis to determine patterns of nest site selection.

Habitat Relationships

Although Ospreys have specialized food habits, they use a wide range of habitats near fish-bearing lakes, coastal waters, large rivers, and reservoirs (Poole 1989). Nests are usually built in large decadent trees near the water's edge. However, Ospreys have been reported to build nests as far as 11 km from water (Verner and Boss 1980). In the Lake Tahoe region most nests occur along undeveloped and remote shorelines and are established atop large diameter snags ranging in height from 40 – 100 ft (USFS unpub. data). Nests in the Tahoe region are located near other large and dead trees along the shoreline. A few nests are located in close proximity to houses and heavily traveled roads and boating lanes (e.g., at the mouth of Emerald Bay). In general, the area around nests is open, giving birds clear access when landing (Mathisen 1968). Additionally, trees selected for nesting presumably provide Ospreys with an unobstructed view in all directions but provide little or no cover from climate extremes. Trees species used for nesting in the basin include Jeffrey pine (*Pinus jeffreyi*), incense cedar (*Calocedrus decurrens*), and white fir (*Abies concolor*) (USFS, unpublished data).

Response to Natural Disturbance

No information is available on Osprey response to natural disturbance. Ospreys may respond positively to wildfire if large dead trees remain intact and standing. Catastrophic wind throw events may eliminate suitable perch and nest trees.

Effects of Human Activities

In the 1960's, Osprey populations in North America declined as a result of organochlorine (e.g., DDT) contamination of prey species. DDT residues affected hormones responsible for the control of calcium deposition in eggshells, causing them to thin. Thinned eggshells were susceptible to dehydration and breakage (Poole 1989). Osprey populations rebounded after DDT chemicals in North America were banned, but concern remains as these chemicals are still used as insecticides in Central and South America where Tahoe's Osprey population is suspected to winter.

In the absence of natural nest structures (e.g., snags, broken-top trees), artificial nest structures have been successful in promoting Osprey reproductive activity (Poole 1989). In the basin, artificial tree topping and nest platforms have been constructed, but have not been used by Ospreys for nesting.

Human disturbance early in the nesting period can reduce reproductive success in Ospreys (Swenson 1979, Van Deale and Van Deale 1982, Levenson and Koplin 1984). However, some studies indicated that human disturbance had little or no impact on reproductive success (French and Koplin 1977). In the Lake Tahoe region there appears to be some habituation to human disturbance as evidenced by nests situated in trees above dwellings or in close proximity to hiking trails or heavily impacted boating areas (pers. observ.). Nevertheless, it is unclear if the reproductive success of nests near human disturbance is similar to that of nests established in more remote areas. Byproducts of human activities may also negativey affect the survivorship of Ospreys. Discarded fishing line and garbage is collected as nest material by Ospreys and can entangle chicks or adults, causing suffocation or impairing their ability to acquire prey (Poole 1989).

Conservation

The TRPA considers the Osprey a "Special Interest Species" and has established a threshold policy for preserving the breeding population in the Lake Tahoe basin (TRPA 1982). According to the TRPA's Goals and Policies (1986), a minimum of four nest sites must be maintained for Ospreys. In addition to this policy, the TRPA Code of Ordinances (1987) protects all historic and current nest sites with a one-quarter mile disturbance radius around each nest. Consequently, since the adoption of the environmental threshold carrying capacities (TRPA 1982), numerous nest sites have been provided protection from human-caused disturbance. Within the disturbance zone for Ospreys, all perch and nesting trees are protected from being physically disturbed, and the habitat within disturbance zones cannot be manipulated unless such manipulation enhances habitat for Ospreys. Thus, according to TRPA (1987), only projects or activities that are beneficial to the species (i.e., habitat enhancement projects) are allowed to occur within disturbance zones unless Ospreys select a nest location in close proximity to development. Additional conservation measures have been established by the LTBMU; disturbing activities (e.g., timber thinning) that occur within disturbance zones are allowed only between mid-August and March, when most birds have fledged young and initiated migration. Although the TRPA and USFS policies attempt to reduce activities within disturbance zones for Osprey, little enforcement or education is promoted to reduce shoreline access via boats or hikers into disturbance zones. Consequently, the effectiveness of one-quarter mile disturbance zones in promoting the viability of Tahoe's Osprey population is in doubt.

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PILEATED WOODPECKER (*Dryocopus pileatus*)

Jennifer S. Hodge

Distribution

The Pileated Woodpecker is a permanent resident of coniferous and deciduous forests throughout southern Canada and the western, midwestern and eastern United States. In California, it is found in the Sierra Nevada, Klamath, Cascade and North Coast ranges in mature montane conifer forests (). It has been recorded throughout the Lake Tahoe Basin; Manley and Schlesinger (in preparation) detected the species at five (5.7 percent) of 88 lentic and 14 (17.5 percent) of 80 lotic riparian sites surveyed, and many other sightings have been recorded, mostly on the basin's west side (USFS, unpublished data). The distribution and frequency of occurrence of Pileated Woodpeckers in upland areas in the basin is unknown.

Ecology

Population Biology and Life history

This species is non-migratory, active year-round, and diurnal (Bull and Jackson 1995). Sexual maturity is attained at one year and the usual lifespan is approximately 7-9 years (Bull and Jackson 1995). Predation (see below) seems to be the major cause of death but, due to their dependence on large dead trees for nesting and foraging sites, Pileated Woodpeckers are also vulnerable to lightning strikes (Bull and Jackson 1995).

Reproductive Behavior

Pileated woodpeckers breed at the age of one year and once annually thereafter; clutch sizes of 4 are typical (the range is one to six) and the average size of broods fledged in NE Oregon, Montana and Louisiana was two (studies summarized in Bull and Jackson 1995).

Foraging

The microhabitats used most frequently for foraging are centered around dead wood (i.e. downed logs and snags) that are greater than 38 cm in diameter and in an advanced state of decay (Bull and Jackson 1995). The most common prey of these woodpeckers—carpenter ants, other insects, larvae and wood-boring beetles—are most abundant in these areas (Bull and Jackson 1995). Woodpeckers use various methods to capture prey, including gleaning from trunks and logs, pecking in bark, scaling bark off trees, and excavating cavities, and their excavations can be so deep that the tree may eventually break (Bull and Jackson 1995). Some nuts and fruits are eaten in trees and off the ground (Bull and Jackson 1995).

Dispersal

After leaving the nest at 24-30 days (this date varies geographically), young Pileated Woodpeckers follow their parents for several months while learning to acquire their own food and to use roost cavities (Bull and Jackson 1995). In September, they leave their parents and "wander" until spring, when they will attempt to nest. Data on distances traveled from natal territories are mostly anecdotal but dispersal distances of 0.7 to 32 km have been recorded (Bull and Jackson 1995).

Home Range

Birds usually move into territories only after the death of a previous occupant (Bull and Jackson 1995). Pairs will defend their territories from other territorial birds all year round, although during winter transient "floater" individuals are tolerated (Bull and Jackson 1995). Data on typical sizes of the home range are limited: pairs in N.E. Oregon had an average home range size of 407 acres (Bull and Holthausen 1993) and in W. Oregon individuals had summer home ranges of 478 ha (Mellen et al 1992). Crude estimates of density, derived from smaller-scale studies, predict 1 pair/ 160-220 ha in California (Harris 1982) and a minimum of 1 nesting pair/ 356 ha in NE Oregon (Bull 1987).

Interactions with Other Species

Pileated Woodpeckers have been observed to share their roost cavities with nesting Vaux's Swifts (*Chaetura vauxi*), and to share their nest trees with individuals of many other species that use different cavities, such as Northern Flickers (*Colaptes auratus*), Williamson's Sapsuckers (*Sphyrapicus thyroideus*), Red-breasted Nuthatches (*Sitta canadensis*), Northern Saw-whet Owls (*Aegolius acadicus*) and Mountain Chickadees (*Poecile gambeli*) (Bull and Jackson 1995). However, potential competitors for nest cavities, such as some other woodpeckers, European Starlings (*Sturnus vulgaris*), Wood Ducks (*Aix sponsa*), and bluebirds (*Sialia* spp.) are not tolerated (Bull and Jackson 1995). The Northern Goshawk (*Accipiter gentilis*), Cooper's Hawk (*Accipiter cooperi*), Red-tailed Hawk (*Buteo jamaicensis*) and Great Horned Owl (*Bubo virginianus*) are the major predators of this species (Bull and Jackson 1995). Martens (*Martes americana*), weasels (*Mustela* spp.), and snakes occasionally climb into nest cavities to remove eggs and young (Ahlborn and Harvey 1990, Bull and Jackson 1995).

Research Needs

More research on the factors regulating and limiting populations would aid efforts to manage for sustainable populations and identify the most critical components of the birds' habitat. Better knowledge of the dispersal dynamics of young woodpeckers would inform attempts to establish an optimally located network of management areas for the species (Bull and Jackson 1995). In addition, research is needed on the effects of human recreation and recreational development on individuals and nesting pairs.

Habitat Relationships

Pileated woodpeckers in California mostly use stands of red fir (*Abies magnifica*), white fir (*Abies concolor*) and Douglas fir (*Pseudotsuga menziesii*) to stands of other conifers (Ahlborn and Harvey 1990) but in Oregon, Washington and Montana they use grand fir (*Abies grandis*), western larch (*Laris occidentalis*), western hemlock (*Tsuga heterophylla*), western redcedar (*Thuja plicata*) and ponderosa pine (*Pinus ponderosa*), as well as deciduous trees, for nesting and foraging. They are thought to avoid lodgepole pine (*Pinus contorta*) forests (Bull and Jackson 1995). They nest in cavities, which helps to regulate temperatures as well as provide protection from the elements and from predators (Bull and Jackson 1995).

This species primarily uses late successional forest, but may be found in younger forests if these include sufficient numbers of large, dead trees (Bull and Jackson 1995). Several studies in Oregon and Washington (Mellen et al 1992, Aubry and Raley 1993, Bull and Holthausen 1993, Nelson 1988) have documented a clear preference for dense, old-growth forests with a high degree of canopy closure. Most of the roost trees in these studies were dead. Coupled with records of the species' avoidance of younger forests (Mellen 1987), this evidence suggests the Pileated Woodpecker specializes on mature forest habitats.

Little specific information is available on this species' response to natural disturbances such as fire, drought, disease.

Effects of Human Activities

Although populations throughout the species' range were significantly affected by hunting in the early part of the century, their numbers recovered during the 1920s and 1930s after protective legislation was implemented (Bull and Jackson 1995). However, the rapid urbanization and deforestation of recent decades has threatened the species once more, as the mature forests on which they depend are disturbed, logged, and increasingly fragmented by development and recreation.

Timber harvest has degraded optimal habitat for Pileated Woodpeckers in many parts of their range. Nest and roost sites, cover, and foraging areas are eliminated when large, old trees (either dead or alive) or downed woody debris are removed and the canopy opened to increase timber production (Bull and Jackson 1995).

Little research has been done on the Pileated Woodpecker's response to prescribed fire. The species' response will probably depend on the extent to which prescribed fires destroy the large snags and downed wood that provide habitat for the birds and their prey. If these resources are not protected either during the burns or through pre-burn treatments, a significant reduction in their abundance might negatively affect persistence of Pileated Woodpecker populations. Fire return intervals of 20 or 40 years might not allow sufficient time for the regeneration of these important components of the habitat. Wildfire, burning more intensely over a larger area, would be even more likely to consume critical resources.

Conservation

The Pileated Woodpecker is not currently listed as threatened, endangered or sensitive by any management agency; however, the Forest Service has identified it as a management indicator species whose presence signals the existence of high-integrity mature forest habitat. In Oregon and Washington, the Forest Service has established 100 management areas (120 ha each) to enhance nesting and foraging habitat for this species. Most of these areas are occupied by Pileated Woodpeckers (Bull and Jackson 1995). Occupancy of most of the management areas designed for their use suggests that creation of such areas may be an effective part of a conservation plan for the Pileated Woodpecker.

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CALIFORNIA SPOTTED OWL (*Strix occidentalis occidentalis*)

Jennifer S. Hodge and J. Shane Romsos

Distribution

The Spotted Owl *(Strix occidentalis)* is found throughout western North America and Mexico, but generally breeds only in forested regions of its range. Of the three subspecies, only the California Spotted Owl *(S. o. occidentalis)* is found in the Tahoe region. In California and Nevada, Spotted Owls occur in the southern Cascades, the northern Sierra, and the Tehachapi Range from near Burney (Shasta County) to Lebec (Kern County) and to the east of the Sierra Nevada crest. The Spotted Owl in California's coastal ranges occur from Monterey County to Santa Barbara County and from the Transverse and Peninsular ranges south to the Sierra San Pedro Martir Mountains in Mexico (Verner et al. 1992, Gutiérrez et al. 1995**).** Within the current distribution of the Spotted Owl, populations have declined significantly although the range itself has probably retained its historical shape and size (Gutiérrez 1994a). Although not noted by Orr and Moffitt (1971), California Spotted Owls were recorded in the Lake Tahoe basin by Johnson and Russel (1962) in 1960 and 1961. In the last decade, owl sightings have been primarily recorded in the northwestern and southern watersheds of the basin with one sighting recorded in an eastern watershed in 1998 (USDA 1998). Surveys conducted by the US Forest Service in 1998 documented the presence of more owls than in any previous year (USDA 1998). This could reflect more intensive surveying efforts, or perhaps an increase in the local population (USDA 1998). Of the 29 sites surveyed in 1998 (representing a total of 40,939 acres), 8 sites harbored owls, which accounted for 20 detections and 4 adult pairs (USDA 1998). Survey in 1999 had similar results: 8 sites harbored owls and accounted for 34 detections. Although no nests where found in 1998 or 1999, sites where owls were detected had been used by owls in previous years, suggesting that they may be permanent territories (USDA 1998).

Ecology

Population Biology/Demographics

A survey of Sierra Nevada Spotted Owl populations revealed that among reproductively active birds, the majority are ≥ 3 years old; 93% of 76 nesting females were adults and 7% were sub-adults, and 99% of reproductively active males were adults (Gutiérrez et al. 1995). Annual reproductive success increases from an average of around 0.25 fledglings/year for year-old females, to an average of 0.3 for two-year olds, to 0.8 for adult females (Thomas et al. 1993). Survival of adults is generally high, while survival of juveniles is low (LaHaye and Gutiérrez 1994). Causes of mortality include exposure to climatic extremes (i.e., high temperatures), predation by Northern Goshawks (*Accipiter gentilis*) and Great Horned Owls (*Bubo virginianus*), accidents, shooting, disease, and starvation (Verner et al. 1992, Gutiérrez et al. 1995).

Since 1997, an average of 3.7 Spotted Owl pairs/year have been detected from surveys in the Lake Tahoe basin. Prior to 1997 (1991 through 1996), surveys only detected an average of 0.67 pairs/year, representing 5.5 fold increase in pair detection rate. This increase in owl pairs detected in the basin may represent a true breeding population increase, reflect a more intense survey effort, or indicate movements of owls into the basin from surrounding forests.

Reproductive Behavior

In general, the breeding cycle of the California Spotted Owl includes five stages (prelaying, laying, incubation, nestling, and fledgling) and extends from February through late September (sometimes early October) (Verner et al. 1992). By the end of the breeding cycle, parents no longer care for young. Spotted Owls are monogamous with pair formation (prelaying) initiated in February through March. Behaviors during prelaying include roosting together, mutual preening, and frequent copulation (Verner et al. 1992). Males are thought to select a nest site around March or April. Spotted Owls do not build nests but instead use cavities and occasionally existing platform structures, such as Common Raven (*Corvus corax*) or hawk nests (Ehrlich et al. 1988). Peak egg laying in the Sierra Nevada occurs in mid to late April (Verner et al. 1992) and one brood is raised per year (Gutiérrez et al. 1995). During egg laying, males provide nearly all the food and females spend most of the time at the nest (Verner et al. 1992). Females lay 1 to 4 eggs (most frequently 2) within 1 to 9 days; incubation is initiated immediately after egg laying and continues for 28 to 32 days (Ehrlich et al. 1988, Verner et al. 1992). During incubation, females develop a prominent brood patch, which can be used to identify this nesting stage. Peak hatching (the onset of the nestling stage) occurs from early- to mid-May in the Sierra Nevada (Verner et al. 1992). During the hatching stage, the female will brood chicks for up to 10 days continuously while the male provides food to the female; the female then passes food to the chicks (Verner et al. 1992). Owl offspring fledge by 34 to 36 days but remain close to one or both parents, as well as to their siblings, until the end of August (Forsman et al. 1984, Ehrlich et al. 1988, Verner et al. 1992, Gutiérrez et al. 1995). In the Sierra Nevada, peak fledgling stage has been recorded from mid- to late-June (Verner et al. 1992). For approximately 3 weeks after first flight, young owls are poor flyers but soon thereafter improve flight and feeding skills. Young are provided for until mid- to late-September at which time young become independent. Reproductively mature owls do not necessarily breed every year (Verner et al. 1992).

Dispersal and Movements

In the fall, as young birds begin to capture their own prey, they exhibit increasing independence from parents and initiate dispersal movements (Gutiérrez et al. 1985). In the Sierra Nevada, Laymon (1988) found that young owls initiated dispersal from natal sites from early to late October. The dispersal of young owls from their natal sites in the fall is obligate (Gutiérrez et al. 1995). Direction of dispersal appears to be random, but owls exhibit a strong fidelity to historic owl breeding sites (Gutiérrez et al. 1995). During dispersal movements, young birds wander through territories of other birds during their first winter and may gain access to sites if resident adults die. In the Sierra Nevada, initial straight-line dispersal distances ranged from 5.7 to 113 km (3.4 to 68 miles) from natal sites to their first territory; some birds traveled additional dispersal distances from their first territory (summarized in Verner et al. 1992).

Migration is rare for the California Spotted Owl, but elevation shifts are not uncommon during the non-breeding season in the Sierra Nevada. Gutiérrez et al. (1995) reported movements of 15 to 65 km to winter ranges, with a downslope elevation shift of 500-1500m. Seasonal migrations occur between early October and mid-December and destination distances and locations are not predictable from year to year or from individual to individual (Verner et al. 1992). However, those individuals that make downslope movements typically make them every year. It is unknown if the breeding population (or portions of the population) of Spotted Owls in the Lake Tahoe basin make downslope movements during the non-breeding season. However, movement and site fidelity information is anticipated in the future as 10 owls from the basin were banded in the summer of 1999 (Hurt, pers. comm).

Foraging

California Spotted Owls forage both at night and opportunistically during the day (especially when raising young) from elevated perch sites from which they locate prey via sight and sound (Verner et al. 1992). Flight sounds of Spotted Owls are virtually imperceptible, allowing owls to drop from perch sites and pounce on prey undetected (Verner et al. 1992). Owls capture their prey with their talons. They are also known to “hawk” prey (such as birds and insects) or capture prey in mid-air.

Spotted Owls consume a variety of small and medium-sized mammal species (mostly rodents); primary prey species in owl diets tend to differ geographically (Gutiérrez et al. 1995). In the northern parts of the California Spotted Owls’ range and at higher elevations, northern flying squirrels (*Glaucomys sabrinus*) are the most important component of Spotted Owl diets, whereas farther south and at lower elevations, the dusky-footed woodrat (*Neotoma fuscipes*) predominates (Gutiérrez et al. 1995). Other prey species in the Sierra Nevada include deer mice (*Peromyscus maniculatus*), voles

(*Microtus* spp.), bats, amphibians, insects (which are consumed with the highest frequency but represent a much lower percentage of the diet by mass), ground and tree squirrels, chipmunks (*Tamias* spp.), and some species of bird (summarized in Verner et al. 1992 and Gutiérrez et al. 1995). Prey may be cached in and around trees, logs and rocks.

Home Range

The California Spotted Owl's home range is large relative to the bird's body size, and tends to increase at higher elevations and in areas where the primary prey is the flying squirrel (Gutiérrez et al. 1995). Results of 5 radio-telemetry studies (summarized in Gutiérrez et al. 1995) estimated a wide range in size of home ranges for Spotted Owls in the Sierra Nevada: 3.3 to 25.2 km^2 per pair (n = 15 pairs) and 2.8 to 75.7 km^2 per individual (n = 37). Estimates of crude density range from 0.12 to 0.21 Spotted Owls per square kilometer (Gutiérrez et al. 1995).

Interactions with Other Species

The species actively defends its nest sites and young from ravens, goshawks, Cooper's Hawks (*Accipiter cooperii*), and Great Horned Owls, some of which represent significant threats as predators (Gutiérrez et al. 1995). In addition, Great Horned Owls may compete with the Spotted Owl for access to territories (Gutiérrez et al. 1995). The more aggressive Barred Owl (*Strix varia*) has been reported to displace Spotted Owls from territories in some areas (Hamer 1988). Barred Owls can also hybridize with Spotted Owls (Verner et al. 1992). Because the diets of Spotted, Barred and Great Horned Owls overlap significantly, competition for food may be important (Gutiérrez et al. 1995). Western Screech Owls (*Otus kennicottii*), Steller's Jays (*Cyanocitta stelleri*), American robins (*Turdus migratorius*), vireos (*Vireo* spp.), hummingbirds, and woodpeckers react defensively or aggressively to the Spotted Owl and often mob individuals upon encountering them (Gutiérrez et al. 1995).

Research Needs

In general, more information on the factors that regulate California Spotted Owl populations would be valuable to assess potential impacts of human activities (Gutiérrez et al. 1995). For example, it is not known whether prey availability, nest sites, continuous habitat, or some other resource has the greatest effect on the distribution and abundance of the species, or how habitat characteristics influence survival, reproduction and other demographic variables (Gutiérrez et al. 1995). A more thorough understanding of metapopulation dynamics and patterns of juvenile dispersal in different habitat types would also enhance attempts to model future responses of the Spotted Owl to natural and anthropogenic environmental change (Gutiérrez et al. 1995). A better understanding of population demographics of Spotted Owls could help to determine whether a petition to federally list the California subspecies as Threatened or Endangered is appropriate. Further research is needed to identify the probable effects of invasion of Spotted Owl habitat by Barred Owls. Data and observations indicate that competition for territories and food may be significant and hybridization my compromise the integrity of the Spotted Owl gene pool (Gutiérrez et al. 1995).

In the Lake Tahoe basin, more fundamental life history information is needed to better understand and manage the California Spotted Owl. Studies that identify habitat use, home range parameters, responses to recreational activities (both direct and indirect impacts), and movements would benefit wildlife managers in the basin.

Habitat Relationships

Throughout the species' range, many different forest types are used: western hemlock, mixed evergreen, mixed conifer, Douglas fir, pine-oak, ponderosa pine, western incense cedar, redwood, Douglas-fir/hardwood and conifer/hardwood (Gutiérrez et al. 1995). In all forest types, however, owls select stands that are complex in structure, represent multiple age classes, contain a high percentage of large trees and have a high degree of canopy closure (Bias and Gutiérrez 1992, Gutiérrez et al. 1992).

Evidence suggests that Spotted Owls are highly specialized for old-growth forest. Late seral stage forests contain attributes thought to promote Spotted Owl prey species: large decadent trees, complex structure, and an abundance of coarse woody debris on the forest floor. Call (1990) found that owls primarily forage in late seral stage forest stands relative to younger stands. Several studies have shown late seral stage forests that are used by Spotted Owls provide suitable micro-climates that help owls avoid heat stress (Barrows and Barrows 1978, Forsman et al. 1984). Gutiérrez et al. (1995) found that landscapes where forests were continuous were more productive than landscapes consisting of fragmented forest stands.

Effects of Human Activities

Throughout the range of the three Spotted Owl subspecies, habitat has been greatly reduced in area (due to extensive clear-cutting) and in quality (even-aged stands managed for timber production do not contain habitat elements required by the owls) (Gutiérrez et al. 1995). In the Pacific Northwest, habitat loss has ranged from 54 to 99% (Gutiérrez 1994) due to the following human activities: logging, urban expansion, agricultural development, mining, reservoir construction, and development of water resources in riparian corridors (Gutiérrez et al. 1995). Some evidence indicates that as long as large trees, snags, and coarse woody debris are retained during selective logging, owls may re-colonize the area over a period of many decades (Forsman 1976, Verner et al. 1992). However, most studies have recorded low densities of owls in logged forests (Gutiérrez et al. 1995). The direct effects of human presence on individuals seem to be relatively minor due to the species' docile nature and apparent indifference to humans during research and monitoring activities (Gutiérrez et al. 1995).

Conservation

The California Spotted Owl is currently listed as a federal and California Species of Special Concern and as a US Forest Service Sensitive Species. The other two subspecies are listed as Threatened under the US Endangered Species Act.

Currently, the management of California Spotted Owl is directed by the California Spotted Owl Sierran Province Interim Guidelines (USDA 1993). The guidelines allow for a wide range of options for managing the California Spotted Owl by maintaining suitable habitat needed to support the existing owl population. The management process is a project-driven analysis process that evaluates the potential effects of a proposed project on Spotted Owls. Necessary adjustments are made to projects to ensure that the proposed action will not reduce or degrade the total suitable owl habitat below levels needed to support the current number of owls in an analysis area. The guidelines require that a Protected Activity Center (PAC) measuring 300 acres of the most suitable nesting and foraging habitat around each known pair is delineated and protected from adverse activities. Within the PAC, no harvest of live trees is allowed unless it can be shown to improve Spotted Owl habitat.

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WILLOW FLYCATCHER *(Empidonax traillii)*

Jennifer S. Hodge

Distribution

The Willow Flycatcher is distributed across North America and was once a common summer resident in riparian willow habitats throughout California (Grinnell and Miller 1944). However, populations have generally declined and/ or disappeared throughout the species' range (Harris et al. 1987; Taylor and Littlefield 1986). Surveys conducted in the late 1980s revealed breeding populations in isolated mountain meadows of the Sierra Nevada and along the Kern, Santa Margarita and San Luis Rey Rivers (Harris et al. 1987). In the Sierra Nevada, most Willow Flycatcher populations were located in 3 general areas: between the Little Truckee River (in the Tahoe National Forest) and Westwood meadow (Lassen National Forest), in the central Sierra from Anderson Meadow to the Shaver Lake area, and along the south fork of the Kern river (Harris et al. 1987). The Willow Flycatcher's formerly extensive distribution has been reduced to a small number of marginal populations in California, representing 3 subspecies. *E. t. extimus*, in Southern California, is undergoing the most rapid decline; *E. t. brewsterii* breeds from the coast to the Sierra Nevada crest, north of Fresno County and is the subspecies in the Lake Tahoe Basin; and *E. t. adastus* breeds east of the Sierra/ Cascades axis (Harris et al. 1987).

Few Willow Flycatchers have been reported in the Tahoe basin in recent years. As part of a larger survey of Willow Flycatcher presence and reproductive success in Calaveras, Alpine and Plumas counties (Bombay unpublished data), 10 meadow and riparian sites in the Lake Tahoe Basin were surveyed in 1998. Willow Flycatchers were detected at 4 of these locations: Washoe Meadow, the Upper Truckee, Morton Rd. and Grass Lake, and a total of 7 males and 5 females were detected using broadcast calling and direct observation (Bombay unpublished data). However, only the Upper Truckee nest site successfully produced fledglings. Grass Lake and Washoe Meadow supported active nests but no young were fledged (USDA 1998). In previous years (1992-1997), some sites had been surveyed in the basin yielding a few positive sightings: 2 males and 1 female at Taylor Marsh in 1992, 1 male and 1 female at Ward Creek in 1994, and 1 bird (sex unknown) at the Upper Truckee site in 1997 (USDA 1998). In addition, a few unconfirmed sightings were reported throughout the basin during this period. There are no records of the status of the basin's population between initial observations of the species in the early 1900s (Orr and Moffitt 1971) and the recent surveys described above.

Ecology

Birds arrive on breeding grounds from early to mid-June, and establish territories and form pairs by late June. Females produce clutches of 2-4 eggs, incubate them for 12-13 days, and hatch altricial young which can fly after 2 weeks in the nest (Ehrlich et al. 1988). Their diet includes berries, some seeds, and a high proportion of insects, which the birds capture by hovering and gleaning (Ehrlich et al. 1988).

Willow Flycatchers exhibit low site fidelity, with fewer than 25 percent of adults returning to breeding sites the following year (Sanders and Flett 1988, Stafford and Valentine 1985). Fewer than five percent of juveniles return to their natal sites to breed (Sanders and Flett 1988, Stafford and Valentine 1985).

Willow Flycatchers may be territorial towards Alder Flycatchers (*Empidonax alnorum*) (Ehrlich et al. 1988). However, despite significant overlap between their diet and that of many other species of insectivorous, riparian-associated birds, Willow Flycatchers apparently coexist with these species without obvious resource-based competition (Rosenberg et al. 1982). Many populations are heavily parasitized by Brown-headed Cowbirds (*Molothrus ater*) (Harris 1991) (see below). Nine studies, conducted from 1951 to 1991, found variable rates of nest parasitism (0-68% of those surveyed) and rates of acceptance of cowbird eggs (0-100%) at sites in Washington, Colorado, California, Arizona and several midwestern states (summarized in Harris 1991). In areas where parasitism was heavy, some Willow Flycatchers managed to nest successfully after rebuilding their nests at new sites, which commonly delayed fledging for 2-4 weeks (Harris 1991). Parasitism also had a negative effect on the birds' ability to prepare for migration, and prohibited some pairs from fledging a second brood later in the summer (Harris 1991). One study found that simulated and live cowbird intrusions prompted an "adaptive" response by the flycatchers: either a decrease in calling and activity or an active defense of the nest (Uyehara and Narins 1995).

Thorough surveys of the status and location of Willow Flycatcher populations in Northern coastal California, Northeastern California, the Klamath range and the Cascades would permit a greater understanding of the species' risk of extinction in California. A more detailed experimental analysis of the species' response to grazing, nest parasitism by cowbirds, and revegetation/ restoration projects would inform future efforts to encourage the recovery of the species (Harris et al. 1987). Information on population dynamics, dispersal and movements within territories would also be valuable.

Habitat Relationships

In the semi-arid western states, researchers have found a strong association between this species and thickets of continuous hydrophitic shrubs (Sanders and Edge 1998). Willow Flycatchers nest in deciduous trees of heights 2-10 ft, generally those in the dense willow thickets of riparian areas or swamps. One survey found no Willow Flycatchers where cover was less than 6 ft in height, and almost all sites used by one or more males included standing water (Harris et al. 1987). Both Harris et al. (1987) and Serena (1982) found that most birds nested in meadows larger than 8 ha., apparently preferring broad, flat areas. The available information suggests that various successional stages of riparian vegetation may be used; high levels of density and continuity seem to be the critical requirements.

The frequent proximity of favorable Willow Flycatcher riparian habitat to preferred Brown-headed Cowbird feeding areas in grazed pastures, stubble fields, and livestock areas increases the vulnerability of the Willow Flycatcher to invasion and parasitism by cowbirds (Harris 1991). However, populations of flycatchers in the Sierra Nevada may not be as severely affected by parasitism as are populations at lower elevations, because at high elevations the breeding seasons of the two species do not overlap to such a great extent and cowbirds may be leaving sites as flycatchers begin to nest (Harris 1991).

Effects of Human Activities

Alteration and loss of riparian habitat in California, especially in the Central Valley, has contributed to the decline of Willow Flycatcher populations (Harris et al. 1987). A study comparing grazed and ungrazed areas in Oregon found high densities of willows (high volume and thick foliage) and high numbers of flycatchers on ungrazed transects in a refuge, but significantly lower densities of both willows and flycatchers on transects that had been grazed (Taylor and Littlefield 1986). When grazing decreased four-fold between 1972 and 1982, Willow Flycatcher populations increased by a factor of eight. At sites outside the refuge, grazing continued, and surveys revealed declines in populations of flycatchers (Taylor and Littlefield 1986).

Cattle grazing not only disturbs nests directly, but cattle may also indirectly reduce the availability of suitable habitat and nest sites by changing the height and volume of willows and altering the structural features of meadows by causing soil compaction, gullying, and drying (Harris et al. 1987). Urbanization and agriculture in general have reduced the availability and quality of habitat for flycatchers in California. In the Sierra Nevada, meadow habitat is also threatened by the development of reservoirs and hydroelectric projects, by the encroachment of conifers into meadows, and by the burning of meadows to enhance their quality as pasture (Serena 1982, Harris et al. 1987).

Limited information is available on the effects of forest management practices on Willow Flycatchers. A study of forested plots in western Oregon that had been clearcut, burned and planted with Douglas fir seedlings found that Willow Flycatchers did use these areas, with an average of 30 birds per 40.5 ha (Morrison and Meslow 1981). The plots were covered by a dense understory of low shrubs, in which the flycatchers foraged, and contained some deciduous trees, which the birds used for singing and perching sites (Morrison and Meslow 1981).

Conservation

The Willow Flycatcher is currently on the Audubon Blue List, is classified as Endangered by the California Department of Fish and Game, and is a Sensitive Species in the US Forest Service's Region 5 (California) and The US Fish and Wildlife Service's

Region 1 (i.e. California, Oregon, Washington, Idaho and Nevada (Harris 1991). The subspecies *E. t. extimus* is federally listed as Endangered.

As the flycatcher's distribution in the Tahoe Basin appears to be restricted to meadows and riparian areas, its response to prescribed burn regimes will depend on the extent to which these are affected by the fires. If sufficient, dense riparian vegetation is protected during the burns, flycatchers may continue to use this habitat. The study of clearcuts in western Oregon (Morrison and Meslow 1981) demonstrated that regenerating vegetation can provide suitable habitat for this species, although initial densities of local populations probably affect the degree to which disturbed areas are recolonized. As so few individuals remain in the Tahoe area (USDA 1998) the sensitivity of the basin's population to management-induced disturbance may be especially high.

To mitigate the detrimental effects of parasitism by cowbirds on Willow Flycatchers, Harris (1991) suggests that trapping cowbirds and/ or removing cowbird eggs from flycatcher nests may be an effective short-term strategy, but to create long-term increases in local populations of flycatchers, management of habitat may control cowbird invasions most effectively. Reducing fragmentation and disturbance of valuable ecosystems, restoring and widening damaged riparian corridors through revegetation projects, and limiting or eliminating grazing to allow regrowth of grasses such that cowbird foraging is inhibited, may all prove to be successful strategies (Harris 1991). Preliminary results from the Nature Conservancy's Kern River Preserve in the Sacramento Valley suggest that Willow Flycatcher populations respond positively to some of these interventions (Harris 1991). Simply limiting or preventing cattle grazing in riparian areas during the flycatchers' breeding season (June-July) may be an effective means of enhancing fledging success (Harris 1991, Taylor and Littlefield 1986). A law passed by the Oregon state legislature in 1981 grants tax advantages to private landowners willing to enhance and protect riparian areas; Taylor and Littlefield (1986) suggest that other states could benefit from similar legislation.

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YELLOW WARBLER (*Dendroica petechia*)

Matthew D. Schlesinger

Distribution

The Yellow Warbler is the most widely distributed wood-warbler (family Parulidae), inhabiting most of the central and northern United States and all but the most northern reaches of Canada and Alaska (Dunn and Garrett 1997). Yellow Warblers winter from southern Mexico through northern South America (Dunn and Garrett 1997). In the Sierra Nevada, they breed as high as 2500 m (8000 ft) (Green 1990). Orr and Moffitt (1971) described Yellow Warblers as “common” in the basin, but the species was detected at only 5 (5.7 %) of 88 lentic riparian sites and 17 (21.3 %) of 80 lotic riparian sites surveyed by Manley and Schlesinger (in prep). Keane and Morrison (1994) detected very few Yellow Warblers in the basin in their extensive surveys. The species has been detected on all sides of the basin (Manley and Schlesinger in preparation).

Ecology

Yellow Warblers feed on insects and spiders, which they glean primarily from foliage (Dunn and Garrett 1997, Green 1990). Occasionally they hawk for insects or eat berries (Ehrlich et al. 1988). Their predators include snakes, corvids, accipiters, and small mammals (Green 1990).

Yellow Warblers build cup nests of grasses, bark, and other plant fibers in forks of shrubs or saplings, usually less than 5 m (18 ft) above ground (Dunn and Garrett 1997, Ehrlich et al. 1988, Green 1990). Clutch size ranges from 3-6 eggs (Green 1990), with clutch size generally increasing with latititude (Briskie 1995, Dunn and Garrett 1997). Females incubate the eggs for 11 days and the young fledge in 9-12 days (Green 1990). The pair often initiates a second brood during a single nesting season (Dunn and Garrett 1997). Yellow Warblers breed first as yearlings (Green 1990).

Yellow Warblers leave their breeding grounds for neotropical wintering grounds in late summer, with some stragglers remaining into October (Dunn and Garrett 1997). The birds return in spring, usually in late April or early May (Dunn and Garrett 1997). While in migration, Yellow Warblers use a wide variety of habitats, but avoid deep forest interiors (Dunn and Garrett 1997).

Yellow Warblers are common hosts for parasitism by Brown-headed Cowbirds (*Molothrus ater*) (Ehrlich et al. 1988, Dunn and Garrett 1997, Green 1990); this interaction has been the focus of much research (e.g., Briskie et al. 1990, Clark and Robertson 1981). Cowbirds can significantly reduce the nesting success of birds they parasitize (Brittingham and Temple 1983, Mayfield 1977), especially in populations that have not evolved with cowbird parasitism. Yellow Warblers in some areas have evolved strategies to reduce the negative effects of cowbirds, such as egg burial, ejection, and nest desertion (Clark and Robertson 1981). However, these strategies have evolved in areas with historical cowbird populations. Warblers in areas that cowbirds have recently colonized might not have evolved similar strategies, and thus might not recognize cowbird eggs as an anomaly. Consequently, warblers might be more susceptible to cowbird parasitism in the Lake Tahoe basin, where cowbirds arrived in the late 1950s (Orr and Moffitt 1971), than in regions with a long history of cowbird occupancy. Studies are needed on Yellow Warbler responses to cowbirds, and the success rate of parasitized nests, in areas where cowbirds are novel.

Very little information is available on Yellow Warbler population biology or home range size. Information on population trends, both locally and at wider ranges, is especially important given the potentially devastating impacts of cowbird parasitism.

Habitat Relationships

Yellow Warblers in the western US breed primarily in riparian areas dominated by willows, aspens, and wet meadows (Dunn and Garrett 1997, Ehrlich et al. 1988, Green 1990). They are also reported to breed in montane chapparral (Dunn and Garrett 1997, Green 1990). Specific habitat requirements on breeding grounds include shrubs or saplings for nesting and larger trees for singing and foraging (Green 1990). Wintering habitat is much more varied (Dunn and Garrett 1997).

Effects of Human Activities

Potential impacts of humans on Yellow Warblers relate to activities in riparian areas and activities that benefit cowbirds, including livestock grazing, land clearing, and possibly recreation. Additionally, chemical pollutants and predation by domestic animals are likely to cause Yellow Warbler declines.

Habitat destruction is one of the primary threats to neotropical migrants. Although the birds' wintering grounds have been the principal focus of conservation attention in this regard, managers, conservationists, and researchers are increasingly recognizing the detrimental impacts of habitat loss on breeding grounds (Terborgh 1992). In the case of the Yellow Warbler, significant impacts to riparian areas are likely to cause population declines. Removal of riparian vegetation due to urbanization or livestock grazing, or damage to riparian areas due to heavy recreational use, will undoubtedly affect Yellow Warblers and a variety of other species associated with riparian habitats.

Livestock grazing also may reduce suitable habitat for Yellow Warblers. Grazing is perhaps the most detrimental activity in riparian areas (Krueper 1993, Kondolf et al. 1996). Taylor and Littlefield (1986) reported that notable increases in Yellow Warbler populations in Oregon followed a decrease in the intensity of cattle grazing and the cessation of willow removal. Their study highlighted the importance of a healthy riparian ecosystem to Yellow Warblers, a condition that was not present when intensive cattle grazing and willow cutting and spraying occurred. Bock et al. (1993) summarized several existing studies and reported that Yellow Warblers showed mixed responses to cattle grazing, but emphasized that the species would be expected to be negatively affected by grazing due to its riparian association and that more research was needed.

Grazing may also adversely affect Yellow Warblers indirectly by facilitating cowbird parasitism. Cowbirds thrive in grazed environments, particularly pastures and feedlots; parasitism rates are generally higher in these areas (Verner and Ritter 1983, Rothstein et al. 1980). Robinson et al. (1993) recommend minimizing cowbird feeding opportunities by reducing grazing and other land-clearing activities, perhaps in combination with more direct cowbird control measures such as trapping and shooting.

Additional factors possibly leading to the decline of Yellow Warblers include chemical pollutants and predation by domestic animals. The widespread use of pesticides and herbicides is likely to have impacts on many songbirds, causing mortality, disease, decreased reproductive success, or adverse behavioral changes, but these potential effects have not been quantified (Gard et al. 1993). Domestic animals, especially cats, in riparian areas could decimate local populations of songbirds including Yellow Warblers. Domestic animals have been shown to be a major factor in songbird declines (Atkinson 1989, Patronek 1998).

Conservation

The Yellow Warbler is a California State Species of Special Concern. It has no other special management status, and no conservation plan exists. Attempts to address Yellow Warbler conservation in the basin should probably focus on maintaining and restoring riparian habitats and reducing the threat of cowbirds, actions which would benefit a wide variety of species. TRPA (1986) regulations prohibit the destruction of riparian habitat in the basin, but grazing and recreation are permitted in many areas.

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Mammals

BLACK BEAR (*Ursus americanus*)

J. Shane Romsos

Distribution

The black bear is the largest land mammal in the Sierra Nevada (Storer and Usinger 1963) and occurs throughout most of North America in forested areas from sea level to high mountain regions. In California, black bears can be found in the San Gabriel and San Bernardino Mountains, North Coast Range, Transverse Range, Cascade Mountains, Sierra Nevada, and parts of the South Coast Range (Ahlborn 1990). Grinnell (1933) described two subspecies of black bear in California: the northwestern black bear (*Ursus americanus altifrontalis*), occurring in the North Coast range, and the Sierra Nevada black bear (*Ursus americanus californiensis*), occurring from the northern Sierra Nevada range to southern California. In Nevada, the black bear is limited to the Carson Range (Lake Tahoe region), Pine Nut Mountains, and Sweetwater Mountains (Goodrich 1993). The black bear is ubiquitous in the Lake Tahoe basin in forested areas (Orr 1949, Goodrich 1993, Manley and Schlesinger in preparation).

Ecology

Population Biology

Black bears have the lowest reproductive rate of any wild terrestrial mammal in North America (Ahlborn 1990) and their age of first reproduction and litter size are related to resource availability (Piekielek and Burton 1975, Goodrich 1993, CDFG 1999). Hence, if a major die-off of black bears were to occur in a region, it would likely take decades for the population to rebound. Black bears typically produce 1 to 3 young (max. 6, average = 1.6 – 1.8) every 2 years after they reach sexual maturity (Burt and Grossenheider 1976, Goodrich 1993). In the Lake Tahoe area, mean age at first reproduction was reported at 5.25 years (n = 4) with some females observed in estrus at 3.5 years (Goodrich 1993). Bunnell and Tait (1981) reported age at first reproduction between 4.2 – 8 years. Black bears can live 25 years or more but average 10 years in the wild (Jonkel 1978, Pelton 1987, Ahlborn 1990). Survivorship tends to be greatest during maternal dependency (first 1.5 years); however, after departing from maternal care (>1.5 years) and during their second spring, young bear mortality rates increase until approximately 3.5 years due to their vulnerability to predators and conspecifics (Goodrich 1993). Causes of mortality include starvation, hunting, disease, vehicular collisions, and predator and conspecific encounters (Goodrich 1993).

Currently, California's black bear population is doing well and has increased over the last fifteen years (CDFG 1999), with the current statewide population estimate at 17,000 to 23,000 individuals (CDFG 1999). Goodrich (1993) estimated that 24 (± 13) individuals occupied the Nevada side of Lake Tahoe basin and concluded that there were 0.26 to 0.88 adult bears and 0.53 – 1.06 bears of all age classes per square mile.

Life History

In general, bears mate between mid-June and mid-July when reproductive females are at peak estrus (Ahlborn 1990). Black bears, like weasels (Mustelidae), delay implantation of the blastocyst (fertilized egg) into the uterus (Ahlborn 1990, Goodrich 1993). Implantation of fertilized eggs occurs four months after copulation and gestation lasts 7.3 months (Ahlborn 1990). Young are born while the female is denning from late January to early February (Orr 1949, Ahlborn 1990). Young nurse for up to 6 months and will stay with the mother for up to 1.5 years.

Black bears are active primarily at night, dawn, and dusk during spring, summer and fall and usually are dormant during winter months (Ahlborn 1990). As winter months approach, bears spend considerably more time foraging in preparation for hibernation. Prior to the onset of hibernation, body fat can be as much as 4.75 inches thick (Goodrich 1993). Hibernation is triggered by a variety of factors including photoperiod, ambient temperature, body condition, and forage availability (CDFG 1999) and the duration of hibernation is dependent on the term of winter (Goodrich 1993). Thus, in northern latitudes, where winters can last for 6 months, bears will hibernate for up to 6 months. Goodrich (1993) recorded den entry from 15 November to 5 December and emergence from dens from 7 March to 7 May in the Sierra Nevada. Males were the first to emerge from dens. Hibernation in bears is different from that in other mammals because black bears do not arise to excrete waste or retrieve resources (e.g., water). Instead, black bears maintain their body temperature by metabolizing fat and recycling metabolic waste during hibernation. In areas with mild winters, on the other hand, some bears are active year-round (Goodrich 1993).

Black bears are mostly solitary animals except during mating, when adult females are tending to young, and seasonally in areas where fish spawn in large numbers (Goodrich 1993). In general, bears are shy animals that are not commonly observed in the wild. However, some bears have habituated to human development and can be observed riffling through garbage cans, wandering through campsites, and even cooling off in backyard swimming pools.

Foraging

Black bears are omnivorous and their diets vary by season. After hibernation, bears primarily feed on grasses and other available herbaceous forage. As fruits and nuts (mast crop) become available in later seasons, bears shift their diet to take advantage of these more nutritious and fatty foods in preparation for winter hibernation (Orr 1949, Ahlborn 1990). Bears forage on the ground as well as in trees and shrubs and also dig, graze, fish, and scratch for food (Ahlborn 1990). Some common plants items consumed by bears include: tree cambium, dogwood (*Cornus* spp.), acorns (*Quercus* spp.), hazel nuts (*Corylys* spp.), manzanita berries (*Acrtostaphylos* spp.), cranberries (*Virbinium* spp.), raspberries, blackberries, and salmon berries (*Rubus* spp.), blueberries and huckleberries (*Vaccinium* spp.), rose hips (*Rosa* spp), gooseberries (*Ribes* spp.), clover (*Trifolium* spp.*)*, pine nuts (*Pinus* spp.)*,* and lupine (*Lupinus* spp.) (Hatler 1972, Jonkel 1978, Pelton 1987). Bears are also known to eat carrion, bees (Apidae), yellow jackets (*Vespula* spp.), garbage, fish (salmonids), ants (*Campanotus* spp.) and termites (Isoptera) (Hatler 1972, Jonkel 1978, Pelton 1987, Ahlborn 1990). Bears will sometimes kill small mammals and deer and elk fawns when opportunities arise.

Dispersal/Movement Behavior

Bears are not migratory, but make seasonal movements through a variety of habitats and altitudes (Ahlborn 1990). Goodrich (1993) recorded seasonal bear movements that ranged from 12.8 to 80 km (8 to 50 miles), presumably to acquire food. Major movements recorded in the Lake Tahoe region were initiated in the fall (Goodrich 1993).

Home Range/Territory

The size of black bear home ranges may be dependent on the availability, quality, and distribution of suitable habitat. Goodrich (1993) found that average black bear home ranges in the Lake Tahoe region were 10.5 km^2 (6.5 $mile^2$) for adult females (>3.5 years), 23.3 km^2 (14.5 $miles^2$) for adult males, and 4.2 km^2 (2.6 $miles^2$) for juveniles (1.5 to 3.5 years). Piekielek and Burton (1975) reported that female black bears may be territorial;

however, Goodrich (1993) recorded considerable home range overlap among females and indicated that females only showed territoriality when in close proximity (100 m or closer) to one another. In areas with sparsely distributed forested and riparian areas, Goodrich (1993) found that home ranges were substantially larger (mean home range up to 83.2 km^2 [52 $miles^2$] for males). Ahlborn (1990) summarized black bear home ranges in the west that ranged from 7.4 to 53.6 km^2 (2.8 to 20.6 $miles^2$) for males in southern California, 2.6 to 19.7 km^2 (1 to 7.6 $miles^2$) in northwestern California, and 51.5 km^2 (19.9 $miles^2$) in western Washington.

Habitat Relationships

Black bears are associated with a variety of habitats, but are most commonly found in mountainous forest habitats with a variety of seral stages. Bears have been known to use forested areas with juxtaposed shrubs, wet meadows, burned areas, riparian areas and clearcuts greater than 20 years old (Pelton 1987). Unsworth et al. (1989) found that bears in Idaho were associated more commonly with mesic timbered habitats than dryer open sites. Goodrich (1993) found that bears in the Lake Tahoe basin used primarily riparian habitats, followed by conifer stands, disturbed areas, and montane scrub. Bears in the Lake Tahoe region avoided open areas (Goodrich 1993). Goodrich (1993) attributed patterns of habitat use to food and water availability (riparian and shrub habitats) and resting and escape cover requirements (forested habitats). The availability of a range of habitats that provide both vegetative and structural diversity affords alternative foods when other food resources are in insufficient supply (CDFG 1999).

Because black bears hibernate, a description of habitat characteristics used for denning is warranted. Goodrich (1993) reported that 53% of dens were in trees, 37% under large boulders, 7% in brush piles, and 3% were excavated in the ground. Typical tree dens were in the bases of trees, but were occasionally elevated in trees or in hollowed out logs and stumps. Den entrances in the Sierra Nevada are most frequently oriented to the northeast (Goodrich 1993). Goodrich (1993) reasoned that a northeast orientation was most advantageous because more snow would accumulate at the entrance and therefore provide better insulation.

Effects of Human Activities

Evidence suggests that black bears are extremely sensitive to human disturbance during hibernation. Goodrich (1993) reported that bears abandoned dens in response human approach 66% of the time in spite of a quiet, on-foot, and downwind approach to den sites. Goodrich (1993) also reported cases in which females abandoned cubs in response to human encounters at den sites. Consequently, den abandonment can potentially impact reproductive success and also jeopardize adult fitness as a result of greater over-winter weight loss and urea poisoning (Goodrich 1993). Thus, recreational activities, such as snowmobiling, skiing, and snowshoeing, may have detrimental effects on Lake Tahoe's black bear population.

Urban development resulting in habitat loss and increased human-bear interactions poses another threat to black bear populations. As human population continues to grow within and outside of the Lake Tahoe basin, pressure to develop forested habitat for housing and recreation will likely continue and human-bear interactions will increase. As a result, less suitable black bear habitat will remain and the potential for animal control officers to remove bears that have habituated to food in urbanized areas and recreation sites will increase.

Forest management practices can positively and negatively affect black bear habitat. Timber harvest techniques that do not consider the large tree and downed wood requirements of black bears may reduce the quality of habitat for bears. Pelton (1987) indicated that controlled burning might enhance bear foraging habitat and create denning habitat.

Conservation

The black bear is not listed by federal or state agencies as sensitive, threatened, or endangered. However, The US Forest Service – Lake Tahoe Basin Management Unit (LTBMU) considers the black bear a "Management Indicator Species" (MIS). The MIS category was created by the US Forest Service to ensure that at least minimum viable populations of species that fall into to this category are maintained. Management Indicator Species have been selected as such to monitor the effects of management activities; their responses to these activities would be indicative of a group of species with similar habitat requirements. Thus, if black bears' responses to management activities were positive (or negative), it would be expected that species that require similar habitat features would be comparable. Unfortunately, the LTBMU is not equipped to monitor MIS responses to management activities other than acknowledging them in environmental documents.

The California Department of Fish and Game (CDFG) considers the black bear a "harvest species," and black bears are occasionally hunted in the basin (Bezzone pers. comm.). Section 1801 of the California State Fish and Game Code establishes policy regarding wildlife resources. The goal of this policy is to maintain sufficient black bear (and other wildlife) populations to 1) provide for the beneficial use and enjoyment of wildlife by all citizens of the state, 2) perpetuate all species for their intrinsic and ecological values, 3) provide for aesthetic and educational uses, 4) maintain diversified recreational uses of wildlife including sport hunting, 5) provide for economic contribution to the citizens of the state through the recognition that wildlife is a renewable resource, and 6) alleviate economic losses or public health and safety problems caused by wildlife (CDFG 1999). Each year the CDFG prepares an environmental document for bear hunting. As part of this environmental documentation, a black bear management plan is included to provide multi-year guidance and measurable goals for bear management within the state.

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COYOTE (*Canis latrans*)

J. Shane Romsos

Distribution

Coyotes are distributed throughout North America (Bekoff 1977). They are common permanent residents throughout the Sierra Nevada (Grinnell 1933), California (Grinnell et al. 1937), and Nevada (Neel pers. comm.). Coyotes and their sign (calls, scat, and tracks) have been detected throughout the Lake Tahoe basin (USFS, unpublished data).

Ecology

Population Biology/Demographics

Gier (1975) reported three limitations to survivorship in coyotes: 1) climatic factors, 2) disease, and 3) food availability. Additionally, human depredation, predation, accidents, and habitat loss can affect coyote populations. Data are highly varied regarding coyotes' longevity. In captivity, coyotes have lived as long as 18 years (Bekoff 1977), but in the wild, they rarely live beyond 8 years (Mathwig 1973). Knowlton (1972) reported a maximum age of 14.5 years in the wild. Mathwig (1973) estimated survivorship from seven studies and concluded that nearly 78% of coyotes in the wild were 4 years old or younger and only 7.3% were greater than 8 years old. Knowlton (1972) reported a 40% mortality rate for coyotes greater than 1 year old and a relatively high survival of coyotes between the ages of 4 and 8. Nellis and Keith (1976) estimated the coyote mortality rate in Alabama at 71% in year 1 and up to 42% for older animals. Mathwig (1973) concluded that the greatest life expectancy in coyotes in Iowa was between 1.5 and 5.5 years old. Nellis and Keith (1976) estimated that at least a 38% survivorship was necessary to sustain a coyote population.

Life History

The first breeding of most males and females is in the second year, but in years of abundant resources and available open space, females will breed in the first year (Gier 1975). Pups are altricial (helpless) at birth. Dens are typically constructed and used to birth and rear pups. Young coyotes are nursed by their mother and are weaned around 5 to 7 weeks. At around 3 weeks, young will eat regurgitated food provided by parents (Bekoff 1977). The role of the father relative to the litter is uncertain, but he is known to provide the lactating female with food during the rearing period. Young coyotes will leave parents at 6 to 9 months (Bekoff 1977), but not all young will disperse. By 9 months, pups reach full size and all teeth have erupted.

Reproductive Behavior

Coyotes in North American latitudes mate from January trough March, with courtship occurring approximately 2 to 3 months prior to copulation (Bekoff 1977). Once a male and female form a pair bond, they tend to remain together for years (Bekoff 1977). Female coyotes have a single period of estrus, or "heat," per year. Litter gestation is about 63 days and young are typically born from March through May. Coyotes produce only one litter per year, which can range from 1 to 11 pups (with an average of 5 to 6) depending on the availability of resources (Bekoff 1977). The percent of females breeding in one year has been reported to range from 33% to 90% and typically depends on local resource conditions (Gier 1975, Knowlton 1972). The sex ratio of a litter is about 1:1 (Bekoff 1977). Specific information on coyotes' reproductive behavior in the Lake Tahoe basin is lacking.

Foraging (Behavior/Needs)

Coyotes are omnivorous opportunists that will eat a variety of animal and plant taxa (Murie 1940, Ferrel et al. 1953, Korschgen 1957, Hawthorne 1972, Johnson and Hansen 1979, Litvaitis and Shaw 1980, Bowyer et al. 1983, Steinberg 1991, McClure 1993). The proportion of items and volume of food in coyote's diet vary among individuals and seasons. Coyote diets can consist of mice, rats, ground squirrels, gophers, lagomorphs (rabbits), opossum, fox, elk, moose, deer fawns, house cats and dogs, domestic livestock and fowl, some insects and crustaceans, reptiles, amphibians, fruits, birds and their eggs, and carrion (Ferrel et al. 1953, Bekoff 1977). Korschgen (1957) reported that coyotes' diets in a population from Missouri contained 56 animal species, 28 plant species, and six miscellaneous food items. Murie (1940) compiled a more comprehensive list food items found in 5,086 coyote scats from the Yellowstone area.

Coyotes will search and pounce, stalk and chase, and may dig out prey. Coyotes also feed opportunistically on insects and fruits and scavenge carcasses. Coyotes will hunt individually, in pairs, or in small packs (Bekoff 1977). They tend to use open habitats to forage, hunt and scavenge.

Dispersal Behavior

Coyotes can travel considerable distances through fragmented landscapes and a variety of habitats. Ozoga and Harger (1966) reported that coyotes dispersed from natal dens up to 180 km in unpredictable directions. Romsos (1998) reported movements from core use areas in a highly fragmented urban landscape of up to 14 km in 2 days. Dispersal distances and directions are unknown for coyotes in the Lake Tahoe basin.

Home Range

Coyotes spend a considerable amount their day on the move (Laundré and Keller 1981). Substantial variation in coyotes' home range have been reported (Table O-1). Hawthorne (1971) reported home ranges for coyotes north of the Lake Tahoe basin in Sierra County at 10 – 100 km^2. Variation in coyotes' home range size is dependent on resource distribution, individual behavior, and availability of open space.

Interactions with Other Species

Golden Eagles (*Aquila chryseatos*) and Great Horned Owls (*Bubo virginianus*) may kill young coyotes. Coyotes can coexist with larger mammalian predators, but are occasionally preyed upon by larger predators (e.g., mountain lions [*Felis concolor*] and wolves [*Canis lupus*]) (Mech 1966, Bekoff 1977, Koehler and Hornocker 1991). Likewise, coyotes do not tolerate smaller predators, such as foxes (*Vulpes vulpes*, *Urocyon cinereoargenteus*) and bobcats (*Lynx rufus*), within their foraging territory (Dekker 1988, Harrison et al. 1989, Sargeant and Allen 1989, Gese et al. 1996). However, White et al. (1994) found that kit foxes (*Vulpes macrotis*) were able to coexist with coyotes, presumably because of differences in resource selection and predator avoidance strategies. The absence of coyotes may contribute to what Soulé et al. (1988) called "mesopredator release," in which the lack of large predators in an ecosystem

Table O-1—Comparison of minimum convex polygon (MCP) estimates of home range size (km^2) for coyotes from different locations in North America, 1979 to 1998.

Study	Location	Habitat Characterization	Home Range (km^2)
Shargo (1988)	Los Angeles, California	Suburban	1.1
Pyrah (1984)[a]	Northcentral Montana	Sagebrush/Grassland	9.0
Holzman et al. (1992)	Southcentral Georgia	Forest/Agriculture	10.1
Gese et al. (1988)	Southeastern Colorado	Prairie	11.3
Roy and Dorrance (1985)	Alberta, Canada	Boreal Forest/Agriculture	12.1
Quinn (1995)[b]	Seattle, Washington	Urban	12.9
Bowen (1981)	Alberta, Canada	Boreal Forest	14.0
Romsos (1998)	Orange Co., California	Urban	14.3
Bounds (1993)	Tucson, Arizona	Suburban	15.7
Bekoff and Wells (1980)	Northwestern, Wyoming	High Meadow/Montane	21.1
Andelt and Gipson (1979)	Nebraska	Prairie/Agriculture	26.4
Harrison et al. (1989)	Eastern Maine	Forest	46.4
Springer (1982)	Southern Washington	Shrub-Steppe	92.4

[a] resident, non-nomadic coyotes

[b] Home ranges estimated with Adaptive Kernel 100% isopleth.

results in increasing populations of smaller predators (e.g., gray fox), which may decimate prey populations. This phenomenon has recently been observed in Texas, accompanied by a decrease in overall mammal diversity (Henke and Bryant 1999).

Research Needs

Because of the economic importance of coyotes, more is known about their ecology than any other carnivore (Bekoff 1977). However, specific information related to coyotes' ecology in the Lake Tahoe basin is lacking. Information on the distribution of coyote population centers in the basin would serve as bases for more detailed research. Basic home range, habitat use, movement, diet, and survivorship data would be valuable in order to understand the basin's coyote population. Because of their role as the predominant carnivore in the Lake Tahoe basin, more information is needed on their impact on prey species and smaller predators. This type of information may aid managers in sustaining populations of rare species if it can be shown that coyotes reduce predator pressure from smaller predators.

Habitat Relationships

Coyotes are considered generalists and occur in almost all habitats and successional stages (Bekoff 1977). Coyotes will use open brush, scrub, shrub, oak woodland, coniferous forest, and herbaceous habitats, and have been associated with croplands and urban environments (Bekoff 1977, Gese et al. 1988, Howell 1982, Holzman et al. 1992, Bounds 1993, Quinn 1995, Romsos 1998). In lower elevations of the Lake Tahoe basin, coyotes have been observed year-round within the urban intermix, wooded riparian corridors, meadows, marshes, and coniferous forests of varying seral stages (pers. observ.).

Den sites are ordinarily located away from direct human disturbance (Romsos 1998) on brush covered slopes, steep banks, thickets, hollow logs, rock ledges and/or in soils that are penetrable (Bekoff 1977). The same den site may be used year after year, may be shared by other breeding females, may have more than one entrance, and may be located near alternate den sites that can be used if an original den site is disturbed (Bekoff 1977, pers. observ.).

Effects of Human Activities

Coyotes' use of urban areas at Lake Tahoe is a concern. Recently it was reported that coyote–human interactions have increased near the Stateline area (Proctor 1999). Reported human–coyote interactions in Lake Tahoe included biting and mauling of both adults and children. No human deaths have been reported in Lake Tahoe as a result of coyote attacks; however, coyotes will readily kill pets if left outside (Bounds 1993, Romsos 1998). Coyotes are adaptable predators and are somewhat tolerant of regular human activities. However, coyotes will shift centers of activity in response to human and/or natural disturbance of preferred habitat (Romsos 1998). Habitat alteration that significantly reduces shrub cover and/or the introduction of regular human contact may cause coyotes to abandon core use areas (Romsos 1998). Shifts from core use areas and subsequent use of adjacent areas suggest that coyotes adjust rapidly to perturbations and changes in their environment without a reduction in their survivorship. Efforts to control or reduce coyote numbers have been mostly unsuccessful (Connolly and Longhurst 1975, Bekoff 1977) and coyotes remain common throughout much of California.

Conservation

There are no management policies specific to coyotes in the basin. However, all wildlife is generally provided protection from habitat destruction in the basin (TRPA 1987). It is the policy of the TRPA to maintain suitable habitats for all indigenous species of wildlife without preference to game or non-game species through maintenance of habitat diversity (TRPA 1987). Finally, an education program is needed in the Lake Tahoe basin to inform residents and visitors how not to attract wild animals and how to reduce human-coyote interactions in the urban intermix.

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DOUGLAS' SQUIRREL (*Tamiasciurus douglasii*)

Jennifer S. Hodge

Distribution

Douglas' squirrels occur from southwestern British Columbia south through the western half of Washington, the western two-thirds of Oregon, Northern California, and the Sierra Nevada (Carey 1991) from 0-11,000 ft (Harvey 1990). Orr (1949) found Douglas' squirrels "throughout the forested parts of the Tahoe region." Hall (1995) described them as common residents of coniferous timber stands above the pinyon-juniper zone and below timberline; he took specimens at Incline Creek, Zephyr Cove, and near the state line at the south end of the lake. Recently, the species has been detected thoughout the basin by Keane and Morrison (1994) and Manley and Schlesinger (in preparation).

Ecology

Life History

Douglas' squirrels are born naked and blind in early-mid summer, remaining in their arboreal nests until they are one-half to two-thirds the size of their mothers (Maser et al. 1981). Weaning occurs in the late summer; in most sites young leave the nest between mid-July and mid-September (Maser et al.

1981, Carey 1991). Families may remain together in the fall, but many young squirrels begin to establish their own territories in September and October (Carey 1991). Maser et al. (1981) state that late-born juveniles along the Oregon coast may not reach maturity until their third summer; Woods (1980) reported high mortality among juveniles in Canada and an average life expectancy for adults of less than 3 years.

Population Biology

Squirrel populations fluctuate seasonally and are strongly affected by the availability of food. The sharpest declines occur over the winter months and may also be related to dispersal by juveniles into sub-optimal habitat (Sullivan and Sullivan 1982, Carey 1991). Detailed studies of the population dynamics of this species have not been done.

Home Range

Home ranges and territories coincide (Smith 1968, cited in Harvey 1990). They are contiguous, exclusive, and vigorously defended with calls and chases (Carey 1991). Home range size varies with food abundance but ranges from 0.2 to 1.4 ha (0.5 to 3 acres) in the Oregon Cascades, with an average diameter of 129 meters (425 feet) (Carey 1991). Squirrel densities of 1.3 to 2.0 per hectare (0.6 to 0.9 per acre) (Carey 1991) and 2 per hectare (0.9 per acres) (Harvey 1990) have been reported. Territories may be abandoned when seed crops are poor (Carey 1991).

Foraging Behavior

Conifer seeds and hypogeous fungi represent the major sources of food, both of which are cached in the summer and fall and stored for consumption during the winter. In late summer, foraging squirrels begin to cut vast quantities of unopened cones from trees storing up to 2500 at a time in centrally located middens (Harvey 1990, Carey 1991). The middens are often placed in cool moist sites (e.g., springs and seeps in the Sierra, Carey 1991) to prevent the cones from drying out and opening. Most caches identified in a Sierran study contained 1-20 cones, with an average of 6 (Carey 1991). In addition to the seeds from ripe and unripe cones, squirrels consume many parts of conifers: emerging terminal shoots (Maser et al. 1981), pollen cones, cambium, mast, twigs, leaves, buds, and sap of conifers (Harvey 1990). Occasionally they may eat arthropods, bird eggs, or bird nestlings (Harvey 1990).

Reproductive Behavior

The breeding season is 4-5 months long (March-July) with female estrus lasting one day or less (Koford 1982). Mating is promiscuous; during estrus, mating ‘bouts’ take place in which neighboring males extend their territories into a female’s home range and attempt to secure matings. During the breeding season, females relax their defensive territorial behavior towards males (Koford 1982). In one Western Sierran site, dominant males (those that had demonstrated prior territorial dominance in the area) had higher mating success than subordinate males even though females did mate with subordinates (Koford 1982).

Usually, each female has one litter each year between May and June (possibly two if she was born early in the year and the cone crop is abundant) containing 4-5 young (ranging from 1-9) (Harvey 1990, Maser et al. 1981).

Interactions with Other Species

Douglas’ squirrels play an important role in the forests’ nutrient cycling processes by eating the sporocarps of ectomycorrhizal hypogeous fungi and dispersing spores of the fungi, along with nitrogen-fixing bacteria, through their feces (Carey 1991). Once in the soil, the fungi and bacteria enhance the ability of trees to take up nutrients. Alternatively, Smith (1970) suggests that predation on lodgepole pine seeds by squirrels of the genus Tamiasciurus has influenced the evolution of mast crop cycles and heavily armed cones.

Interspecific competition for resources occurs when the sizeable caches of cones and fungi made by Douglas’ squirrels are raided by northern flying squirrels (*Glaucomys* sabrinus) and chipmunks

(*Tamias* spp.), and squirrels defend their stores from these animals as well as from conspecifics (Carey 1991).

Major predators in the Pacific Northwest are the Northern Goshawk (*Accipiter gentilis*) and the Great Horned Owl (*Bubo virginianus*) (Carey 1991); predation by pine martens (*Martes americana*) (Zielinski et al. 1983) and bobcats (*Felis rufus*) has been recorded and predation by weasels (*Mustela* spp.), foxes (Canidae) and coyotes (*Canis latrans*) is assumed (Harvey 1990). Douglas' squirrels, active year-round, may represent an important source of food during the winter when many other species of small mammal hibernate.

Research Needs

Few studies of Douglas' squirrel ecology in the pine forests of the Sierra have been conducted. Responses to natural and anthropogenic disturbances, such as prescribed and wild fires, are unknown. Data on preference of squirrels for old-growth versus younger forests are conflicting and suggest variation from site to site; further investigation to attempt to reveal a pattern would inform forest management decisions.

Confirmation that squirrel populations are limited primarily by cone crop production in these forests would be valuable. For example, whether they would switch tree species depending on cone availability or travel in search of more productive stands is unknown.

Data on the effects on predation and interspecific competition are limited and mostly anecdotal.

Habitat Relationships

The Douglas' squirrel is a habitat specialist, requiring large coniferous trees for food (seeds) and nest sites (Carey 1991). Within the habitat, it uses many elements: moving over the ground, tree trunks, limbs, and out to tips of twigs; storing food underground and in trees (Hall 1995). Throughout its range it uses conifer, hardwood-conifer, and riparian habitat types (Harvey 1990). In the Tahoe basin, it is found in lodgepole pine (*Pinus contorta*), ponderosa/ Jeffrey pine (*P. ponderosa* and *P. jeffreyi*), white fir (*Abies concolor*) (Hall 1995) and mixed conifer forests.

Douglas' squirrels seem to prefer intermediate-mature conifer stands that include large trees, snags, and tree-shrub ecotones, with a high degree of canopy closure (Harvey 1990). In Douglas-fir (*Pseudotsuga menziesii*) forests in Washington, old-growth stands with multi-layered canopies supported higher numbers of Douglas' squirrels than did younger, more uniform stands, apparently because larger and more reliable cone crops were produced by older trees (which receive maximal sunlight through canopy gaps) and these were supplemented by seeds of understory species such as western hemlock (*Tsuga heterophylla*) that occur more frequently in old-growth stands (Buchanan et al. 1990). Several other studies suggest preferential use of old-growth habitat; however, some workers found lower numbers of individuals in old-growth plots than in younger stands (Waters and Zabel 1998 in northeastern Californian fir forests) and others found no difference (citations in Carey 1991).

Nests are made in cavities of mature trees and snags, generally using old woodpecker, vole, woodrat or squirrel nests, and are lined with grass, lichens, bark and moss (Harvey 1990; Carey 1991). Hollow logs and underground burrows may also be used, and weather-tight nests are sometimes constructed in dense tree foliage (Carey 1991).

As population sizes appear to be highly correlated with the size of local cone crops (Smith 1970, Buchanan et al. 1990, Sullivan and Sullivan 1982), disturbances that reduce cone and seed production may be expected to cause declines or extinctions of local populations. The response of populations to cone crop failures of varying severity and frequency has yet to be studied thoroughly (Buchanan et al. 1990).

The effects of natural disturbances such as wildfire have not been well studied. In the Tahoe basin, the mature stands of conifers pine used by Douglas' squirrels would probably retain important habitat even after a fire. Long-term maintenance of these forests depends on fire, even if cone crops and/or squirrel habitat might decline locally after a fire.

Effects of Human Activities

Domestic cats are reported to prey on individuals (Maser et al 1981).There is apparently no detrimental effect on squirrels of recreational use of forests.

Studies of habitat use in old-growth vs. even-aged, young managed forests report conflicting result regarding potential impacts of harvesting. Although Waters and Zabel (1998) captured significantly more squirrels in mature than than old-growth stands of fir in northeastern California, this may have been due to the greater absolute numbers of cones in these denser stands, following a prolific cone crop. Buchanan et al.'s (1990) results led them to speculate that the conversion of mature, multi-layered stands of Douglas-fir into structurally simplified plantations would adversely affect the squirrels by reducing the availability of nest sites and alternative food sources to supplement poor cone crops.

The response of the species to natural or prescribed fire may depend significantly on the habitat type examined. Lodgepole pine forests tend to experience intensive and extensive fires, after which they establish fairly rapidly from wind-dispersed seed (Atzet and McCrimmon 1990). Most trees are killed during the fire, which would force squirrels to emigrate. Ponderosa pine, however, is generally better able to resist low-severity fires due to its enhanced adaptations, and moderate- to high-severity fires will kill mainly trees that are pole-sized and smaller (Lampi 1960). Thus, squirrel habitat would probably be preserved under most conditions.

Conservation

The Douglas' squirrel is not currently listed as a species of concern; its populations are not actively managed and it has no specific conservation plan. As a potentially important prey item of the sensitive Northern Goshawk, its management could be valuable under certain conditions. Its role in dispersing fungi spores (thus enhancing the nutrient uptake of trees) may significantly affect the nutrient cycling of the ecosystems in which it occurs. Finally, the rapid response of Douglas' squirrel populations to abundant cone crops suggests that they might limit regeneration of conifers in years of extremely heavy predation. Further research is needed to confirm and describe these relationships and, if desired, to suggest their relevance to future conservation efforts in the basin.

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MARTEN (*Martes americana*)

Jennifer S. Hodge

Distribution

In western North America, martens (*Martes americana*) are found in boreal forests from Alaska to Canada, and south through the Rockies, Cascades and Sierra Nevada to New Mexico. The distribution of martens in Alaska and Canada has remained fairly stable in the last century, but farther south in western North America, many populations are now disjunct or isolated in parts of the species' former range. This fragmentation has been exacerbated by the logging of coastal old-growth forests in California, Oregon and Washington (Gibilisco 1994). In the Lake Tahoe basin, martens were most frequently detected during track-plate surveys in late seral stage confer stands on the north, south, and west sides of the basin (USFS, unpub. data).

Ecology

Population Dynamics

Martens rely on prey populations whose intrinsic rate of increase exceeds their own. Unharvested marten populations undergo frequent changes in population- and age-specific causes of mortality, and rarely exhibit characteristic age structures or age-specific rates of survivorship (Powell 1994). Trapping tends to skew the population structure in favor of juveniles and females. The sex ratio in the wild is thought to be 1:1 (Powell 1994).

Life History

Martens are active year-round, solitary except during courtship and mating and kit rearing, and typically spend their time foraging, traveling to maintain territories, and resting (Clark et al. 1987).

Reproduction

The breeding season varies slightly with geographic location but generally falls between July and August. After a gestation period of 220-276 days (including delayed implantation, in which the fertilized egg is not immediately implanted into the uterus), young are born during March and April in nests made in hollow trees, cavities, logs and rock piles (Clark et al. 1987). They are weaned at around 6 weeks, leave the nest at 7 weeks, and reach their adult length by 3 months. After kits have traveled with their mother until late summer to early fall, the family group disperses. Martens attain sexual maturity by 15 months and most yearling females (as well as all mature females) are inseminated at this time. Females remain reproductively active until at least 12 to 15 years of age. Mean fecundity has been estimated at around 3.2 offspring per year unless food is limited (Clark et al. 1987).

Dispersal

Although martens do cross patches of sub-optimal habitat to reach more suitable areas, they may not colonize suitable areas if these areas are substantially isolated (Buskirk and Powell 1994). Juveniles leave the family group and travel to new territory in the first fall (Clark et al. 1987). They appear to be less selective than adults in their choice of habitat and are more often observed in apparently sub-optimal areas during and after this dispersal period (Buskirk and Powell 1994).

Home Range

Both sexes are territorial, but only toward members of their own sex. Males have significantly larger home ranges than do females (Powell 1994). Home range size may be inversely related to prey availability. Thompson and Colgan (1987) found that home ranges increased when prey populations decreased in recently logged forests. Analysis of 19 studies of martens throughout their range revealed that the mean size of males' home ranges was 8.1 km^2 and the mean size of females' home ranges was 2.3 km^2 (values varied from 0.6 to 27.0 km^2) (Powell 1994). The spacing of females may be primarily affected by the availability of prey, whereas the distribution of males is also affected by the distribution of females (Powell 1994). One male's home range usually overlaps those of 2 to 6 females (Clark et al. 1987).

Foraging

In 3 of 4 marten diet studies in California, vegetation (e.g., berries) was found in a high percentage of fecal samples (24 to 44%) although it is thought to be of secondary importance compared to mammalian prey such as voles (*Microtus* spp.) and Douglas' squirrels (*Tamiasciurus douglasii*) (Martin 1994). Insects and passerine birds make up much of the remainder of marten diets. Throughout the range of the marten, voles are a major item in the diet, but prey choices appear to vary with local and seasonal availability (Martin 1994). The diets of populations in the Pacific states are more diverse than those of populations found farther east and north (Zielinski et al. 1983, Hargis and McCullough 1984, Martin 1994).

The ease with which martens can capture their prey in a given area may influence their choice of habitat more than does the absolute abundance of prey in that environment. Studies of foraging behavior suggest that certain attributes of the habitat, such as physical structure and patch characteristics, may be integrated with the martens' assessment of the availability and behavior of their prey (Buskirk and Powell 1994).

Interactions with Other Species

Predation on martens is thought to be infrequent and to have little impact at the level of the population (Clark et al. 1987, Buskirk and Powell 1994); some reports cite predators such as owls, eagles, lynx (*Lynx canadensis*), fishers (*Martes pennanti*), accipiters, red fox (*Vulpes vulpes*), and cougars (*Felis concolor*). There is limited evidence that fishers and martens compete for food, although the fisher's greater dietary flexibility and the marten's dependence on microtine rodents apparently allow the two species to co-exist (Clark et al. 1987, Slough 1994).

Research Needs

Both the direct and indirect effects of habitat loss on marten populations must be more thoroughly studied if managers are to encourage the persistence of this species. Analysis of the degree to which martens depend on stable populations of their prey and the degree to which these prey species are affected by manipulation or reduction of the habitat would be extremely valuable (Martin 1994); at present it is unclear whether martens are primarily limited by availability of habitat or by availability of food. Thompson and Harestad (1994) recommend a thorough investigation of which components of old-growth forests are most critical for martens. Koehler and Hornocker (1977) emphasize the need for further study of the effects of natural disturbance such as fire on the persistence and dynamics of populations of martens and their prey.

Habitat Relationships

Martens generally occupy conifer-dominated forest landscape mosaics (Buskirk and Powell 1994). Populations are often found on isolated mountain ranges, as land downslope of the conifer zone represent barriers to dispersal. Within their geographic range, martens use mesic forests more than dryer forests; thus at temperate latitudes they select riparian areas within the dryer forested landscapes for foraging and resting. Martens are closely associated with late-successional forest types dominated by spruce and fir. However, ecologists have debated the degree to which they have specialized on old-growth habitat; some field studies have indicated their habitat requirements may be more general and flexible than previously thought (Buskirk and Powell 1994).

In the Sierra Nevada, studies have found that martens used forests with 40 to 60% cover more than those with less than 30% cover (Koehler and Hornocker 1977, Spencer et al. 1983). The need to avoid aerial predators, or the increased number of opportunities to hunt preferred prey, may explain the marten's choice of structurally complex, closed canopy forests (Buskirk and Powell 1994). The patchiness of a habitat and the degree of separation of favorable patches may predict the extent to which martens are able to use an area (Buskirk and Powell 1994). Large open spaces (e.g., meadows greater than 50m across) tend to be avoided, although the animals will travel through smaller gaps and clearings (Hargis and McCullough 1984). There is some evidence that forest-meadow edges provide favorable habitat (e.g., at Sagehen Creek in the Sierra Nevada, Martin 1987). Koehler and Hornocker (1977) found that martens used a diverse mosaic of habitat types and successional stages created by a series of past fires in the spruce-fir forests of north-central Idaho. The animals were observed in edge and open habitats, as well as in dense patches of forests, when cover and prey conditions were favorable (Koehler and Hornocker 1977).

Habitat use varies seasonally, as martens use older stands and stands dominated by fir in winter but a wider range of types and ages of stands in summer (Buskirk and Powell 1994). In winter, because of snow cover, martens rely on logs, snags, and small diameter trees to provide access to subnivean cavities for foraging or shelter (Buskirk and Powell 1994, Hargis and McCullough 1984). Several studies (summarized in Buskirk and Powell 1994) have demonstrated that energetic constraints on martens in winter cause them to alter their use of resting sites according to changes in temperature. At cold temperatures, individuals rest in cavities below the snow and around coarse woody debris to conserve energy, but choose above-ground sites when temperatures are warmer at the surface.

Effects of Human Activities

Historically, trapping of martens and other furbearers may have had significant effects on populations as the animals' curiosity tends to draw them towards traps or poisoned carcasses, and the large size of their home ranges increases exposure to such hazards. However, local extirpations have been reversed or averted by limiting human activity--enforcing quotas for trappers, increasing the spacing between traps, establishing 'closed' seasons and performing re-introductions of some populations (Buskirk and Powell 1994). The combined effect of these regulations has been to limit 'take' such that large-scale declines of the species are no longer likely (Buskirk and Powell 1994). However, current and future threats to the species' persistence, in the form of logging and fragmentation of forest habitat, may have a much more serious impact over the long term.

Martin (1994) has speculated that the relative lack of diversity in the marten's diet and the small size of its home range compared to ranges of larger carnivores may increase its vulnerability to anthropogenic changes in its habitat. Timber harvest may cause declines in many forest-dwelling species on which the marten preys, such as red-backed voles (*Clethrionomys* spp.), which need dense canopy cover and coarse woody debris. Some research (e.g. Thompson and Colgan 1987) has shown that fecundity and population sizes of martens may decrease as a consequence of the reduction in abundance of voles, although the links between management, prey availability and the responses of the marten populations need to be more fully elucidated. In the Sierra Nevada, marten diets are probably higher in diversity than are those of populations in areas such as Alaska or Canada where large-bodied prey such as snowshoe hares and red squirrels are more abundant (Martin 1994). Thus, some adaptation to changes in availability of prey species may be expected.

Conservation

The marten is classified as a Sensitive Species by the US Forest Service.

In areas in which marten populations have been significantly reduced or extirpated, loss of genetic variation may become a serious problem. Re-introduction efforts, often undertaken to counter this, have been fairly successful: Slough's (1994) survey of 37 re-introductions and 9 introductions of martens throughout America and Canada found that 27 populations considered self-sustaining have been established. The success of these efforts has been attributed partly to the high quality of habitat into which the martens were introduced, and high numbers of martens in re-introduced populations (all efforts involving 30 or more animals were successful) (Slough 1994).

It is difficult to predict the response of the marten to prescribed burns due to the limited and/ or contradictory nature of data on the degree to which this species depends on components of the habitat such as downed logs, coarse woody debris, large dead and living trees, and a dense understory (Koehler and Hornocker 1977, Buskirk and Powell 1994). As well as protecting these elements to reduce the potentially negative effects of a prescribed fire, managers might also need to assess and if necessary mitigate the possible impacts of such a burn on populations of the marten's prey. Given the limited amount of habitat thought to be suitable for martens in the Tahoe basin, a high-intensity wildfire would be likely to render existing habitat unusable and significantly slow the development of potentially valuable forest stands.

Thompson and Harestad (1994) suggest that in areas in which optimal habitat is limited (such as the Tahoe basin), a basic conservation objective for this species should be to maintain as much old forest as possible for as long as possible, and plan for the development of potentially suitable habitat in adjacent areas. This could be accomplished using such strategies as a pest management program to limit loss of valuable trees to insect infestations; a limited harvesting program that would remove patches of heavy mortality or decadence but maintain connections between intact stands; silvicultural techniques such as thinning or fertilization to enhance growth of large trees; monitoring and enhancement of the prey base; and careful monitoring and modeling of the development of both the habitat and the marten populations (Thompson and Harestad 1994).

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NORTHERN FLYING SQUIRREL (*Glaucomys sabrinus*)

Sanjay Pyare and Jennifer S. Hodge

Distribution

The northern flying squirrel is primarily distributed in coniferous forest habitat in northern and western North America (Burt and Grossenheider 1980). Although the species is generally not considered to be threatened, its status is of concern in several isolated habitats, most notably in the southeastern US, southern California, and Prince of Wales Island in southeast Alaska. In the Sierra Nevada Range, its distribution is poorly understood, but it appears to be primarily associated with red fir (*Abies magnifica*) forests (Orr 1949, Verner et al. 1992). The flying squirrel rarely occurs in the xeric mixed conifer forests of the eastern slope of the Sierra Nevada, possibly due to rare occurrence of a primary food item, hypogeous fungi, and/or extensive clearcutting activity that occurred 70-120 years ago in that region. In the Lake Tahoe Basin, the species is most likely to be found in relatively undisturbed, upper elevation (>6500 ft) red fir forests, especially in patchworks of mature trees (> 80 yr), small tracts of remnant old growth (> 200 yr) habitat, and perhaps in conifer habitat adjacent to riparian zones (Doyle 1990). Although this species is not strictly associated with mature or old-growth forests (Rosenberg et al. 1996), it is typically less abundant in younger (< 50 yr), extensively fragmented forest which is more typical of the habitat found on the lower slopes of the basin.

Ecology

Diet

This species is omnivorous and forages on the ground as well as in trees (Mowrey and Zasada 1984). McKeever (1960) found that in ponderosa pine, lodgepole pine and mixed-fir forests in northeastern California, flying squirrels consumed fungi and lichen according to seasonal availability and did not eat conifer seeds even when abundant. Other authors have documented heavy use of hypogeous fungi (truffles) and lichens in Alaska, California, Oregon, and Washington (Hall 1991, Maser et al. 1981, Pyare a, in review, Waters and Zabel 1995). Occasional consumption of a wide variety of other foods, including the seeds, nuts and fruits of conifers, oaks, and shrubs; arthropods; eggs; and birds has also been recorded (Thysell et al 1997, Wells-Gosling and Heaney 1984, Harvey and Polite 1990).

Nesting Habits

Nests may be made inside larger structures, such as cavities of trees or abandoned woodpecker holes, or constructed on the outside (“dray” nests), using twigs, barks, roots, mosses and other locally available materials (Wells-Gosling and Heaney 1984). Cavity nests are generally smaller, may house single animals or mothers with young, and provide the main winter quarters (Wells-Gosling and Heaney 1984). In contrast, dray nests often house females with litters and are mostly used in the summer. Both types of nest are lined with a variety of items such as lichens, shredded bark, pine needles, grasses, feathers, and fur (Harvey and Polite 1990) and may be 1-50 m above the ground (Wells-Gosling and Heaney 1984, Pyare, pers. obs.). Insulation in nests is thought to aid in thermoregulation; squirrels may also aggregate in nests to conserve energy in the winter (Wells-Gosling and Heaney 1984).

Reproduction and Development

Mating occurs between late March and July, with a probable peak between May and June in the Pacific Northwest and the Sierra Nevada (Wells-Gosling and Heaney 1984, Forsman et al 1994, Pyare, unpublished data). Offspring are born from late May to September. The gestation period is 37 to 42 days (Muul 1969). One litter per year is typical, although two to three per year have been recorded. Litters usually contain 2-4 young (Wells-Gosling and Heaney 1984).

Squirrels weigh 5 to 6 g at birth and are about 70 mm in length. They can crawl by day 18, open their eyes by day 32, and they start to walk, emerge from the nest and eat solid food by day 40. Young are weaned at around 2 mos of age but remain with their mother for some time (Wells-Gosling and Heaney 1984). Females raise the litter without assistance from males; sexes may be segregated (Maser et al. 1981). Sexual maturity is attained in the first year and the lifespan is generally up to 4 yr.

Activity and Movements

Flying squirrels are nocturnal and in summer exhibit a biphasal pattern of activity with peaks just after sundown and just before sunrise (Wells-Gosling and Heaney 1984). In winter they remain active at temperatures as low as -24° C (Wells-Gosling and Heaney 1984) but regulate their energy losses by varying the amount of time spent outside the nest according to temperature (Ferron 1983). When active, they glide from tree to tree or, less often, travel on the forest floor (Mowrey and Zasada 1984). Distances traveled between dens and within home ranges appear to vary with habitat quality, availability of food and shelter, and population density (Carey et al. 1997). When populations were low and/ or females were confined in dens with only their young, males traveled farther than usual, apparently in search of mates and denning companions (Carey et al. 1997).

An early study showed typical home range sizes to be 0.8 to 1.2 ha (Seton 1929) but more recently radio telemetry work by Witt (1992) documented home ranges from 3.5 to 5 ha in stands of Douglas fir in western Oregon. Wells-Gosling and Heaney (1984) report population densities ranging from 0.3 animals/ha to 10 animals/ha in optimal habitat.

Predators

Major predators are Spotted Owls (*Strix occidentalis*), as well as other species of owls, Northern Goshawks (*Accipiter gentilis*), red-tailed hawks (*Buteo jamaicensis*), martens (*Martes americana*), weasels (*Mustela* spp.), domestic cats (*Felis domesticus*), bobcats (*F. rufus*) and foxes (Canidae) (Harvey and Polite 1990, Wells-Gosling and Heaney 1984). Flying squirrels appear to be the most important prey of Northern Spotted Owls in much of the owls' range. Forsman et al. (1994) found that on the Olympic Peninsula, WA, there was a marked increase in the proportion of juvenile flying squirrels in the diet of Spotted Owls in September and October, reflecting a pulse of births in August and September. Young flying squirrels seem to leave the nest when the fall bloom of hypogeous fungi (an important food source) is occurring.

Habitat Relationships

Macro-level

The northern flying squirrel has been described as a specialist that requires mature forests with complex stand structures, large trees and snags for nest sites and cover (Carey 1991, Harvey and Polite 1990); however, this has not been clearly substantiated (Rosenberg et al. 1996). This generalization may have initially been made due to the dependence of Spotted Owls, an old growth specialist, on flying squirrels as a food source within old-growth habitat. Some investigators have found empirical support for this hypothesis. Carey et al. (1999) have found that the carrying capacity of flying squirrels was in part explained by amount of decadence and habitat breadth (within-stand heterogeneity resulting from disturbance and forest development) – both of which are generally more prevalent in mature stands. In addition, Carey et al. (1992) found squirrel densities to be twice as great in old than in young stands in Oregon and Washington. Furthermore, Waters and Zabel (1995) found 45% higher densities in old growth (> 200 years) than in young (75-95 years) stands and substantially lower densities in shelterwood stands in California, and Witt (1992) reported a density of 0.85 squirrels/ ha. in old-growth forests and 0.12 squirrels/ ha in second-growth forests in Oregon. In contrast, both Rosenberg and Anthony (1992) and Hayes et al. (unpublished data) reported similar densities between old-growth and second-growth stands, and Rosenberg and Anthony (1992) and Martin (unpublished data) found similar patterns in several crude measures of survival and fecundity between old and young stands. Given the specialization of flying squirrels on hypogeous fungi, fungal abundance in different stands may confound comparisons among different types of habitats; Waters and Zabel (1995) showed an overall correlation between flying squirrel density and relative abundance of a primary food item, hypogeous sporocarps.

Micro-level

Carey et al. (1997) examined the use of different types of nests and found that, compared to cavities, outside nests were used more than expected in Washington and that two-thirds of all dens located were in live trees, of all ages, rather than snags. Cavities were often selected by females with young and hence this feature may contribute to reproductive success, but this study did not reveal a dependence by squirrels on a single type of tree or structure for nest sites. The range of den types appeared to vary inversely with population density; in high-density populations, dens were confined to old-growth trees, but in stands where squirrels were less abundant, they denned in a wider variety of trees and supporting structures (Carey et al. 1997).

Within old-growth habitat in the Lake Tahoe Basin, Pyare (b; in review) found a strong relationship between the local abundance of hypogeous sporocarps, flying squirrel occurrence, and soil diggings related to mycophagous (fungus-consuming) behavior, suggesting that the relative availability of hypogeous sporocarps within flying squirrel home ranges influenced the fine scale pattern of habitat use by this species. In addition, availability of understory cover was the only structural microhabitat feature that consistently explained flying squirrel occurrence among the stands studied. Carey et al. (1995) also found microhabitat associations between understory components and flying squirrel occurrence. Given that flying squirrels forage among the base of trees for hypogeous sporocarps, understory cover may be important in providing protective cover from predators like Spotted Owls.

Effects of Human Activities

Historic

Whereas historically flying squirrels probably inhabited most of the Lake Tahoe Basin that consisted of conifer habitat, except very young stands (Hayes et al., unpublished data), extensive clear cutting in the late 19th to early 20th centuries may have severely reduced the availability of suitable habitat. The overall effect of this activity may have been to isolate populations wherever forest cover remained, including upper elevation stands that were relatively inaccessible and in narrow buffer zones along riparian habitats. This isolation may have been due to the following: direct mortality, removal of nesting cavities (snags) (Bull et al. 1997), removal of understory cover (Pyare b, in review, Carey 1995), creation of extensive forest canopy gaps that flying squirrels may not have been able to disperse across (Mowrey and Zasada 1984), and decreases in the abundance and species richness of ectomycorrhizal fungi, which are associated with both the roots of live trees and coarse woody debris on the forest floor (Pyare, in prep, Amaranthus et al. 1994, Waters et al. 1997). Fruiting bodies of ectomycorrhizal fungi are the primary food items of flying squirrels in California (Pyare a, in review, Hall 1991, and Zabel and Waters 1997). Clarkson and Mills (1994) found that the abundance of hypogeous fungi was 20-40 times lower in clearcuts than in old growth habitats in Oregon.

Current

Although clear cutting is no longer practiced in the Lake Tahoe Basin, flying squirrel populations may continue to be affected by several types of human activities. Severe to moderate thinning practices (shelterwood or seed-tree harvest regimes) may have negative consequences for the densities of flying squirrels (Waters and Zabel 1995, Witt 1992, Carey et al. 1992, Taulman et al. 1998, Rosenberg and Anthony 1992). For instance, in the Lake Tahoe Basin (1997-1998), Pyare (unpublished data) found little evidence of nest box use by flying squirrels in three stands that appeared to be thinned ca. 40 to 50 yrs ago despite the fact that these stands exhibited some features typically associated with old-growth habitat (large diameter trees, logs, and snags) and were located near (< 1 km) three old-growth stands in which flying squirrels were active. In general, moderate and severe thinning practices may affect population densities by reducing nest site availability (Taulman et al. 1998), increasing forest cover fragmentation (Mowrey and Zasada 1984), removing large diameter, coarse woody debris (Amaranthus et al. 1994), and reducing abundance of hypogeous sporocarps (Colgan 1997, Waters and Zabel 1995).

Development activity that fragments forest cover through creation of clearings, particularly in upper elevations of the basin, may adversely affect flying squirrels. Although flying squirrels may occasionally be active at the periphery of forest/matrix interface, they appear to be restricted to forested habitats. On the other hand, moratoriums on development (50-100 yrs) are most likely to have positive effects on the recovery of extensive tracts of second-growth forest habitat. Recovery of mycorrhizal fungal diversity, replenishment of coarse woody debris on the forest floor, and the creation of forested corridors between adjacent stands may all be positive developments for the re-establishment of suitable flying squirrel habitat.

Broadcast burning may indirectly affect flying squirrels by reducing ectomycorrhizal activity (Harvey 1980a,b) and/or altering composition of the fungal community (Waters et al. 1994). Light levels of prescribed burning practices that do not reduce the availability of nesting habitat in the overstory (i.e., snags, dray nests) and that occur in stand types in which flying squirrels are most likely to occur (i.e., old growth remnants) are least likely to affect flying squirrel populations in the Lake Tahoe Basin. No studies have focused on the effects of broadcast burning on flying squirrel populations. Rosenberg and Anthony (1991) found above-average density of flying squirrels in one second-growth stand following natural regeneration after a wildfire (30 to 60 yr after initial burn) when compared to old-growth stands. Additionally, Waters and Zabel (1995) found a mean density of flying squirrels of 2.28/ha in four stands that had regenerated for 75 to 95 yr after an initial stand-replacing wildfire, compared to a mean density of 3.29/ha in four old-growth stands. Thus, despite any proximate effects of fire (e.g. dispersal, interruption of breeding), it appears that flying squirrel populations are capable of recovering in the long term even after severe prescribed burns. Several factors may be important in this recovery process, including initial animal densities, stand age, timing of burn relative to breeding, and perhaps most importantly, the composition of stands surrounding the burn area. In the Lake Tahoe Basin, habitat types in which flying squirrels are most likely to occur, such as remnant old-growth stands, may be isolated in a matrix of disturbed, second-growth habitat. These surrounding habitats may be incapable of providing source populations for recovery following burns in primary habitat areas. Finally, an indirect factor that may influence flying squirrel populations may be the status of ectomycorrhizal fungal populations after a burn. Harvey et al. (1978a, b) found negative short-term effects (three years after broadcast burning) on the number of ectomycorrhizal root tips, while Waters et al. (1994) found differences in fungal diversity following a nine-year recovery period after a prescribed fire. Recovery of ectomycorrhizal fungal populations that give rise to hypogeous fruiting bodies may be a precursor to flying squirrel persistence and recovery in burned stands, although rates of recovery for populations of hypogeous fungi are poorly understood.

Conservation

There are no current management objectives for flying squirrels in the Tahoe basin (USDA 1996). General management guidelines, however, should include the following:

- Limitation of extensive gaps in forest cover (Verner et al. 1992, Mowrey and Zasada 1984)
- Retention of snags (Verner et al. 1992)
- Maintenance of understory cover (Pyare b, in review)
- Maintenance of ectomycorrhizal activity and hypogeous fungal diversity (Pyare a, in review)
- Maintenance of large diameter, coarse woody debris (Amaranthus et al. 1994, Waters et al.
- 1997, Pyare, unpublished data)
- Maintenance of substrates (i.e. large, live trees) for growth of aboreal macrolichens (Rosentreter et al. 1997)

Currently, there are no conservation guidelines for the northern flying squirrel in either the Tahoe basin or the Sierra Nevada, largely because the species' status is unknown (SNEP 1996), and ecological baseline information of Sierra Nevada populations is based on few studies (McKeever 1960, Hall 1991, Waters and Zabel 1995, Pyare a, b in review). The species has received more attention in the Pacific Northwest because of concerns about Spotted Owls, which prey extensively upon flying squirrels. Verner et al. (1992) suggest that California Spotted Owls prey heavily on flying squirrels, especially at higher elevation forests (>4000-5000 ft), and the authors specifically recommend management strategies which maintain populations of flying squirrels in Sierra Nevada conifer forests. Underlying mechanisms of flying squirrel abundance in the Sierras, however, have yet to be elucidated.

Aside from the importance of the flying squirrel as a major prey item to predators such as Spotted Owls and martens, conservation of the flying squirrel may have important consequences for the long-term growth, productivity, and resilience of conifer forests. Flying squirrels disperse spores of ectomycorrhizal fungi, which form obligatory symbioses with conifers and hardwoods (Colgan 1997, Pyare, unpublished data). The loss of flying squirrel populations may represent the loss of an integral ecosystem process, which in turn may reduce the ability of conifers to colonize adjacent areas, the ability of forests to regenerate and recover following disturbances, ectomycorrhizal diversity, and perhaps the physiological functioning of conifers and hardwoods.

Envirogram of the Northern Flying Squirrel

The envirogram of the northern flying squirrel (Figure O-3) depicts important habitat elements, food resources, interspecific interactions, and reproductive requirements of the species.

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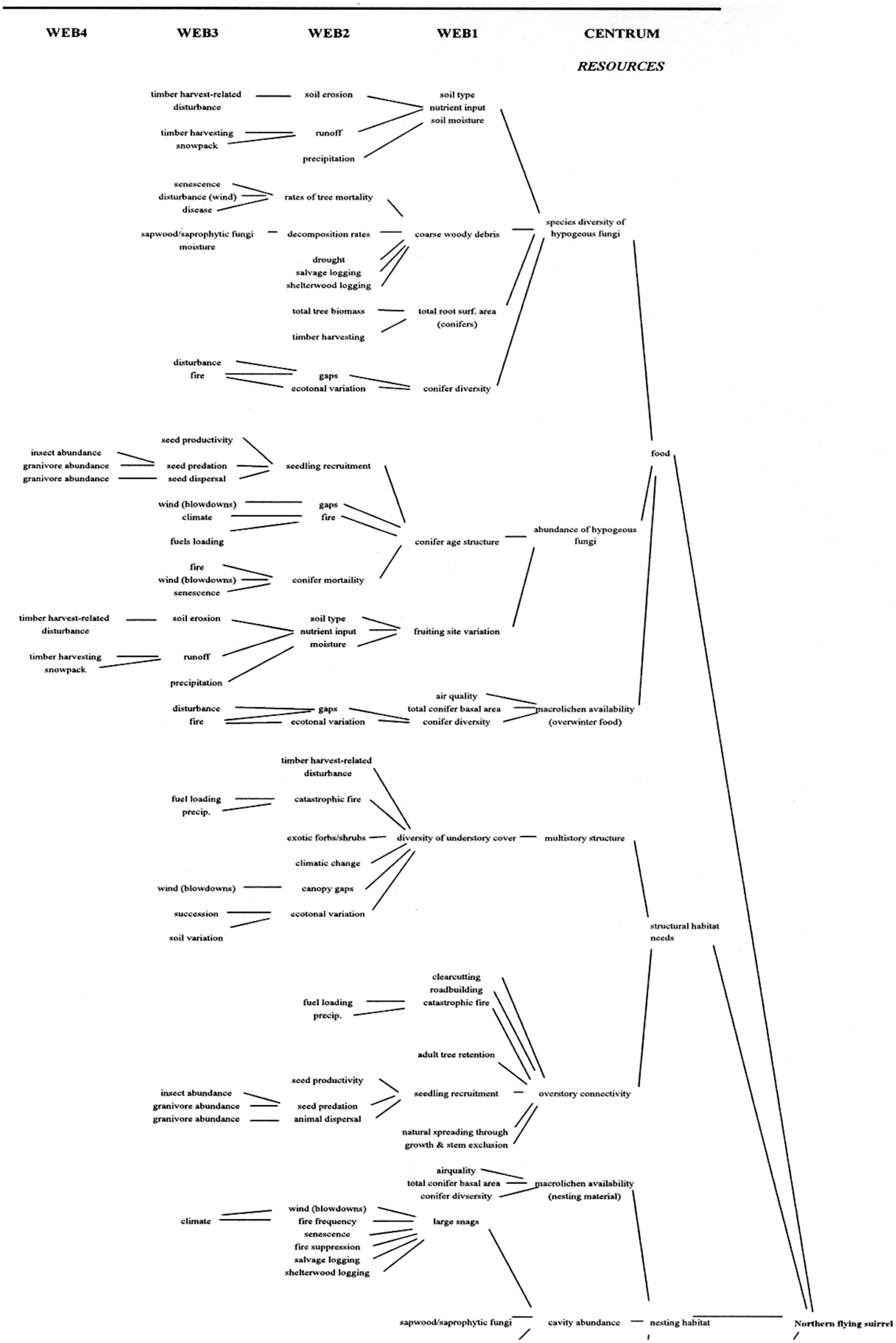

Figure O-3—Envirogram for the northern flying squirrel (*Glaucomys sabrinus*) (page 1 of 2).

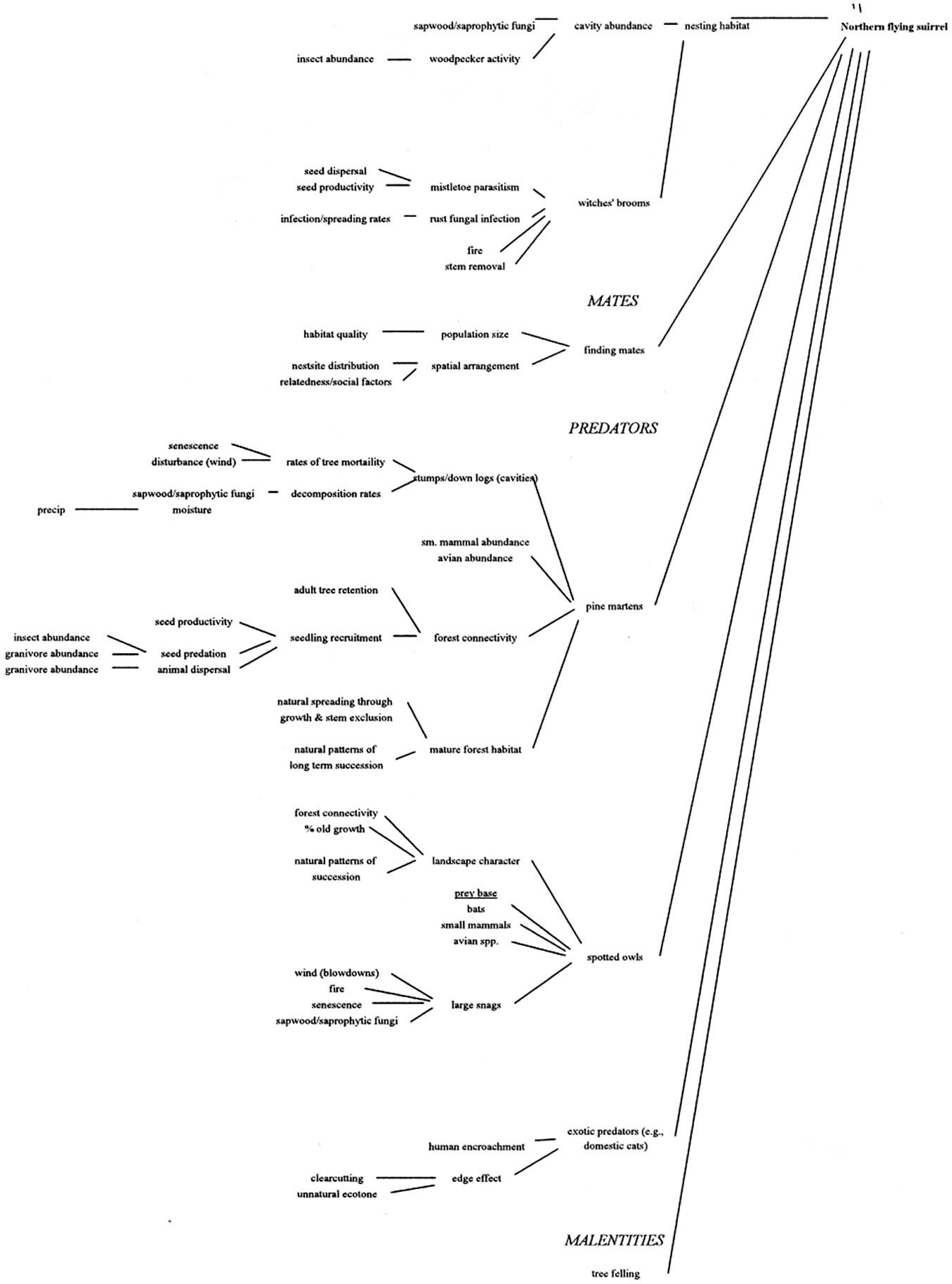

Figure O-3—Envirogram for the northern flying squirrel (*Glaucomys sabrinus*) (page 2 of 2).

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PALLID BAT (*Antrozous pallidus*)

Matthew Rahn and Jennifer S. Hodge

Distribution

The pallid bat is distributed throughout western North America, from Mexico to Canada (Burt and Grossenheider 1980). It is common at low elevations in arid or semi-arid regions of California, but absent or rare in the high Sierra from Shasta to Kern counties, and absent from the northwestern corner of the state (Harris 1990) In Nevada, it has been found in the southern and western regions and as far north as Fallon (Hall 1995). In the Lake Tahoe basin, few surveys for bats have been conducted, but the pallid bat was recently detected by Tatum (1998b) at Cave Rock and possibly by Pierson (1998) at Heavenly Valley. The bats were detected acoustically; no individuals have been captured in the basin. Because it is not commonly found in montane areas, the pallid bat should be considered a unique and valuable asset to the Lake Tahoe area.

Ecology

Life History

Pallid bats occupy their habitats year-round, hibernating through each winter at sites near summer day roosts (Harris 1990). Their nocturnal activity patterns are characterized by peaks shortly after sunset and before dawn (Harris 1990). Roosts are usually occupied by groups of 20-160 individuals (Harris 1990). This social behavior enhances metabolic efficiency and promotes the growth of the young animals (Harris 1990). An additional physiological adaptation of pallid bats is their ability to conserve water by concentrating urine; individuals can go for long periods of time without drinking water as they gain all they need from their prey. The longest recorded lifespan to date is 9 years 1 month (Harris 1990).

Foraging

Like most bats, pallid bats forage nocturnally and find prey using echolocation. The pallid bat is the only species of bat in the Lake Tahoe area that can catch ground dwelling arthropods; it maneuvers easily both on and above the ground as well as in foliage (Hermanson and O'Shea 1983). Typical prey items include large flying and flightless insects, scorpions, centipedes, crickets, and occasionally small vertebrates (Bell 1982).

Home range and dispersal

This species forages 0.5 to 2.5 km (0.3 to 1.5 miles) from day roosts (Harris 1990). Dispersal occurs after the breeding season. Short trips are made to hibernation sites late in the fall (Harris 1990).

Reproduction

As in most bats of the temperate regions, pallid bat males and females segregate during the summer and breed during the fall. Females have young in the spring, fertilizing themselves early in the season with sperm stored from the previous fall. Gestation lasts for about nine weeks, and the females typically have twins (litter size ranges from 1-3) (Harris 1990). Males may or may not roost with the nursery colony. After 7 weeks, altricial young are weaned and begin to fly (Harris 1990).

Interactions with Other Species

Pallid bats often roost with other species of bats, primarily *Myotis* spp. and Brazilian free-tailed bats (*Tadarida brasiliensis*), and are preyed upon by owls and snakes (Harris 1990).

Habitat Relationships

The pallid bat's habitat requirements are relatively general; it is typically found in Mojave or Great Basin shrub-lands, shrub-steppe ecosystems, piñyon-juniper woodlands and, rarely, in montane forests (Hermanson and O'Shea 1983). It usually roosts in caves, crevices, rocky outcrops, and abandoned mines, but can also roost in buildings, bridges, and trees (Hermanson and O'Shea 1983, Zeiner et al 1990). Little information is available on the habitat use of forest dwelling bats. However, those bats that do use trees are typically found in snags and under exfoliating bark (Vonhof and Barclay 1996, Brigham et al. 1997, Rabe et al. 1998, Thomas 1998) and often depend on old growth stands for roosting habitat.

Effects of Human Activities

Any management activity that reduces the availability of roosting habitat or fragments the forest will have detrimental impacts on bats. Thinning practices may remove current and potential roosting sites, as well as disturb roosting individuals. Prescribed burning may also affect roosting individuals or decrease the availability of their insect prey. Burning in the fall is unlikely to affect pallid bats, as they likely migrate out of the area or return to hibernation roosts before the fall. A short fire return interval may not provide sufficient time for important components of the habitat (snags, exfoliating bark) to recover after each fire. Catastrophic wildfire, especially in summer, is likely to be most detrimental to bats, likely causing high mortality of forest roosting bats and declines in insect populations. Such a wildfire would also destroy important habitat elements, such as snags and exfoliating bark.

Conservation

The pallid bat is listed as a species of special concern in California and as sensitive by the USDA Forest Service (USDA 1998b).

Conservation of this species should be mainly concerned with roost sites, especially those at which females rear their young. Since this bat can roost in caves, mines, and live or dead trees, protection is difficult. Identification of roost sites should be the primary task. Surveys of caves and mines can identify habitat used for both summer activity and hibernacula. Identification of the trees and boulders used by bats is more difficult. After they have been captured at water sources, caves, or mines, they can be equipped with radio telemetry units and tracked to trees and boulders. Once roost sites are identified, they can be protected by putting up signs, gates, or preventing forest thinning or firewood removal.

Current management activities should take into consideration any potential impact on bats. Forest management practices should be designed to limit the impact on roosting bats during peak activity periods and especially during the maternity season (June-August). It is very important to determine what species of bats are using the area, and estimate their relative abundance. This includes surveys not only of forested areas, but of caves and abandoned mines as well. Bat populations have been declining throughout the west due to disturbance or loss of roost sites (Kuntz and Pierson 1994). Bats are an important component of forest ecosystems and their protection and conservation should be given high priority.

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Amphibians

LONG-TOED SALAMANDER (*Ambystoma macrodactylum*)

Matthew D. Schlesinger

Distribution

The long-toed salamander is distributed throughout the northwestern United States, from southern Alaska through central California (Stebbins 1985). The subspecies *A. m. sigillatum* occurs in the Sierra Nevada, but only as far south as Tuolumne County. Populations in the Lake Tahoe basin are therefore near the southern edge of the long-toed salamander's range. The species has a broad elevational tolerance, from sea level to 2800 m (Basey and Morey 1988), and life histories and habitat requirements vary between low- and high-elevation populations (Anderson 1967, Basey and Sinclear 1980).

The long-toed salamander is only beginning to receive attention in the Lake Tahoe basin; aquatic surveys by Manley and Schlesinger (in prep), the California Department of Fish and Game (Lehr pers. comm.), and Leyse (pers. comm.) have documented the salamander at several temporary ponds, wet meadows, and small lakes, primarily those without trout, on the west side of the basin. Leyse (pers. comm.) detected salamanders at "most of the unnamed lakes that [she] surveyed" in the basin in 1999, suggesting that the species is "much more widespread in the fishless waters of Desolation [Wilderness] than we've known."

Long-toed salamanders appear not to have been detected in Nevada before 1998; Banta (1965) does not include the long-toed salamander in his checklist of Nevada's amphibians, nor do distribution maps in Stebbins (1985) and Behler and

King (1979) appear to include Nevada. The detection of two larvae at Edgewood Golf Course in 1998 (Manley and Schlesinger in prep) might therefore represent the only known occurrence of long-toed salamanders in Nevada.

Because most detections of long-toed salamanders in the basin have been of only a few larvae (Manley and Schlesinger in prep, K. Leyse pers. comm.), salamanders might occur in small numbers frequently, hindering their detection. Thus, the species might occur at more sites in the basin than surveys would suggest.

Ecology

Few studies have examined long-toed salamander population biology or life-history. Kezer and Farner (1955) noted 3 life-history patterns among long-toed salamanders at different altitudes: a single season larval period, a two-season larval period in permanent waters, and a facultative single-season larval period in temporary ponds. Therefore, it is possible to observe multiple age classes of larvae at a single site (Anderson 1967), especially at high elevations. The "cut-off" in terms of elevation is not known.

Long-toed salamanders at high elevations breed in the Sierra Nevada in late spring or early summer (Behler and King 1979, Stebbins 1985, Basey and Morey 1988). Females attach eggs singly or in small, loose clusters to vegetation (Behler and King 1979) or to the undersides of submerged or floating logs (Basey and Morey 1988). Diets of adult long-toed salamanders are restricted to invertebrates, while larvae may also consume tadpoles (Basey and Morey 1988).

Breeding migrations are extensive, with individuals traveling up to 1,000 m (3,300 ft) to reach breeding sites (Basey and Morey 1988). Adults in Idaho were shown to move mostly at night, with some individuals traveling over 100 m (330 ft) on a single evening, even in snowy conditions (Howard and Wallace 1985). Apart from breeding migrations, home ranges appear small. Long-toed salamanders have been reported not to defend territories (Basey and Morey 1988), although the spacing of large larvae in breeding ponds suggests otherwise (Leyse 1999).

Interactions of long-toed salamanders with other species have not been well-studied. Larvae appear to be the most susceptible to predation, usually by aquatic invertebrates, garter snakes, fish, and possibly other vertebrates (Tyler et al. 1998, Basey and Morey 1988). Trout are known to have decimated populations of other ambystomatid salamanders (Shaffer 1999). Adults have noxious skin secretions that may provide some predator protection (Anderson 1963, cited in Basey and Morey 1988), although effects of skin secretions have not been well studied (Shaffer 1999).

Habitat Relationships

Throughout their range, long-toed salamanders breed chiefly in temporary ponds, but also in permanent lakes (Basey and Morey 1988), and wet meadows (Manley and Schlesinger in prep). Breeding sites may be located within a variety of terrestrial habitat types, including sagebrush, conifer forest, alpine meadow, and barren, rocky habitats (Behler and King 1979, Stebbins 1985). Verner and Boss (1980) report that long-toed salamanders require permanent bodies of water at 2,265 m (7,400 ft), but that temporary ponds are sufficient at 1,830 m (6,000 ft). In the basin, salamanders probably breed successfully in temporary ponds at the lowest elevations only and breed in permanent waters at higher elevations due to the improbability of larvae metamorphosing in the short time that temporary ponds contain water. Salamander eggs and larvae have been detected at several temporary ponds in the basin, including some over 2,424 m (8,000 ft) (Manley and Schlesinger in prep), but whether the larvae at those sites survived to metamorphosis is unknown. Anderson (1960) noted that in many temporary ponds, salamander larvae do not survive to metamorphosis. More research is needed on the interaction between the retention of water in breeding sites and larval survivorship along an elevational gradient.

Salamanders in the basin appear to breed only in fishless waters (Manley and Schlesinger in preparation, Leyse 1999). Given that most permanent lakes in the basin contain fish, and that salamanders may not be able to breed successfully in temporary ponds at high elevations, it is possible that salamanders are not able to breed successfully at high elevations in the basin.

Adult animals spend most of the year underground, usually in animal burrows, but also in rock crevices and human structures (Basey and Morey 1988). During the breeding season, adults use rocks and downed logs for cover near breeding sites (Basey and Morey 1988). In the basin, recent metamorphs have been found under downed logs near breeding ponds (Leyse 1999).

Effects of Human Activities

Introduced trout are known to prey upon long-toed salamander larvae as well as alter their behavior and habitat use (Tyler et al. 1998). The introduction of nonnative fish into previously fishless waters has likely caused declines and perhaps eliminated the salamander from permanent waters in the basin and elsewhere (Shaffer 1999). Because salamanders are probably unable to breed in temporary ponds at high elevations, and cannot use permanent lakes because of the presence of fish, they are essentially restricted to ponds that retain water all year but that cannot support fish (Shaffer 1999). Drought could seriously reduce the amount of remaining breeding habitat. Whereas before the introduction of trout, large permanent waters may have provided a source of dispersing individuals when local populations (existing in a "metapopulation"-like arrangement) were extirpated because of drought, currently no source population may be available and "the critical link for long-term sustainability [may have] been lost" (Shaffer 1999).

Potential effects of introduced bullfrogs (*Rana catesbeiana*) have not been studied, although bullfrogs are predators of other native amphibians (Hayes and Jennings 1986) and may affect salamander distributions.

Effects of forest management practices are uncertain but possibly significant. Because long-toed salamanders, particularly recent metamorphs, often use large downed logs for cover, any management activity that reduces the number of downed logs might negatively affect salamanders. In the breeding season (May to July in the basin, depending on elevation), adult salamanders are likely to use downed logs near breeding sites especially. Prescribed or natural fires in riparian areas during the salamander breeding season might remove essential habitat elements for salamanders. During the late summer and fall, however, when adult salamanders are usually underground, fires are less likely to affect adults, but are more likely to affect young metamorphs. Potential effects of deposition of ash into breeding sites have not been studied.

Equally (or perhaps more) important is the indirect effect on salamanders of a reduction in burrowing mammals. Post-metamorphs spend most of the year underground, typically in the burrows of mice, gophers, squirrels, and other mammals. Any forest management activity that makes areas unsuitable for burrowing mammals by compacting or eroding soil will reduce habitat for salamanders (Shaffer 1999).

Conservation

The long-toed salamander is not currently listed by any federal or state agency (with the exception of the subspecies *A. m. croceum*, a federal and state Endangered species). The status of the salamander in the basin is unknown; recent surveys have detected salamanders at a greater number of sites than they were previously thought to occupy, but it is unclear whether populations can be maintained in the long term. Decisions on the effort to be put into salamander conservation would be informed by additional surveys and monitoring to determine the status of the salamander in the basin. Because of the negative impacts of exotic trout on salamanders and other biota (such as the mountain yellow-legged frog [*Rana muscosa*]), eradicating trout in some lakes could be considered as a strategy to restore habitat for the basin's declining amphibians.

Envirogram for the Long-toed Salamander

The envirogram of the long-toed salamander (Figure O-4) depicts important habitat elements, food resources, interspecific interactions, and reproductive requirements of the species.

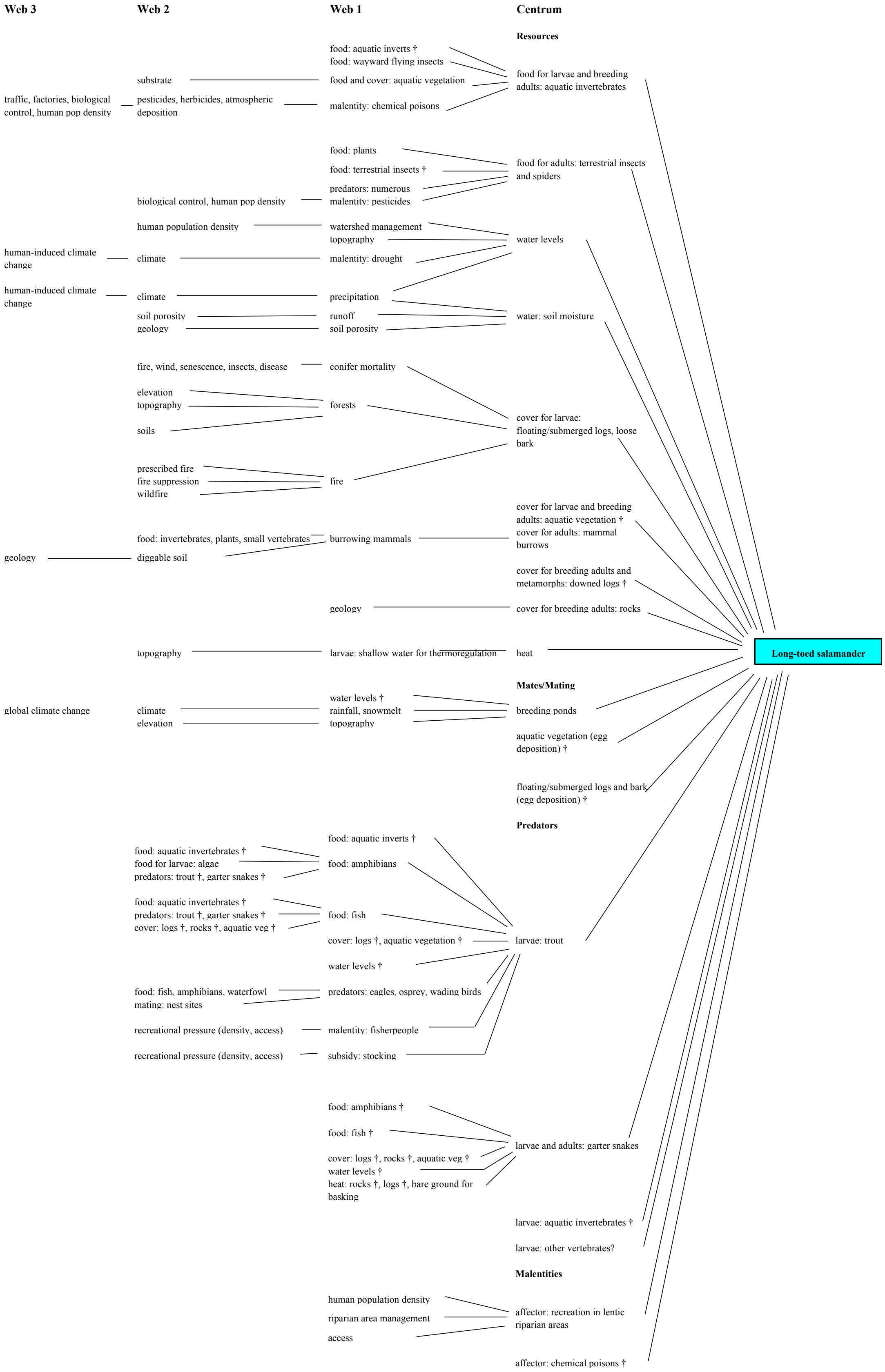

Figure O-4—Envirogram for the long-toed salamander (*Ambystoma macrodactylum*). A † indicates that that branch of the web was expanded above in the envirogram.

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MOUNTAIN YELLOW-LEGGED FROG (*Rana muscosa*)

Matthew D. Schlesinger

Distribution

The mountain yellow-legged frog occurs from southern Plumas County through southern Tulare County in the Sierra Nevada, from about 1370 m (4500 ft) to greater than 3650 m (12,000 ft), and also in the mountains of southwestern California (Jennings and Hayes 1994). Mountain yellow-legged frogs have probably disappeared from over 99% of their former range (Jennings and Hayes 1994). In the Lake Tahoe basin, which is near the northern edge of the species' range, historical sightings of mountain yellow-legged frogs include several lakes in Desolation Wilderness (Museum of Vertebrate Zoology, University of California, Berkeley) a site in the Mount Rose Wilderness (Zweifel 1955), and the mouth of Edgewood Creek (Jennings 1984). Scattered sightings in the basin exist over the last few decades, including at least one in Desolation Wilderness (Manley and Schlesinger in prep) and two in Nevada (K. Goodwin pers. comm.). Surveys of several historic sites have located no mountain yellow-legged frogs, but a moderately-sized breeding population was discovered in 1997 at Hell Hole, a bog in the Trout Creek drainage (Manley and Schlesinger in prep).

Ecology

The population biology of the mountain yellow-legged frog has not been studied extensively. Information on longevity, survivorship, or individual growth is not available. Futhermore, inferences about mountain yellow-legged frog population biology drawn from other *Rana* species are problematic due to the wide range of life histories in the genus; for example, yearly adult survivorship in other *Rana* species ranges from 2 to 69 percent (Duellman and Trueb 1986).

Available information on mountain yellow-legged frog life history includes the following. Eggs are laid in the spring (or early summer at the highest elevations) in clusters typically of 100-350 eggs (Zweifel 1955) but occasionally containing up to 500 eggs (Morey 1988). Time to hatching is unknown (Jennings and Hayes 1994). Tadpoles require 2-3 summers to metamorphose, overwintering under ice at high elevations (Zweifel 1955). The time required for juvenile frogs to reach sexual maturity is also unknown (Jennings and Hayes 1994).

Limited information is available on mountain yellow-legged frog feeding habits and predator relations. Tadpoles are known to eat algae and diatoms (Morey 1988), while juveniles and adults eat a variety of terrestrial and aquatic insects (Jennings and Hayes 1994, Morey 1988). Predators of mountain yellow-legged frogs include garter snakes (*Thamnophis* spp., Mullally and Cunningham 1956), trout (Hayes and Jennings 1986, Bradford 1989), coyotes (*Canis latrans*, Zweifel 1955), Clark's Nutcrackers (*Nucifraga columbiana*, Zweifel 1955), and Brewer's Blackbirds (*Euphagus cyanocephalus*, Bradford 1991).

Adults of this species hibernate under ice in frozen lakes and ponds (Zweifel 1955) and also in underwater rock crevices in which ice may form (Pope and Matthews 1999). Adults and tadpoles may remain in hibernation for as long as 9 mo (Bradford 1983). Many adults may die when oxygen levels are depleted, although tadpoles appear to be more tolerant of reduced oxygen (Bradford 1983). Individuals may not emerge from hibernation until June at high elevations, at which point breeding may begin.

Other aspects of mountain yellow-legged frog ecology, such as dispersal and home range, are not well-studied. Home ranges are thought to be quite small (Morey 1988), but recent studies of marked individuals have shown greater movements than previously recorded (Pope and Matthews 1999). Additional research is needed on mountain yellow-legged frog movement patterns, use of oviposition sites, and ability to recolonize previously inhabited areas (Jennings and Hayes 1994).

Habitat Relationships

Mountain yellow-legged frogs occur in lentic and lotic habitats at appropriate elevations, with the exception of very small streams (Mullally and Cunningham 1956). They rarely stray more than a few meters from water (Mullally and Cunningham 1956). The species prefers gently sloping shores with abundant pebbles and cobbles for basking and cover (Mullally and Cunningham 1956) and eggs are generally attached to rocks or vegetation in shallow water in lakes or streams (Zweifel 1955, Morey 1988) or under stream banks (Zweifel 1955). Because tadpoles overwinter at least once before metamorphosing (Zweifel 1955), they require waters that do not freeze solid; hence, ponds and streams without areas deeper than 1.5 m (5 ft) are rarely occupied (G. Fellers pers. comm.).

Effects of Human Activities

As for many amphibian species, a variety of human activities appear to have contributed to the decline of mountain yellow-legged frogs. Possible human-induced causes for the species' decline throughout the Sierra Nevada include habitat loss, introduction of non-native predatory fish, ultraviolet light exposure, and chemical pollutants, including pesticides and acid rain (Drost and Fellers 1996, Hayes and Jennings 1986).

Outright habitat loss is probably not a major concern for mountain yellow-legged frogs in the Lake Tahoe basin, as potentially suitable habitat for this species occurs primarily in Desolation Wilderness and other high-elevation areas experiencing little direct alteration of aquatic habitats. However, the introduction of non-native predatory fish into formerly fishless lakes has probably contributed to mountain yellow-legged frog declines in the basin, as it appears to have elsewhere (Drost and Fellers 1996, Bradford 1989, Bradford et al. 1993, Hayes and Jennings 1986). Viable mountain yellow-legged frog populations and large populations of exotic trout appear not to coexist in the Sierra Nevada (Bradford 1989, S. Lehr pers. comm., K. Matthews pers. comm). Mountain yellow-legged frogs are particularly susceptible to trout predation because they remain as tadpoles for at least a year (Zweifel 1955). Trout have been introduced into a majority of the basin's lakes, potentially further isolating any remaining populations of frogs by preventing successful dispersal of adults and tadpoles (Bradford et al. 1993).

Interactions between mountain yellow-legged frogs and introduced bullfrogs (*R. catesbeiana*) have not been studied, but bullfrogs have negatively affected other native ranid frogs (Moyle 1973, Fisher and Shaffer 1996, Kiesecker and Blaustein 1998, Hayes and Jennings 1986) through predation. Populations of bullfrogs exist in the basin above their previously recorded elevational limit (Manley and Schlesinger in prep), although bullfrogs and mountain yellow-legged frogs currently overlap little in elevation. If bullfrogs continue to move up in elevation and colonize existing mountain yellow-legged frog sites, mountain yellow-legged frog populations in the basin might be further threatened.

Little is known about the effects of cattle grazing on mountain yellow-legged frog populations, but grazing might adversely affect other amphibian species (Jennings and Hayes 1994), presumably through trampling and the removal of vegetative cover. Because the basin's one known breeding population exists in a grazing allotment, the Forest Service is considering ways to minimize the effects of cattle on frogs at that site (J. Reiner pers. comm.).

No information is available on the effects of fire on mountain yellow-legged frogs, or on most amphibians (Friend 1993). However, prescribed burning is not likely to affect mountain yellow-legged frogs directly, as all life stages are aquatic. Potential indirect effects of burning include ash deposition in lentic aquatic ecosystems and increased sediment load in streams. Effects of these processes on amphibians are unknown.

Conservation

The mountain yellow-legged frog is a federal species of special concern, as well as a California state species of special concern (Jennings and Hayes 1994). The frog was recently designated a USDA Forest Service sensitive species (USDA 1998), a status that obligates the Forest Service to consider impacts of management activities to mountain yellow-legged frogs in environmental documents.

Mountain yellow-legged frogs appear to be critically imperiled in the Lake Tahoe basin, with only a single known population (Manley and Schlesinger in prep). Surveys for additional locations are needed. Further, the maintenance of a single population is not likely to allow the species to persist in the basin; small, isolated populations of mountain yellow-legged frogs are subject to extirpation due to stochastic environmental and demographic events (Bradford et al. 1993) as well as inbreeding. Therefore, networks of sites allowing movement of frogs among sites may be necessary for the species to persist. Additional sites would need to be colonized, possibly by reintroduction.

Reintroduction of mountain yellow-legged frogs would need to be carefully considered, as it has been attempted unsuccessfully in other parts of the Sierra Nevada (G. Fellers pers. comm.). The appropriate considerations in site-selection for mountain yellow-legged frog reintroductions have not been elucidated, but most likely would include suitable habitat, historical frog presence, current presence of exotic trout and bullfrogs (or the possibility of eradication), connection to streams or lakes with trout or bullfrogs, recreation pressure, and grazing intensity. The prevalence of exotic trout in Desolation Wilderness and the ease of movement for trout up and down most streams would probably necessitate that entire drainages be devoted to frogs, with fish populations eradicated. Clearly, such a procedure would be complex politically and possibly expensive, but very likely necessary for the persistence of mountain yellow-legged frogs in the basin.

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Reptiles

WESTERN AQUATIC GARTER SNAKE (*Thamnophis couchii*)*

Matthew D. Schlesinger

Distribution

The western aquatic (or "Sierra") garter snake is restricted to eastern and central California and western Nevada (Rossman et al. 1996). Authors who have reported a much larger range for the species (e.g., Behler and King 1979, Stebbins 1985, Morey 1988a) included distributional information for species formerly recognized as subspecies of *T. couchii* (see note below). The western aquatic garter snake inhabits a wide elevational range, from 91 m (300 ft) to 2450 m (8000 ft) (Rossman et al. 1996, Behler and King 1979). The species does not appear to be especially common in the Lake Tahoe basin, occurring at 4 (4.5 %) of 88 lentic and 4 (5.0 %) of 80 lotic sites surveyed by Manley and Schlesinger (in prep), with a few observations in Keane and Morrison (1994). All sightings to date have been on the west and south sides of the basin, primarily at sites with low human disturbance (Manley and Schlesinger in prep).

Ecology

No studies specific to western aquatic garter snake population biology have been performed; in fact, little is known about the population biology of most snakes (Seigel 1996). Garter snake densities range in the literature from 1.7 to 845 individuals/ha (summarized by Seigel 1996). Survival estimates from the few existing long-term studies are similarly wide-ranging (summarized by Seigel 1996), and few such studies, necessary for improved conclusions about garter snake survivorship, have been published.

Diets of western aquatic garter snakes have also not been well-studied, but include amphibian larvae and recent metamorphs, as well as fish such as salmonids and cyprinids (Rossman et al. 1996). Whereas other garter snake species in the basin have been shown to feed on invertebrates in other parts of their ranges (Rossman et al. 1996), western aquatic garter snakes appear to depend exclusively on small vertebrates. All lentic sites in which Manley and Schlesinger (in prep) located western aquatic garter snakes also contained fish or amphibians, supporting this idea. Western aquatic garter snake populations are thus likely to be tied to fish and amphibian abundances. Many species of garter snake display geographic, temporal, ontogenetic, and sexual variation in diet, but no relevant studies have been performed on *T. couchii* (Seigel 1996).

Mammals such as raccoons (*Procyon lotor*), foxes (Canidae), and minks (*Mustela vison*), birds such as hawks (Accipitridae), and other snakes are the primary predators of garter snakes (Seigel 1996, Morey 1988a), but no studies have documented specific predators of *T. couchii*. Additionally, introduced bullfrogs (*Rana catesbeiana*) have been implicated as predators of garter snakes in Arizona (Rosen and Schwalbe 1988, cited in Seigel 1996). In the Lake Tahoe basin, the most common predators are most likely raccoons, hawks, and perhaps bullfrogs, due to the apparent low densities of other potential predators. Both bullfrogs and exotic trout might also serve as prey for snakes in earlier life stages while being potential predators as adults.

Western aquatic garter snake reproductive ecology is not well documented. However, the following information is available in the literature. Mating occurs in the spring (Morey 1988a); however, some species of garter snake breed in both spring and fall (Seigel 1996). Western aquatic garter snakes are live-bearing and produce 7 to 25 young (Stebbins

1985) or 4 to 30 young (Morey 1988a), depending on food availability, female size, and female foraging ability (Seigel 1996). The young are born in late summer or early fall and soon hibernate for the winter. Offspring grow rapidly until sexual maturity, at which point growth slows (Seigel 1996). Sexual maturity is attained for most garter snake species at 1 to 4 years, with males generally maturing sooner than females (Seigel 1996).

Garter snakes' migration toward hibernacula begins when diurnal temperatures fall to the point at which digestion is inhibited (Ford 1996). Snakes choose den sites that prevent dehydration and freezing, and may return to the same den sites year after year (Ford 1996). Warming temperatures in the spring instigate the movement of snakes out of dens toward summer breeding and foraging grounds (Ford 1996). The western aquatic garter snake does not appear to be territorial at summer grounds (Morey 1988a) and no information on the snake's home range is available.

Habitat Relationships

Western aquatic garter snakes appear to depend on aquatic habitats more than the other garter snakes in the Sierra Nevada (*T. elegans* and *T. sirtalis*) (Morey 1988a). They occupy a wide variety of lentic and lotic types, including mountain creeks and rivers, wet meadows, and small lakes and reservoirs (Rossman et al. 1996), as well as large alpine lakes (Manley and Schlesinger in prep). Western aquatic garter snakes can apparently occupy any aquatic habitat with a sufficient prey base.

Many of the specific habitat components required by western aquatic garter snakes relate to the snakes' thermoregulation needs. Western aquatic garter snakes bask on rocks and vegetated stream banks to increase their body temperature and they retreat from excessive heat in mammal burrows, crevices between rocks, and rotting logs (Morey 1988a).

Effects of Human Activities

Manley and Schlesinger's (in prep) finding of western aquatic garter snakes only at less disturbed sites in the basin suggests that the species might be sensitive to some human activities. Road construction and the introduction of exotic species have been suggested to adversely affect garter snakes; furthermore, both recreation and grazing have the potential to affect garter snakes. Finally, the decline of amphibians in the basin has perhaps caused declines in garter snakes as well.

Habitat destruction is apparently the cause of declines in several garter snake populations in California and elsewhere (Seigel 1996). The destruction of aquatic habitat in the Lake Tahoe Basin (see Chapter 5, Issue 5) might have caused declines in western aquatic garter snake populations. However, the construction of roads has likely been a greater influence on the basin's western aquatic garter snake population. The basin's abundant roads are barriers to garter snake dispersal and migration, and garter snakes are often killed by automobiles (Seigel 1996).

Seigel (1996) reported that introduced trout have possibly caused declines of western aquatic garter snakes in California, but whether declines have been caused by predation or indirectly through competition for food was not specified. Trout have not been reported to prey upon garter snakes, but they are known to eat amphibians and small fish, potentially reducing the prey base for garter snakes. Introduced bullfrogs also could have either effect, as they prey on snakes themselves and also on the prey of garter snakes (Morey 1988b).

Effects of recreation and grazing in riparian areas on garter snakes have not been documented. However, they potentially range from trampling of individuals by bicyclists and cattle to destruction of riparian vegetation important for cover. Mechanical vegetation treatments are unlikely to affect garter snakes, except through excess sediment load to streams, lakes, ponds and meadows. Prescribed burning is also unlikely to affect garter snakes significantly in the short term, as several studies have showed minimal effects of burning on reptiles and amphibians, especially aquatic species (e.g., Ford et al. 1999). Burning might have beneficial effects on other reptile species in the long term through changes in microhabitats (Mushinsky 1985, Friend 1993), but no data are available for western aquatic garter snakes in the Sierra Nevada.

Finally, the decline of amphibians in the basin, the Sierra Nevada, and globally (Barinaga 1990, Blaustein and Wake 1990) has likely had negative effects on western aquatic garter snakes, for whom amphibians are important prey items. Alternatively, increased abundance of trout brought about through stocking might actually have replenished garter snakes' prey base, allowing populations to persist despite amphibian declines. Any management actions causing additional declines in amphibians are likely to affect garter snakes negatively as well. Such actions include the introduction of non-native trout species, habitat destruction, and chemical poisons (Hayes and Jennings 1986, Drost and Fellers 1996). Eradication of nonnative trout should be accompanied by reintroductions of amphibians so as to minimize the effects on garter snakes' prey base.

Conservation

The western aquatic garter snake is not listed by any federal or state agency, and no management plans for the species exist in the Lake Tahoe basin. The species is not known to have experienced population declines, but garter snake populations might have declined in the basin due to a reduction in their prey base, and garter snakes appear to be sensitive to a variety of human activities. Adverse impacts to western aquatic garter snakes could be prevented through consideration in management activities in and around aquatic habitats.

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* NOTE: *Thamnophis couchii* was split in 1987 into 4 distinct species: *T. atratus*, *T. couchii*, *T. gigas*, and *T. hammondii* (Rossman and Stewart 1987, cited in Rossman et al. 1996). Therefore, some information on *T. couchii* obtained from publications before 1987 may apply primarily to other species of aquatic garter snakes.

Fish

LAHONTAN CUTTHROAT TROUT
(*Oncorhynchus clarki henshawi*)

Jennifer S. Hodge

Distribution

Historically, the distribution of the Lahontan cutthrout trout encompassed the entire extent of Pleistocene Lake Lahontan (13, 000 km-2) in northwestern Nevada and northeastern California (Gerstung 1988). After this lake shrank from its maximum size (attained 25,000 years ago) to its current fragmented state around 5000-9000 years ago, the distribution of its endemic trout was reduced to approximately 6100 km of stream habitat and 11 lakes whose combined surface area totaled 135,000 hectares (Gerstung 1988). Of these lakes, Pyramid and Walker are remnants of Lake Lahontan, and the Truckee, Carson, Walker and Humboldt river basins represent the remainder of the Lahontan basin's stream systems. Over the past century, however, populations of the Lahontan cutthroat trout have been disappearing or declining in all of these areas, and currently there are pure, self-sustaining populations of the species in only 0.4% of its historic lake habitat and 7% of its historic stream habitat: Summit Lake, Independence Lake, the headwater streams of the Humboldt River drainage, and some tributaries of the Truckee, Carson and Walker Rivers (Gerstung 1988).

In the 19th and early 20th centuries, Lake Tahoe supported one of the largest cutthroat trout populations in the Truckee River basin. Like commerical fisheries at Pyramid and Winnemucca lakes, the one at Tahoe thrived for several decades; contemporary accounts indicate that the annual harvest from the lake at the turn of the century sometimes reached 33, 000 kg, and that sport fishermen often caught 50-100 trout per day (Scott 1957, Gerstung 1988). As thousands of cutthroat trout migrated up the Truckee River to spawn in tributaries of Lake Tahoe each spring, permanent traps were built on these streams to capture the runs, as well as to obtain millions of eggs for the California Fish and Game Commission's stocking operations between 1882 and 1938. This program returned some trout to Lake Tahoe but transferred most of the hatchlings outside the basin (Gerstung 1988). The combined effect of these activities, coupled with increases in pollution and habitat degradation resulting from logging and stream diversion, caused a precipitous decline in the species' populations in the lake itself and in the larger Truckee River system. Despite a ban on commercial fishing at Lake Tahoe in 1917, the population never recovered and the last spawning runs in tributaries occurred in 1938 (Cordone and Frantz 1966). Both before and during the species' decline, competition with increasingly well-established populations of introduced trout (e.g., rainbow [*Oncorhynchus mykiss*], brook [*Salvelinus fontinalis*], brown [*Salmo trutta*], and lake [*Salvelinus namaycush*] trout) may have significantly affected the cutthroat trout's persistence (Gerstung 1988). Although the California Dept. of Fish and Game planted almost 1 million hatchling and yearling cutthroat trout in Lake Tahoe from 1956 to 1962, this attempt and all subsequent reintroductions to Lake Tahoe have failed, perhaps suggesting long-term displacement of the Lahontan cutthroat trout by nonnative species (Gerstung 1988, Cordone and Frantz 1968).

In 1990, the USDA Forest Service introduced several hundred Lahontan cutthroat trout to southern reaches of the Upper Truckee River; the population is currently estimated at 3,000 individuals and appears to be self-sustaining (Reiner, pers. comm.).

Ecology

Life History

Both fluvial and lacustrine populations of Lahontan cutthroat trout are obligatory stream spawners, migrating to spawning sites when minimum stream temperatures reach 5 degrees Celsius (Gerstung 1988). During the incubation period (April- July) eggs are harmed by temperatures above 13.3 degrees Celsius or decreases in dissolved oxygen levels (USFWS 1979). Individuals typically attain maturity at 4 years of age (ranging from 3 to 5) in the wild; hatchery-reared fish may grow faster and mature earlier (Gerstung 1988). Growth rates are correlated with the fertility, temperature and size of the water body in which the fish live, with the fastest growth occurring in large, warm, fertile lakes, and the slowest growth occurring in streams (Gerstung 1988). Fluvial populations generally do not reach more than 5 years of age, but lake-dwelling fish may live up to 9 years (USFWS 1994).

Population Biology

Within the historic range of the Lahontan cutthroat trout, major river systems created a network within and among basins that supported a metapopulation of connected subpopulations among which migration and gene exchange could occur (USFWS 1994). The species persisted because if subpopulations became extinct in certain tributaries or mainstem rivers, these areas could be recolonized by fish dispersing from another area (Peacock 1998). The fragmentation and degradation of much of the species' habitat has effectively prohibited migrations and isolated these subpopulations (USFWS 1994). The few remaining populations are increasingly vulnerable to declines through stochastic processes (climatic change, natural disasters) and from the detrimental effects of inbreeding and genetic drift on their genetic diversity and potential resilience to future environmental change (USFWS 1994). Genetic divergence of isolated subpopulations makes reintroduction or supplementation efforts increasingly difficult.

Reproductive Behavior

Lahontan cutthroat trout spawn between April and July, depending on the temperature, elevation, and rate of flow of the streams to which they migrate (Calhoun 1942 in USFWS 1994). Individuals form pairs, perform their courtship rituals, lay eggs in the redds that females dig, and defend their nest from intruders (USFWS 1994). Spawning mortality rates of 60-70% for females and 85-90% for males have been recorded (Cowan 1982) and most survivors delay their next spawning for two or more years (USFWS 1994). Fecundity appears to be highly variable, and is correlated with length, weight and age such that lake-dwelling females may produce from 600-8000 eggs but females inhabiting small streams produce only 100-300 eggs (USFWS 1994, Coffin 1981). Eggs hatch after 4-6 weeks and fry emerge 13-23 days later (Johnson et al. 1983).

Foraging

Stream-dwelling populations usually feed opportunistically on drift organisms such as insects (Moyle 1976, Gerstung 1988) while the diets of lacustrine populations include zooplankton, benthic invertebrates and, in certain lakes, other species of fish (these are taken only by the largest individuals and only when the prey species has co-evolved with the cutthroat) (Gerstung 1988, USFWS 1994).

Dispersal Behavior

Dispersal patterns of Lahontan cutthroat trout fry appear to vary with location, but may be generally correlated with fry density and the timing of fall and winter freshets (Johnson et al. 1983). Behavior of lacustrine and fluvial populations often differs: some fluvial populations of young fish spend 1-2 years in their nursery streams (Johnson et al.

1983) while fry at Summit, Blue and Independence Lakes begin to disperse very soon after they emerge (Cowan 1991, Gerstung 1988).

Reports of migrations to spawning sites are varied, but also indicate a difference between the behavior of lake- and stream-dwelling fish. The size of streams influences the distances traveled by lake residents (USFWS 1994); fluvial populations do not tend to migrate as far (Gerstung 1988). Lahontan cutthroat trout from Pyramid and Winemucca lakes were said to have traveled more than 100 miles to Lake Tahoe up the Truckee River (Sumner 1940 and LaRivers 1962, cited in USFWS 1994.) Some adult trout in the Truckee River have been tagged and followed more recently; their daily movements averaged 0.75 km although a maximum distance of 11 km was recorded (USFWS 1979).

Interactions with Other Species

Lahontan cutthroat trout do not perform well in the face of competition with other, non-native trout species (such as rainbow, brook, brown and lake trout) and have rarely been able to co-exist with them for more than 10 years in streams in the western part of the Lahontan basin (Gerstung 1988**.** The less specific spawning requirements of these species may allow them to persist in lower quality or more disturbed habitat than that needed by the Lahontan cutthroat trout (Gerstung 1988). Hybrids are sometimes formed between cutthroat and rainbow trout (Behnke 1979), but hybridized populations tend to be replaced with pure strains of rainbow trout over time (Gerstung 1988).

Research Needs

After the USFWS Recovery plan for the species was completed in 1994, the Biological Resources and Research Center of the University of Nevada, Reno identified several major research needs (Peacock 1998). These included identification of populations with the greatest risk of extinction, using genetic data and population viability analyses; phylogenetic analysis of existing populations in the Lahontan basin; identification and characterization of suitable occupied and non-occupied habitat within the historic range; investigation of the role of water temperature in limiting the distribution of the species; and investigation of the dynamics of competition and co-existence of the Lahontan cutthroat trout with nonnative salmonid species. The results of such studies would both facilitate efforts to prioritize areas and population segments for conservation, and indicate which management strategies might be most successful in different contexts.

Habitat Relationships

The formerly wide distribution of the Lahontan cutthroat trout suggests that its association with habitats was general in nature. The species was found in many different types of aquatic environments, including oligotrophic alpine lakes (such as Lake Tahoe and Independence lake), alkaline lakes (such as Pyramid and Walker Lakes), headwater tributary streams (such as Donner Creek), and rivers with a range of characteristics—from slow- to fast-moving and from high to moderate gradients (USFWS 1994).

Fluvial populations of cutthroat trout prefer habitats with cover provided by overhanging shrubs, logs or banks, or areas containing rocks, riffles and deep pools (USFWS 1994). These features are often found in small streams with cool water and stable banks. Lacustrine populations tolerate a wide range of conditions including high levels of alkalinity and dissolved solids (USFWS 1994). Both lacustrine and riverine trout spawn in riffles with gravel substrate; lake-dwelling populations travel up tributaries to spawn (USFWS 1994).

Effects of Human Activities

Many Human activities have reduced and degraded habitat for this species. Human settlement in California and Nevada over the last century has altered the course and flow of most major river systems in the Lahontan basin, influencing the quality and connectivity of habitat for all species of native trout (USFWS 1994). Several specific events and processes may have contributed to the decline of the Lahontan cutthroat trout in the streams and lakes of the Tahoe basin: diversion and alteration of stream channels to facilitate logging and mining around the turn of the century, increases in sedimentation and nutrient loading of water bodies from these activities, degradation of riparian zones through agricultural and recreational use as well as urban development, and pollution from multiple sources including wastewater discharge. All of these factors probably decreased the quality and availability of spawning habitat, preventing normal levels of annual reproduction, as well as causing mortality of individuals year-round. Population declines were also caused directly by heavy commercial and sport fishing, which took a steady toll on the basin's populations from the 1880s to the 1930s. Finally, native trout have been displaced in many areas through competition from the several species of nonnative salmonids introduced to California and Nevada in the last century (Gerstung 1988, USFWS 1994).

Conservation

The Lahontan cutthroat trout was among the first species to be listed as endangered under the Endangered Species Act of 1973. In 1975 its status was changed to threatened so that angling could be permitted and certain management actions facilitated (Gerstung 1988). As a threatened species, the Lahontan cutthroat trout has been the subject of numerous conservation and management efforts, many mandated by the eight separate management plans developed for the species by state, federal, and/or tribal agencies since 1983 (USFWS 1994).

Management strategies proposed and implemented for the Lahontan cutthroat trout in various parts of its current range include transplanting programs, habitat acquisition through land exchanges, habitat improvement work, population and habitat surveys and inventories, regulation and exclusion of grazing in sensitive areas, fencing of riparian zones, regulation and/ or closure of fishing seasons, development of fishery management plans for some individual basins, and genetic analysis of subspecies, subpopulations, and hybridized populations (USFWS 1994). Any or all of these programs could be undertaken in the Lake Tahoe basin if additional reintroductions are attempted there. To date, at least 32 reintroductions have been made within the species' historical range, and 15 self-sustaining populations have become established from these (USFWS 1994).

The recovery plan produced by the US Fish and Wildlife Service in 1994 described steps needed to achieve the objective of delisting the species; this action will be taken, or considered, when "management has been instituted to enhance and protect habitat required to sustain appropriate numbers of viable self-sustaining populations" (USFWS 1994: iii). Reintroduction efforts are outlined and will be judged successful when reintroduced populations include multiple age classes for five years and demonstrate a statistically significant trend of growth toward their target densities (USFWS 1994). Other needs identified by the recovery plan include the management of harvested populations, such that take is regulated and population viability maintained, and the development of genetic research programs and population viability analyses for the species (USFWS 1994).

The combined efforts of many federal, state and local agencies, interest groups, and the public will be critical to the successful conservation of this species. A watershed restoration project on the Marys River in eastern Nevada (site of one of Nevada's largest native populations of the Lahontan cutthroat trout) serves as a model for the type of collaboration required; partners and donors include the BLM, the US Forest Service, the USFWS, NDOW, Trout Unlimited, Barrick Goldstrike Mines Inc., and local ranchers and sportsmen (Dunham 1998).

In areas such as the Lake Tahoe Basin, where native populations have been completely extirpated, conservation efforts face several challenges. In addition to addressing the need to restore suitable habitat and remove or reduce competition from populations of nonnative salmonids, a genetically and ecologically appropriate strain of trout must be chosen for reintroduction (Dunham, 1999, pers. comm.). Recent proposals to restock Taylor Creek with Lahontan cutthroat trout taken from Heenan Lake may have educational value for residents of the Tahoe basin, but reintroduced populations may be more successful if their genotypes closely match those of the original native strain, and if research has guided the restoration of optimal habitat (including spawning habitat) before reintroduction is attempted (Dunham, 1999, pers. comm.).

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RAINBOW TROUT (*Oncorhynchus mykiss*)

Erik M. Holst

Distribution

Rainbow trout are native to Pacific slope drainages from the Kuskokwim River in Alaska to Baja California, Mexico (Fuller 1997a, Moyle 1976). Artificial propagation of steelhead rainbow trout (an anadromous form of *O. mykiss*)[2] began as early as the 1870s in the San Francisco Bay area (Busby et al. 1997). Since then, this species has been established outside of its natural range in 47 states (Boydstun et al. no date, Fuller 1997a).

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[2] Lohr and Bryant (1999) note that steelhead trout and rainbow trout are not morphologically or genetically distinct, but differ rather only in their life history patterns.

In the Sierra Nevada, trout introductions to formerly fishless waters above 1,800 m (5,900 ft) in elevation began in the mid-nineteenth century (Moyle et al. 1996, Knapp 1996). Early introductions of rainbow trout in the Lake Tahoe basin were probably carried on by various groups and private individuals around 1895 or earlier (Supernowicz pers. comm., CDFG 1957). However, "…in the early 1900s, the California Fish and Game Commission…began coordinating the fish planting effort, and by the 1940s fish stocking was conducted almost entirely by the California Department of Fish and Game" (Knapp 1996, p. 369). From 1939 to 1957, over eleven million rainbow trout were planted in Lake Tahoe (CDFG 1957). *Oncorhynchus mykiss* is now established in many aquatic systems throughout Lake Tahoe basin and is the most widely distributed trout species in California (CDFG 1969); it also is found throughout Nevada (Vinyard 1997).

Ecology

Rainbow trout inhabit both lotic and lentic waters with summer water temperatures between approximately 10 and 20°C (50 and 68°F) and will move to deeper, cooler water at temperatures above 21°C (70°F) (Froese and Pauly 1999, WDFW 1991). Because they require cool, well-aerated running water to spawn successfully, they cannot establish self-sustaining populations in lakes without inflow or outflow streams (Maslin 1996). The redd, or nest, is generally constructed by the female "in a gravel substrate at the head of a riffle or the downstream edge of a pool" in the spring of the year (Hunter 1991, p. 13). Using her tail and body, the female dislodges sediment and gravel to form an egg pocket; the male fertilizes the eggs as the female deposits them (Hunter 1991). The female then moves upstream and immediately begins digging another egg pocket; as a second egg pocket is created, the current carries the dislodged gravel downstream and covers the first egg pocket (Hunter 1991). The process continues and eventually a basin is constructed upstream of the final egg pocket to cover the eggs. Collectively the upstream basin, the egg pockets, and the disrupted gravel or tailspill are referred to as the redd (Hunter 1991). Up to 8,000 eggs may be deposited before the final egg pocket is covered with gravel by the female (Delaney 1994). After an incubation period of anywhere from a few weeks to as long as four months, depending on the water temperature, the fry hatch, emerge from the gravel, and eventually migrate to sheltered pools or bodies of water (Delaney 1994).

Fry of rainbow trout primarily feed on zooplankton, gradually consuming larger prey such as aquatic macroinvertebrates, terrestrial invertebrates, and becoming increasingly piscivorous as they grow in size; adults also feed on eggs, mollusks, and crustaceans (Froese and Pauly 1999). Trout are highly effective opportunistic predators (Knapp 1996, USDA 1998). In streams, they will seek and defend territories; "territories must be large enough to include adequate space, food, and areas for resting and hiding" (Hunter 1991, p. 24). Trout are bottom drift feeders, but occasionally feed on the surface (Froese and Pauly 1999).

Habitat Relationships

Although rainbow trout have somewhat specific habitat requirements to maintain self-sustaining populations, they can be found in both lotic and lentic waters throughout Sierra Nevada and the Lake Tahoe basin. They prefer cool, well oxygenated water and are obligate stream spawners; they require running water and clean gravel in which to spawn. Water velocities must be sufficient to keeps eggs free of sediment (CDFG 1969). Fry emergence is dependent on moderate to high water velocities over a gravel substrate, whereas fry development is dependent on sheltered pools or bodies of water and suitable forage. In the Pacific Northwest, preferred water velocities for spawning are between 0.5 and 0.9 m (1.6 and 3 ft.) per second (Hunter 1991). Similar water velocities have been documented in New Mexico; however, velocity data are specific to both fishery and stream characteristics and as such should be considered an approximation for conditions necessary in the Lake Tahoe basin (Hunter 1991, NMDFG 1997).

Adult forage and dispersal patterns appear to vary with the local conditions, environmental factors, and other fish species in the aquatic system (Meehan and Bjornn 1991, Moyle 1976). In lakes, rainbow may school and utilize the entire lacustrine system, whereas an individual in a small riverine system may complete its life cycle within a few hundred meters (Moyle 1976). Stream dwelling rainbows tend to prefer waters with a higher percentage of riffles than pools (Moyle 1976). Hunter (1991) notes suitable habitat for stream dwelling rainbow, in autumn at the end of the growing season, includes stream reaches where pools occupy between 35 and 65 percent of the habitat.

Rainbow trout can withstand water temperatures from 0^{o}C to 28^{o}C (32^{o}F to 82^{o}F); however, the recommend short-term maximum water temperature for rainbow trout is 24^{o}C (75^{o}F) and optimal temperatures for growth appear to be between 13^{o}C and 21^{o}C (55^{o}F and 70^{o}F) (Maloney et al., 1999, Moyle 1976). Optimum growth is achieved in waters with a pH between 7 and 8; however, rainbow can inhabit waters with a pH range between 5.8 and 9.6 (Moyle 1976).

Effects of Rainbow Introductions

The feeding behavior of trout may have severe impacts on oligotrophic Sierran lakes (Knapp 1996). Introduced trout not only have the potential to change zooplankton assemblages in lakes from larger-bodied species to smaller-bodied species, but also to affect amphibian populations (Knapp 1996). Impacts to amphibian populations by introduced trout not only include direct impacts such as predation, but also such introductions have the potential to isolate amphibian populations (Bradford et al. 1993, Knapp 1996). Knapp (1996) suggests that smaller, isolated populations maybe be more susceptible to extirpation and that interbreeding may affect genetic integrity. The decline of the mountain yellow-legged frog (*Rana muscosa*) has been attributed, in part, to predation by introduced trout (Knapp 1996). Gill and Matthews (1998) suggest that "trout and frogs cannot both live in the same lakes, for if there are trout in lakes there are rarely any frogs or tadpoles." However, it should be noted that while there may be long-term impacts to amphibian populations by introduced trout such as those noted by Knapp (1996), yellow-legged frogs and trout, including rainbow trout, and have been observed co-existing in lakes and streams in Desolation Wilderness and in the Eldorado National Forest to the west of Lake Tahoe (Elliott pers. comm., USDA 1998). The dynamics of this co-existence have not been documented, and the long-term impacts to ranid populations in these waters relative to persistent predation and other environmental stresses are unknown (Elliott pers. comm.).

Rainbow trout introductions also have the potential to affect native fish populations negatively through predation, competition, and displacement. Rainbow can also affect the genetic integrity of native populations by hybridizing; rainbow trout have hybridized with six species of native trout in the western United States (Table O-2) and have been considered a factor in the decline the populations of some of these species (Fuller 1997a). Cutbow trout

Table O-2—Status of native fish species that hybridize with rainbow trout (*Oncorhynchus mykiss*) (from Fuller 1997a).

Scientific name	Common name	State listed/protected†	USFW T & E Listed
Oncorhynchus apache	Arizona trout	AZ	Threatened
Oncorhynchus gilae	Gila trout	NM, AZ	Endangered
Oncorhynchus aguabonita	Golden trout		
Oncorhynchus clarki henshawi	Lahontan cutthroat trout	NV, OR	Threatened
Oncorhynchus mykiss subsp.	Redband trout		‡
Oncorhynchus clarki subsp.	Alvord cutthroat trout	Extinct (USGS 1994)	

† Includes state listed threatened, endangered, or protected species, as well as species of concern.

‡ The US Fish and Wildlife Service published a positive finding on a petition to list 'Great Basin redband trout' on November 16, 1998. The 90-day comment period closed on March 16, 1999.

(*Oncorhynchus clarki x O. mykiss*) are an artificial rainbow x cutthroat hybrid that has been introduced as a sport fish, but the hybridization "can occur 'naturally' where both species come in contact through stocking" (Fuller 1997b, p. 1). In addition to the aforementioned impacts, stocking hatchery rainbow trout can introduce pathogens into native fish populations. Fuller (1997a) notes that stocking has led to the introduction of a parasitic infection known as whirling disease into approximately 20 states.

Effects of Human Activities

Angling directly effects individuals and has the potential to adversely affect habitat features such as riparian vegetation. Human activities that affect water quality, water chemistry, or degrade spawning habitat can also adversely impact rainbow trout populations. Recreational activities such as horseback riding, mountain biking, and off-highway vehicle use can degrade stream bank stability, thereby increasing sedimentation and resulting in the degradation of spawning habitat. Likewise, land management activities such as road construction, timber harvest, and grazing have the potential to increase sedimentation and nutrient loading (Hicks et al. 1991). Activities such as timber harvest and grazing also have the potential to reduce riparian vegetation and streamside canopy cover, resulting in increased exposure to solar radiation; changes in light levels and stream water temperatures can adversely affect spawning, emergence, and fry survival (Hicks et al. 1991, WDFW 1991).

Conservation

In the State of California, "management of purposeful legal fish introductions includes CDFG (California Department of Fish and Game) protocols for new species introductions, policy statements, harvest regulations, habitat enhancement, and research monitoring" (Lee 1998, p. 65). The Draft Fisheries Management Program of the Nevada Board of Wildlife Commissioners (1999) contains similar considerations. The management strategies of both states acknowledge the potential for detrimental impacts to native fisheries by stocking rainbow and other non-native fish species; however, fish stocking has traditionally had strong public support because of the recreational, social, and economic benefits angling provides (Lee 1998). Based on these considerations, it is apparent that future conservation efforts for native fish species that include cessation of stocking and/or non-native eradication efforts will need to balance the public demand for angling with potential impacts of stocking not only to fish, but also to other aquatic biota. If such conservation efforts are undertaken, strategies should also include measures to reduce the potential for future anthropogenic and/or natural migratory introductions of nonnative trout such as rainbow into affected aquatic systems.

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SMALLMOUTH BASS (*Micropterus dolomieui*)

Erik M. Holst

Distribution

Smallmouth bass are members of the sunfish family (Centrarchidae). They are native to the “St. Lawrence, Hudson Bay (Red River), and Mississippi River basins from southern Quebec to North Dakota and south to northern Alabama and eastern Oklahoma; Atlantic and Gulf slope drainages from Virginia to central Texas” (Fuller 1999, p. 1). They have been widely introduced in the United States and have been reported in 38 states outside of their natural range (Boydstun et al. no date).

Smallmouth bass were first introduced to California in 1874, and have subsequently been introduced in waters throughout the central and northern part of the State (CDFG 1998). It is unknown when smallmouth bass were first introduced into Lake Tahoe; Lee (pers. comm.), could not find any documentation in Department records indicating an authorized release. Lehr (pers. comm.) notes only one confirmed report of smallmouth bass in the basin, at the Tahoe Keys, South Lake Tahoe.

Ecology

Smallmouth bass are flexible in their habitat use and can be successful in both lotic and lentic systems. They are considered a warmwater game fish (CDFG 1998). Smallmouth generally inhabit areas of lakes and streams with gravel substrates and somewhat sparse vegetation (Steiger 1998, TPW 1999). Spawning occurs in the spring in shallower waters near the shore when temperatures approach 15.5 ° C (60 °F) (TPW 1999). In moving water, the male tends to build nests downstream from a boulder or other obstruction that offers protection from the current (TPW 1999). After building the nest, the male may spawn with several females, and after spawning, the female may leave and spawn with another male. The number of eggs a female can lay depends on her body size. Females generally produce 7,000 to 8,000 eggs per pound of body weight (IDNR no date). Thus, a mature female has the potential to lay 2,000 to 15,000 eggs; however, nests generally average approximately 2,500 eggs (TPW 1999). Eggs hatch within 2 to 10 days depending on water temperature (TPW 1999). Males guard and fan the nest until the fry emerge; they protect the nest and the fry from predation until the fry disperse (IDNR no date). Growth rates of fry vary with water temperature and food availability (Steiger 1998). Fry feed on zooplankton, eventually moving on to insect larvae and larger food types. Water temperature and predation can contribute to loss of smallmouth eggs and fry (VFWIS 1998, Steiger 1998). Smallmouth bass are carnivorous feeders whose food preference may vary with habitat and diurnal changes; they feed from the surface and off the bottom (Steiger 1998). Preferred food of adult smallmouth includes insect larvae, adult aquatic and terrestrial insects, crustaceans, and other fishes (IDNR no date, Steiger 1998). Smallmouth of 0.5-1.4 kg (1-3 lb) are common in Sierran foothill lakes west of Lake Tahoe. The largest smallmouth bass caught in California weighed slightly over 4 kg (9.1 lb) (CDFG 1996). The range of smallmouth bass in the higher elevations of the Sierra Nevada is not well documented; however, in the eastern United States the range of smallmouth may be limited to a single home pool (VFWIS 1998).

Impacts of smallmouth introductions vary. In south-central Texas, Smallmouth bass (*Micropterus dolomieui*) have hybridized with Guadelupe bass (*M. treculii*) creating fertile offspring "capable of backcrossing to the parent species" (Fuller 1999). Smallmouth bass have also hybridized with spotted bass (*M. punctulatus*) and largemouth bass (*M. salmoides*) (Fuller 1999). Because of their predatory nature, smallmouth bass have the potential to affect small fish populations (Fuller 1999). Bennett (1998) notes that the Lower Granite Reservoir along the Snake River, smallmouth bass are the main predators of salmonids.

Habitat Relationships

Smallmouth bass are flexible in both their habitat and feeding requirements. They may be found in both lotic and lentic systems. And although they are considered warmwater fish, smallmouth bass generally prefer water temperatures between 15.5°C (60°F) and 21°C (70°F) (Stieger 1998). The winter surface water temperatures of Lake Tahoe range from 4.5°C to 10°C (40°F to 50°F) and warm to 18°C to 21°C (65°F to 70°F) in August and September (USDA 1997). Thus, because temperature plays a major role in spawning behavior and contributes to mortality in eggs and fry, this species in the Lake Tahoe basin would likely be confined to the shallower and warmer waters such as those found in the Tahoe Keys.

Effects of Human Activities

The lack of documentation on authorized smallmouth bass introductions in Lake Tahoe by the California Department of Fish and Game suggests that the species was either intentionally or unintentionally introduced into the lake by a private individual(s). At present there is no qualitative or quantitative information on smallmouth bass in the lake, but the confirmation of one individual combined with the life history of this species suggests that further unauthorized introductions might enable smallmouth bass to establish a self-sustaining population in Lake Tahoe. Given the disparity between the preferred habitat of smallmouth bass and that of Lake Tahoe, it is difficult to predict with any degree of certainty what the effect on the lake's fishery would be. However, in a more general sense, exotic species that survive initial introduction and develop self-sustaining populations are often tolerant of adverse, altered, or changing conditions (Boydstun et al. no date). Thus, such a population might adversely impact salmonid populations.

Conservation

In concert with federal guidelines, the California Department of Fish and Game and the Nevada Division of Wildlife Fisheries Bureau manage fisheries programs in their respective states, including policies and protocols for introductions of exotic fish. Presently in California, the "management of illegal and unintentional introductions includes laws and regulations governing importation and movement of fish, research and monitoring, eradication, public education and punishment of violators" (Lee 1998, p. 65). Therefore, it appears that there are current conservation provisions already in place to deal with illegal introductions and/or the discovery of the presence of exotic fish species that have the potential to adversely impact existing fisheries.

Nonetheless, smallmouth bass have been introduced to Lake Tahoe and could affect native fish if their population increases. Assuming that smallmouth are not desirable in the lake, eradication is currently a viable option given the apparently small population.

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Invertebrates

LAKE TAHOE BENTHIC STONEFLY (*Capnia lacustra*)

Erik M. Holst

Distribution

The Lake Tahoe benthic stonefly, *Capnia lacustra,* is endemic to Lake Tahoe. This species is associated with deep-water plant beds and is most abundant at depths from 60 to 110 m (200 to 360 ft) although it has been found as deep as 274 m (899 ft) in McKinney Bay (Frantz and Cordone 1996). Although complete surveys of these plant bed assemblages have not been conducted, such communities have documented in two locations, both in the southeast part of Lake Tahoe (Beauchamp et al. 1992). (For further discussion on deep-water plant beds, see the Ecologically Significant Area account for deep-water plant beds in this chapter, Appendix C.)

Ecology

C. lacustra is a small wingless stonefly that ranges from 4.5 to 5.5 mm in length with little pigmentation (Frantz and Cordone 1996). Little is noted of the life history of *C. lacustra.* Even the manner in which they obtain oxygen is of some debate because they do not possess external gills (Frantz and Cordone 1996, Jewett 1963). This stonefly spends its entire life cycle at depths of 60 to almost 275 m (200 to almost 900 ft) in Lake Tahoe. The only other known stonefly with a similar life cycle is a member of the genus *Baikaloperla*; it is found in Lake Baikal, Siberia. Both species are "wingless and share similar morphological and ecological characteristics" (Frantz and Cordone 1996 p. 22, after Baumann 1979).

Cordone (pers. comm.) suggests that the introduction of the Opossum shrimp (*Mysis relicta*) may also adversely impact *C. lacustra*. *M. relicta* is both a predator and filter feeder. Zooplankton tend to serve as the primary food source; however, when zooplankton are scarce, *M. relicta* will feed on detritus and/or benthic organic material (Foster 1997). Additionally, Linn and Frantz (1965) note that *M. relicta* also feed on phytoplankton. Such opportunistic feeding habits have made dramatic changes in certain aquatic communities and "extinctions of native zooplankton communities have been attributed to this lifestyle." (Foster 1997, p.1) And although Goldman et al. (1979) suggest that *M. relicta* may in part be responsible for the population decline in three pelagic cladoceran species, Frantz and Cordone (1996) note direct effects of *M. relicta* on the macrobenthos such as *C. lacustra* in Lake Tahoe have note been documented. This is due to the fact that studies of *M. relicta* vertebrate and invertebrate interactions in Lake Tahoe have been complicated by eutrophication, fish stocking, and fishing pressure (Richards et al. 1991).

Members of the genus *Capnia* are shredders (Merrit and Cummins 1996). Thus, it is not surprising that *C. lacustra*, as previously noted, is associated with the deep-water plant beds of Lake Tahoe.

Habitat Relationships

Lake Tahoe's deep-water plant beds "are composed of bryophytes (mosses and liverworts), multicellular algae of the 'filamentous' type and Characeae (stoneworts)" (Frantz and Cordone 1996, p. 30). Frantz and Cordone (1966) note that the maximum depths of these deep-water plant beds are the deepest noted in any lake and that distribution of these deep-water plant beds is dependent on available light. Thus, as water clarity diminishes, decreases in the vertical distribution of these plant beds can be expected. Further Frantz and Cordone (1996) state, "Should further significant enrichment occur, reduced light penetration might permanently eliminate this unique plant community. It may already be too late for some of the plant beds. The loss of the deep-water plant beds at Lake Tahoe would substantially reduce the lake's biological diversity." (See the Ecologically Significant Area account for deep-water plant beds in this chapter, Appendix X, for further discussion.)

Effects of Human Activities

Human activities that lead directly or indirectly to increases in phytoplankton and/or sediment transport will decrease lake clarity (Frantz and Cordone, 1996, Jassby et al. 1999); such decreases in clarity will have an adverse impact on the deep-water plant beds. Because of the association between *C. lacustra* and these deep-water plant beds, a corresponding decrease in distribution of *C. lacustra* could be expected with such activities. Likewise, competition with introduced exotic invertebrates can be expected to have a negative effect on *C. lacustra* populations.

Conservation

C. lacustra is currently listed as a Species of Concern by the US Fish and Wildlife Service. Additionally, *C. lacustra* is assigned a Global Rank of 1 (G1) and a State Rank of 1 (S1) by the Nevada Natural Heritage Program (NNHP 1998). The G1 ranking indicates that on a global scale *C. lacustra* is "critically imperiled due to extreme rarity, imminent threats, or biological factors" (NNHP 1998). Similarly the S1 rating indicates that "based on distribution within Nevada at the lowest taxonomic level" *C. lacustra* is "critically imperiled due to extreme rarity, imminent threats, or biological factors" (NNHP 1998).

At present, information on the macrobenthos of Lake Tahoe is limited, including information specific to *C. lacustra*. Preliminary baseline information has been provided by Frantz and Cordone (1966, 1996), but the present distribution and abundance of the species are unknown. Given the recent decline in lake clarity, the possible effects on deep-water plant beds, and the introduction of exotic invertebrates, *C. lacustra* could face extinction. Further inventory and research are needed to assess adequately the distribution and frequency of occurrence of *C. lacustra* as well as its association with deep-water plant beds.

Envirogram of the Lake Tahoe Benthic Stonefly

The envirogram of the Lake Tahoe benthic stonefly (Figure O-5) depicts important habitat elements, food resources, interspecific interactions, and reproductive requirements of the species.

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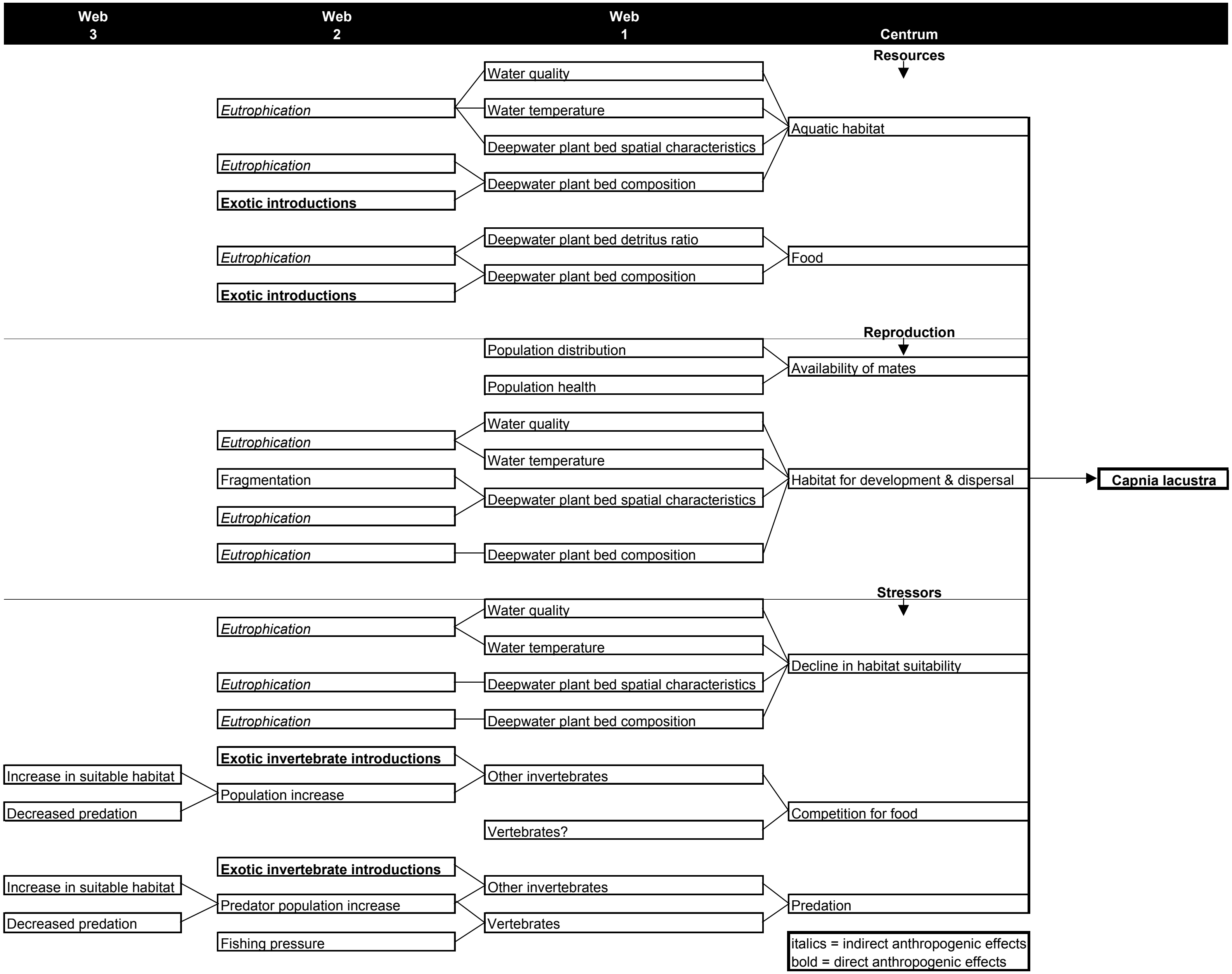

Figure O-5—Envirogram for the Lake Tahoe benthic stonefly (*Capnia lacustra*).