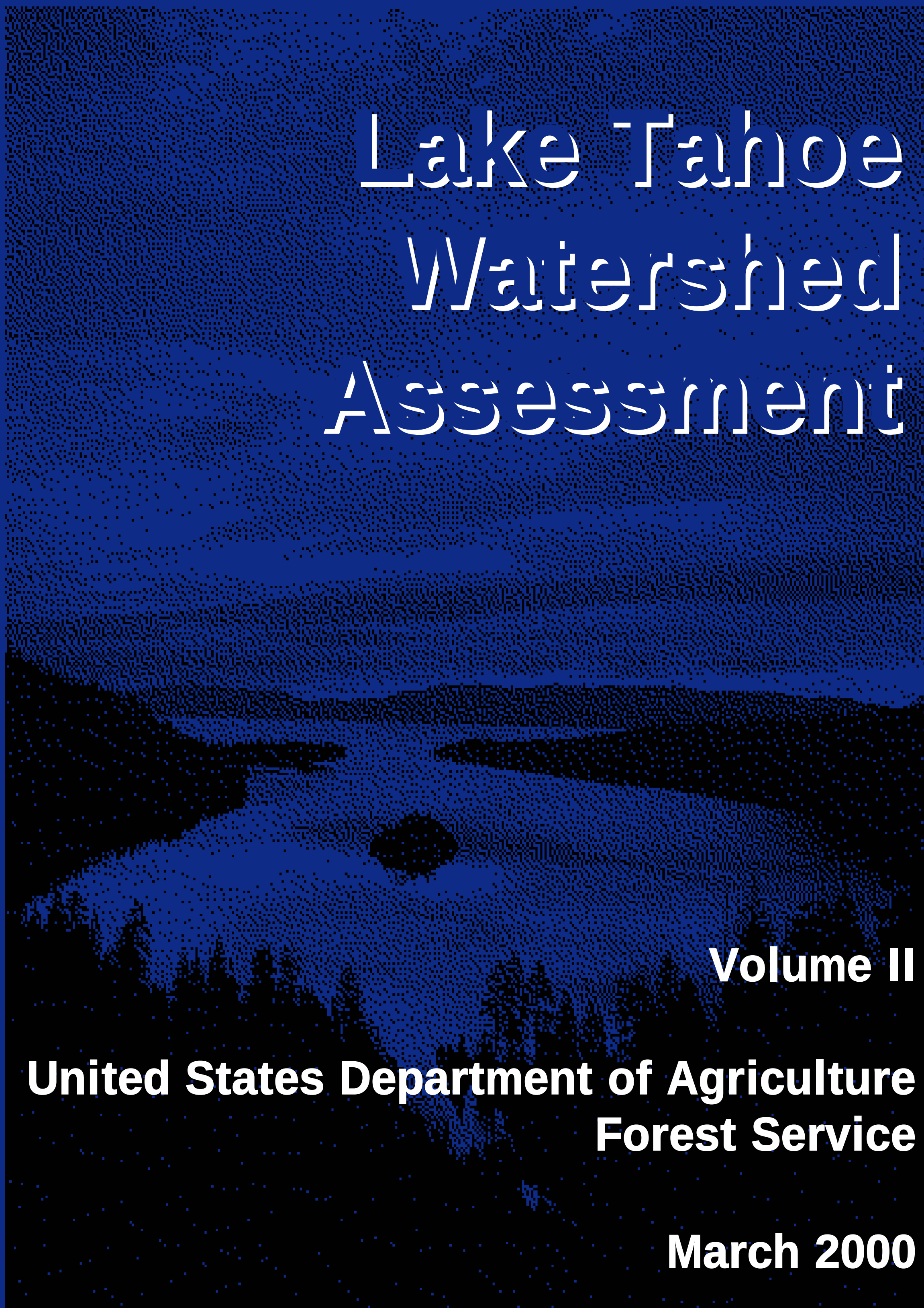

Lake Tahoe Watershed Assessment

Volume II

United States Department of Agriculture
Forest Service

March 2000

Abstract:
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The Lake Tahoe Basin has been the subject of decades of research and monitoring efforts. However, the Lake Tahoe Watershed Assessment is the first attempt to collate, synthesize, and interpret available scientific information with a comprehensive view toward management and policy outcomes. The seven-chapter assessment presents new and existing information in subject areas pertinent to policy development and land and resource management in the basin, including environmental history, air quality, watershed dynamics and water quality, biological integrity, and socioeconomic conditions.

Volume II is supporting documentation for several of the discussions in Volume I. Its appendices offer more detailed information regarding vascular and nonvascular plant, vertebrate, and invertebrate species, fungi, and a range of conservation applications for each. The appendices also discuss modeling assumptions and a partial list of important monitoring considerations for several resources areas.

Retrieval Terms: environmental history, air quality, water quality, biotic integrity, socioeconomics, adaptive management, California, Nevada

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The Lake Tahoe Watershed Assessment Volume II

Edited by

Dennis D. Murphy
and
Christopher M. Knopp

March 2000

In collaboration with USDA-Pacific Southwest Region and Research Station, the Tahoe Regional Planning Agency, the University of California at Davis, the University of Nevada at Reno, and the Desert Research Institute, Reno, Nevada.

Lake Tahoe Watershed Assessment: Volume II

Technical Editors: Dennis D. Murphy, Christopher M. Knopp

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APPENDIX A

WILDLAND FIRE SUSCEPTIBILITY ANALYSIS

(From Wildland Fire Risk Assessment for the Lake Tahoe Region, 10/28/99, Completed For The USDA-Forest Service, Lake Tahoe Basin Management Unit, By Jones and Stokes Associates, Sacramento, California, Fire Program Solutions, Estacada, Oregon, Dr. Mark A. Finney, Missoula, Montana)

Don Carlton, Kelly Berger, Steve Holl, and Mark Finney

The wildland fire susceptibility analysis integrates the probability of an acre igniting and wildland fire behavior. It combines the data from the FOAs with fire behavior data developed by FlamMap. This analysis calculated a Wildland Fire Susceptibility Index (WFSI) for each 30x30 meter cell in the study area. The analysis also included a factor that would limit the size of a fire, because of containment by suppression resources and/or the presence of non-burnable surfaces, such as water or rock.

Factors Affecting Fire Size

Expected fire size was assessed by determining the relationship between rate of spread and expected fire size when the fire was contained by initial attack resources and when the fire was not contained by initial attack. Limitations on fire size because of the presence of non-burnable surfaces was also evaluated in the susceptibility analysis.

Successful Initial Attack. The size of contained fires was evaluated using the Interagency Initial Attack Assessment (IIAA) program and data provided by the LTBMU, the Eldorado National Forest and the Tahoe National Forest. The IIAA program contains fire program initial attack options, used to determine initial attack efficiency by fuel models. All assumptions used for resource staffing and dispatch philosophies were defined in the IIAA data files for the Eldorado and Tahoe National Forests and LTBMU for program option (M30), the Most Efficient Level minus 30%. Staffing under this fire program option was selected because it best represented current fire suppression resource staffing and a level of staffing that is most likely in the near future.

The fire size upon containment is estimated by the IIAA using the double ellipse area model developed by Fons (1946) as documented by Anderson (1983). The model calculates fire size (Area) as:

$$\text{Area} = K * D^2 \quad \text{Equation 1}$$

where K is a constant dependent solely on mid-flame wind speed and D is the distance the fire has traveled from its point of origin (D = rate of spread times containment time). Mid-flame windspeed was set at 7.6 mph since this is the value used in the IIAA (Booher, personal communication).

The LTBMU, Eldorado and Tahoe National Forest IIAA mdb data for all Fire Management Zones (FMZ) were used to determine the relationship between containment time and rate-of-spread (Figure 8).

Equation 2 ($r^2 = 0.80$) describes the relationship between containment time and rate of spread (ROS) in Figure 2.

Containment Time (CT) = 4.826 * Rate-of-Spread (ROS) Equation 2

The main variation comes from the variation in containment time at the various representative fire locations.

Inserting the containment cime versus rate-of-spread (ROS) relationship (Equation 2) into Fon's formula with a 7.6 mph midflame windspeed produces the following relationship:

Contained Fire Size (CFS) = $0.0002544333 * ROS^{4}$ Equation 3

Equation 3 was used to estimate fire size for fires spreading at rates of spread from 1 to 24 ch/hr. These rates of spread were selected based on the IIAA data files which showed that fires escape initial attack at approximately the following rates-of-spread: LTBMU - 24 ch/hr; Eldorado - 37 ch/hr; Tahoe - 40 ch/hr.

Escaped Fires. For escaped fires (fires not contained by initial attack resources), the expected fire size is estimated by the IIAA and empirical data from large fires in the Central Sierra and Southern Cascades. Four fires were selected that burned in fuel types similar to those in the study area and are well documented. To examine the relationship between the net rate-of-spread of a fire during its major growth period and the fire's final size, data were evaluated from the Cleveland and Pelican fires on the Eldrorado National Forest. During the initial burning periods for the Cleveland fire, a 41 chains/hour (ch/hr) ROS resulted in 5400 acres burned in the first burning period. During the initial burning periods for the Pelican fire, ROS was 48 ch/hr and the fire was 6,300 acres. The Paulina Fire on the Deschutes National Forest spread to a final fire size of 23,000 acres under a net spread rate of 54 ch/hr and the Lone Pine fire on the Winema National Forest spread to a final fire size of 30,000 acres under a net spread rate of 60 ch/hr.

A curve fit using the LTBMU, the Eldorado National Forest and the Tahoe National Forest IIAA data as well as the Pelican, Cleveland, Paulina and Lone Pine Fire data (Figure 9) resulted in the following relationship for escaped fires. These are fires spreading at a rate greater than 24 chains per hour.

$$FFS = (0.000000279)*ROS^{6.222} + (31.02)*ROS^{-3.527} \quad \text{Equation 4}$$

Figure 8

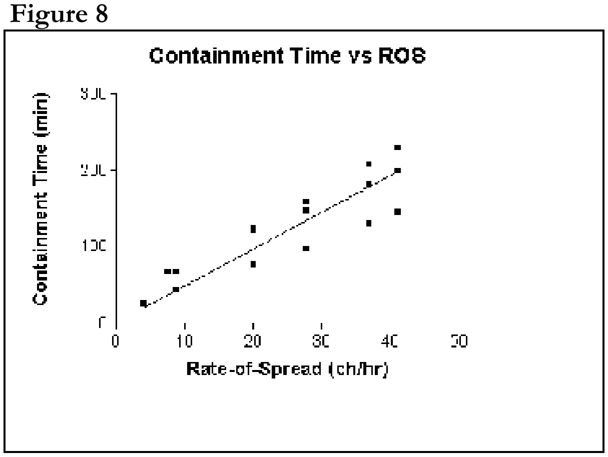
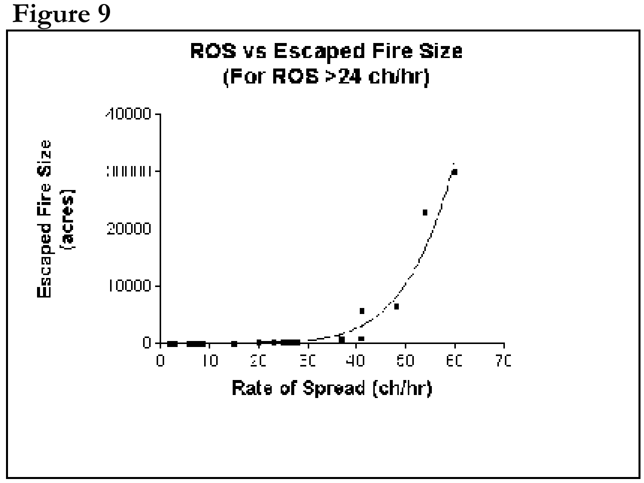


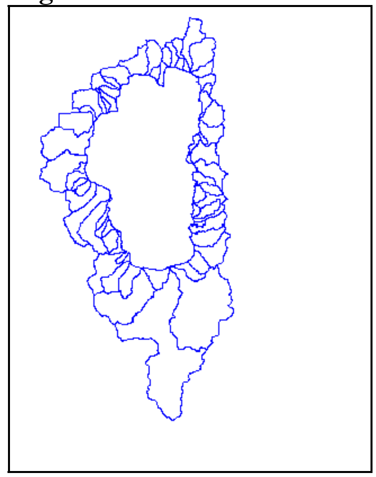
Figure 9



Drainage Orientation, Wind Direction, Presence of Barren and Water Surfaces As It Relates to Maximum Fire Size

The maximum size of escaped wildfires in the LTBMU would also be affected by the presence of barren areas along the crest of the mountains and the water in Lake Tahoe, and the orientation of sub-watersheds (Figure 10).

Figure 10



Drainage Orientation and Wind Direction.

Wind direction and speeds between June 1 and November 15 at Meyers Weather Station are shown in Table 13. The predominant (88%of the time) wind direction is from the north, northwest, west, southwest, or south. Most drainages in the LTBMU are oriented in a west/southwest to east/northeast direction. Winds from the southwest, south, and southeast occur 54th% of the time and are the strongest. This orientation of drainages will "funnel" fires within drainages which will tend to limit for spread to one for several sub-watersheds.

Table 13 - Wind Speed and Direction at Meyer Weather Station

	No.	% of	90th %ile	20' Wind Speed (mph)		
				Mod	High	Ext
N	895	27%	10	8	12	14
NE	173	5%	10	8	11	14
E	59	2%	10	7	13	15
SE	149	4%	14	9	14	26
S	668	20%	15	11	16	17
SW	680	20%	15	10	16	20
W	291	9%	11	8	12	15
NW	411	12%	10	8	11	14

Presence of Barren and Water Surfaces. The number of burnable acres in each sub-watershed in the LTBMU was calculated by subtracting acres of barren areas and water from the total acres in each sub-watershed (Table 14). The average size of a sub-watershed is 3,211 acres; however, the average size in terms of burnable acres is 2,779 acres and the median size is 1,368 acres. On the west side of the LTBMU, the drainages are bounded on the west by large rocky areas and on the east by Lake Tahoe. On the east side of the LTBMU, a similar situation exists with Lake Tahoe on the west and higher terrain to the east with vegetation becoming more sparse are the higher elevations. Fires burning under the strongest winds (from the southwest, south, or southeast) have the greatest opportunity to become larger in the area south and the area north of Lake Tahoe. In these areas, the topography lines up better with the wind direction and these areas contain more area with continuous fuel profiles.

Table 14 Total and Burnable Acres By Sub-Watershed			
Drainage	Total Acres	Non-Burnable Acres	Burnable Acres
UPPER TRUCKEE RIVER	36223	5583	30640
TROUT CREEK	26432	2365	24067
WARD CREEK	8179	527	7652
BLACKWOOD CREEK	7423	657	6766
TAYLOR CREEK	11789	5581	6208
GENERAL CREEK	5777	352	5425
MEEKS	5608	929	4679
TRUCKEE RIVER	4371	133	4238
INCLINE CREEK	4296	227	4069
EDGEWOOD CREEK	4276	271	4005
BURTON CREEK	3665	45	3620
TAHOE VISTA	3476	266	3210
GLENBROOK CREEK	3232	115	3117
BURKE CREEK	3180	124	3056
THIRD CREEK	3863	842	3021
MKINNEY CREEK	3134	134	3000
SLAUGHTER HOUSE	3144	147	2997
GRIFF CREEK	2910	113	2797
MARLETTE CREEK	3167	417	2750
EAGLE CREEK	5640	2917	2723
SECRET HARBOR CREEK	2726	71	2655
CARNELIAN CANYON	2664	159	2505
MCFAUL CREEK	2523	28	2495
TALLAC CREEK	2932	570	2362
CAMP RICHARDSON	2652	640	2012
NORTH ZEPHPR CREEK	1676	9	1667
BIJOU PARK	1974	324	1650
LINCOLN CREEK	1648	2	1646
BIJOU CREEK	1807	227	1580
RUBICON CREEK	1827	290	1537
WATSON	1492	11	1481
LOGAN HOUSE CREEK	1380		1380
MADDEN CREEK	1462	107	1355
SAND HARBOR	1376	51	1325
WOOD CREEK	1514	235	1279
NORTH LOGAN HOUSE CREEK	1307	30	1277
MILL CREEK	1408	132	1276
CASCADE CREEK	3020	1793	1227
CEDAR FLATS	1167	59	1108
DOLLAR CREEK	1166	92	1074
TUNNEL CREEK	1096	49	1047
SECOND CREEK	1183	171	1012
QUAIL LAKE CREEK	1049	38	1011
FIRST CREEK	1117	116	1001
CAVE ROCK	1010	38	972

Table 14 Total and Burnable Acres By Sub-Watershed			
Drainage	Total Acres	Non-Burnable Acres	Burnable Acres
ZEPHYR CREEK	938	19	919
BLISS STATE PARK	930	49	881
DEADMAN POINT	870	0	870
EAST STATELINE POINT	875	77	798
SIERRA CREEK	763	29	734
TAHOE STATE PARK	782	74	708
PARADISE FLAT	709	40	669
LONELY GULCH CREEK	692	27	665
BARTON CREEK	716	53	663
HOMEWOOD CREEK	645	12	633
CARNELIAN BAY CREEK	641	13	628
KINGS BEACH	726	103	623
BONPLAND	565		565
EAGLE ROCK	521	9	512
SKYLAND	503	12	491
BURNT CEDAR CREEK	579	107	473
BLISS CREEK	398	3	395
LAKE FOREST CREEK	448	77	371
SOUTH ZEPHYR CREEK	263	4	259
TOTAL ACRES	205525	27693	177832

Maximum Fire Size Assumption

Historic data on fire size and watershed variables were used to develop an assumption about the maximum fire size in the study area. No fires greater than 10,000 have occurred in the study area, although several have occurred in other areas of the Eldorado and Tahoe National Forests. From 1908 to 1939 and 1973 to 1996, one fire greater than 1,000 acres occurred in the LTBMU and a total of six occurred in the entire study area (Table 4 and 5). Thus, fires greater than 1,000 acres are a rare occurrence. Additionally, considering the orientation of the drainage in each watershed, the number of acres of burnable vegetation in each watershed, and the current fuels profiles, a maximum fire size of 3,000 acres was used in this analysis for wildland fire susceptibility.

Estimates of Fire Sizes Based on Rates of Spread.

Using equation 3 for contained fires, equation 4 for escaped fires, and a maximum final fire size of 3,000 acres, the final fire size used based on rate-of-spread is summarized in Table 15. As mentioned earlier, the rate of spread were a wildland fires escapes initial attack is about 24 chains/hr in the LTBMU.

Table 15 - Summary of Final Fire Size Based on Rate-of-Spread			
Rate of Spread (ch/hr)	Final Fire Sized Used	Final Fire Size (Acres) Contained Fires - Equation 3	Final Fire Size (Acres) Escaped Fires - Equation 4
5	0.16	0.16	Equation 3 does not fit well here as
10	2.50	2.50	
15	12.9	12.9	
20	40.7	40.7	
24	84.0	84.0	
25	170	1573	170
30	463	2265	463
35	1160	3083	1160
40	2623	4027	2623
45	3000	5096	5425
50	3000	6296	10420
55	3000	7614	---
56+	3000	---	---

CALCULATION OF THE WILDLAND FIRE SUSCEPTIBILITY INDEX

The WFSI is calculated with a spreadsheet of which an example portion is shown in Table 16. Appendix F contains the printouts of spreadsheets used to calculate the WFSI for the study.

Table 16 - Example of Calculation of Wildland Fire Susceptibility Index For A Two Specific Fire Occurrence Areas (FOA 1 and FOA 2)			
Calculation Is For The Moderate Weather Class The Probability of a Fire in The Weather Category is 0.71 For the Example			
Row		FOA 1	FOA 2
1	Total FOA Acres (Excluding water)--->	541,578	56,746
1a	Total Non-Burnable Acres--->	86,304	7,647
1b	Total Burnable Acres--->	455,274	49,099
2	Total Fires in FOA (1970-1998)-->	1,293	497
3	Number of Years for Data-->	27	27
4	Total Fires/Yr in FOA-->	47.89	18.41
5	Total FOA Rate (Fires/1000ac/Yr)-->	0.0884	0.3244
6	No of Fires/Yr in Wx Class in FOA-->	34.00	13.07
7	Rate-of-Spread = 5 Ch/Hr	0.000012	0.000042
8	Rate-of-Spread = 25Ch/Hr	0.010395	0.037048
9	Rate-of-Spread = 45Ch/Hr	0.224048	0.798545

Row 1. This is the total number of acres within the FOA not cover by water.

Row 1a. This is the total number of non-burnable acres within the FOA.

Row 1b. This is the total number of burnable acres within the FOA (Row 1 - Row 1a).

Row 2. This is the total number of fires for the time period noted within the FOA.

Row 3. This is the number of years in the time period.

Row 4. This is the Annual Number of Fires within the FOA and is calculated by dividing by Row 2 by Row 3:

Row 4 = Row 2 / Row 3 Equation 5

Row 5. This is the fire occurrence rate in the FOA expressed in fires per 1000 acres per year. It is calculated as follows:

Row 5 = (Row 4 * 1000) / Row 1 Equation 6

Row 6. This is the number of fires per year in the weather class. For this example, the moderate weather class is being used which has a frequency of occurrence of 0.75 but only 71% of the wildland fires historically occur in this weather class. Hence, this row is the product of Row 6 and 0.71:

Row 6 = Row 6 * 0.71 Equation 7

Overview of Rows 7-9. These rows provide the WFSI for each FOA and for a rate-of-spread from FlamMap output.

The WFSI is calculated as follows:

WFSI = (Expected Acres Burned In The FOA) / (Total Burnable Acres in the FOA) Equation 8

The rate-of-spread allows for estimation from Equation 3, Equation 4 or the maximum fire size of the estimation of the final fire size (FFS) for a single ignition that occurs within the cell (Table 15). This FFS is based on the **assumption** that the wildland fire is burning uniformly and continuously in a fuels and topographic situation as is described in the cell. Since there are no contagion effects considered, the calculated value for the WFSI is best viewed as an index that ordinates Wildland Fire Susceptibility based on the probability of wildland fire ignition (FOA) and fire spread potential (FlamMap). If the expected acres burning could be precisely determined, then the WFSI could be viewed as the "probability of an acre burning." For rates-of-spread less than 24 chains per hours, it is a close approximation of the "probability of an acre burning" as the resultant fire size is small.

The "Expected Acres Burned In The FOA" is calculated as follows:

Expected Ac. Burned In The FOA =
FFS * Number of Fires/Year in FOA in Weather Class Equation 9

Row 7. This row provides the WFSI for each FOA and for a rate-of-spread from FlamMap of 5 chains per hour. Since this rate-of-spread is between 1 and 24 chains per hour, Equation 3 (contained fire) is used to estimate the FFS. For FOA 1, this calculation is as follows:

WFSI (FOA 1 & ROS=5 ch/hr) =
(FFS * Number of Fires/Year in FOA in Weather Class) / (Burnable Acres in the FOA)
Equation 10

= (0.16 acres * 34.00 fires/yr) / (455,274 acres in FOA)

= 0.000012 .

Row 8. This row provides the WFSI for each FOA and for a rate-of-spread from FlamMap of 25 chains per hour. This rate-of-spread is greater than 24 chains per hour; therefore, Equation 4 (escaped fire) is used to estimate the FFS up to a maximum FFS of 3,000 acres. For FOA 1, this calculation is as follows:

WFSI (FOA1& ROS=25 ch/hr) =
(FFS * Number of Fires/Year in FOA in Weather Class) / (Burnable Acres in the FOA)
Equation 10
= (139.18 acres * 34.00 fires/yr) / (455,274 acres in FOA)

= 0.010395 .

Row 9. This row provides the WFSI for each FOA and for a rate-of-spread from FlamMap of 45 chains per hour. This rate-of-spread is greater than 24 chains per hour and hence Equation 4 (escaped fire) is used to estimate the final fire size (FFS) up to a maximum FFS of 3,000 acres. Using Equation 4, the FFS would be 5,394 acres which is greater than the 3,000 acre maximum FFS assumed. For FOA 1, this calculation is as follows:

WFSI (FOA1& ROS=45 ch/hr) =
(FFS * Number of Fires/Year in FOA in Weather Class) / (Burnable Acres in the FOA)
Equation 10
= (3,000 acres * 34.00 fires/yr) / (455,274 acres in FOA)

= 0.224048 .

Summary of WFSI Calculation

The WFSI value is proportional to the FOA rate (Row 6). The rate in FOA 2 is about 4 times that in FOA 1 and the WFSI values in FOA 2 are about 4 times those in FOA 1. This is a result of the use of the standard "expected value" methodology used to calculate the WFSI. Also note that if a dollar or index "value" were assigned to each cell in a Effects Layer, the product of the WFSI and the index value in the Effects Layer would yield an "expected effects index."

Table 17- Summary for Example of Wildland Fire Susceptibility Index			
Calculation Is For The Moderate Weather Class The Probability of a Fire in The Weather Category is 0.71 For the Example			
7	Rate-of-Spread = 5 Ch/Hr	0.000012	0.000042
8	Rate-of-Spread = 25Ch/Hr	0.010039	0.037048
9	Rate-of-Spread = 45Ch/Hr	0.224048	0.798545

APPENDIX B

AQUATIC ECOSYSTEM RATINGS FOR THE SIERRA NEVADA AND THE LAKE TAHOE BASIN

APPENDIX B

AQUATIC ECOSYSTEM RATINGS FOR THE SIERRA NEVADA AND THE LAKE TAHOE BASIN

Jeffrey Reiner and Craig Oehrli

Aquatic ecosystem ratings for the Sierra Nevada and the Lake Tahoe Basin, based on the system of Moyle (1996). Ratings for the Sacramento-San Joaquin Province and the Great Basin Province are from Moyle (1996). "Rating" is based on the sum of the ratings on the three criteria. "Confidence" reflects the reliability of the rating: H = high, M = moderate, L = low.

Sacramento-San Joaquin Province (selected ecosystems common to the Lake Tahoe Basin and the Sac-San Joaquin Province)

Ecosystem	Rarity	Disturbance	Protection	Status/ Score	Rating	Confidence
Lentic ecosystems						
Mountain pond	5	5	5	15	secure	M
Alpine lake w/o native fish	5	3	5	13	secure	H
Sphagnum bog	2	3	4	9	sp. concern	M
Fen	3	4	3	10	sp. concern	L
Lotic ecosystems						
Alpine snowmelt stream	5	5	5	15	secure	H
Cnfr forest snowmelt stream	5	4	5	14	secure	H
Alpine stream	5	3	5	13	secure	M
Forest stream	4	3	3	10	sp. concern	H
Spring	5	3	5	13	secure	M
Meadow stream	5	2	3	10	sp. concern	H
Trout headwater stream	5	5	4	14	secure	H
Stream with trout	4	4	4	12	secure	H
Mainstem river	2	1	1	4	threatened	H

Great Basin Province (selected ecosystems common to the Lake Tahoe Basin and the Great Basin)						
Ecosystem	**Rarity**	**Disturbance**	**Protection**	**Status/ Score**	**Rating**	**Confidence**
Lentic ecosystems						
Mountain pond	5	5	5	15	secure	M
Alpine lake w/o native fish	5	3	5	13	secure	H
Fen	3	3	3	9	sp. concern	M
Sphagnum bog	1	4	4	9	sp. concern	M
Alpine lake w/ native fish	3	3	2	8	sp. concern	M
Lotic ecosystems						
Alpine snowmelt stream	5	5	5	15	secure	H
Cnfr forest snowmelt stream	5	4	5	14	secure	H
Alpine stream	5	3	5	13	secure	H
Spring	4	3	3	10	sp. concern	M
Forest stream	5	3	5	13	secure	H
Meadow stream	5	2	3	10	sp. concern	H
Trout headwater stream	4	3	4	11	sp. concern	M
Stream with trout	4	3	2	9	sp. concern	M
Mainstem river	5	3	2	10	sp. concern	M

Lake Tahoe Basin-North						
Ecosystem	**Rarity**	**Disturbance**	**Protection**	**Status/ Score**	**Rating**	**Confidence**
Lentic ecosystems						
Mountain pond	3	2	2	7	threatened	L
Alpine lake w/o native fish	3	2	2	7	threatened	L
Fen	2	2	2	6	threatened	L
Sphagnum bog	1	2	2	5	threatened	L
Alpine lake w/ native fish	0	-	-	-	N/A	-
Lake Tahoe	1	3	3	7	threatened	H
Marsh	0	-	-	-	N/A	-
Wet meadow	3	3	3	9	sp. concern	M
Lotic ecosystems						
Alpine snowmelt stream	0	-	-	-	N/A	-
Cnfr forest snowmelt stream	5	3	4	12	secure	M
Alpine stream	0	-	-	-	N/A	-
Spring	3	2	2	7	threatened	M
Forest stream	3	2	3	8	sp. concern	M
Meadow stream	3	3	4	10	sp. concern	H
Trout headwater stream	5	3	3	11	sp. concern	H
Stream with trout	4	3	3	10	sp. concern	H
Mainstem river	0	-	-	-	N/A	-

Lake Tahoe Basin- South						
Ecosystem	**Rarity**	**Disturbance**	**Protection**	**Status/ Score**	**Rating**	**Confidence**
Lentic ecosystems						
Mountain pond	4	3	4	11	sp. concern	M
Alpine lake w/o native fish	3	2	2	7	threatened	H
Fen	1	2	2	5	threatened	L
Sphagnum bog	2	3	4	9	sp. concern	H
Alpine lake w/ native fish	0	-	-	-	N/A	-
Lake Tahoe	1	3	3	7	threatened	H
Marsh	1	1	3	5	threatened	H
Wet meadow	4	3	3	10	sp. concern	M
Lotic ecosystems						
Alpine snowmelt stream	4	4	4	12	secure	H
Cnfr forest snowmelt stream	4	4	4	12	secure	H
Alpine stream	4	4	4	12	secure	H
Spring	4	3	3	10	sp. concern	M
Forest stream	3	3	2	8	sp. concern	M
Meadow stream	2	3	2	7	threatened	H
Trout headwater stream	5	2	4	11	sp. concern	M
Stream with trout	4	2	4	10	sp. concern	M
Mainstem river	1	1	1	3	imperiled	H

Lake Tahoe Basin- East						
Ecosystem	**Rarity**	**Disturbance**	**Protection**	**Status/ Score**	**Rating**	**Confidence**
Lentic ecosystems						
Mountain pond	2	1	2	5	threatened	L
Alpine lake w/o native fish	2	1	2	5	threatened	L
Fen	1	1	2	4	threatened	L
Sphagnum bog	1	1	2	4	threatened	L
Alpine lake w/ native fish	0	-	-	-	N/A	-
Lake Tahoe	1	3	3	7	threatened	H
Marsh	0	-	-	-	N/A	-
Wet meadow	4	3	3	10	sp. concern	M
Lotic ecosystems						
Alpine snowmelt stream	4	2	4	10	sp. concern	L
Cnfr forest snowmelt stream	4	2	4	10	sp. concern	M
Alpine stream	2	1	4	7	threatened	M
Spring	3	2	2	7	threatened	H
Forest stream	3	2	2	7	threatened	H
Meadow stream	1	1	2	4	threatened	H
Trout headwater stream	5	3	3	11	sp. concern	M
Stream with trout	4	3	3	10	sp. concern	H
Mainstem river	0	-	-	-	N/A	-

Lake Tahoe Basin- West						
Ecosystem	**Rarity**	**Disturbance**	**Protection**	**Status/ Score**	**Rating**	**Confidence**
Lentic ecosystems						
Mountain pond	4	5	5	14	secure	M
Alpine lake w/o native fish	5	4	5	14	secure	H
Fen	1	3	4	8	sp. concern	L
Sphagnum bog	1	3	5	9	sp. concern	L
Alpine lake w/ native fish	1	2	4	7	threatened	H
Lake Tahoe	1	3	3	7	threatened	H
Marsh	1	2	3	6	threatened	H
Wet meadow	4	3	4	11	sp. concern	M
Lotic ecosystems						
Alpine snowmelt stream	5	5	5	15	secure	H
Cnfr forest snowmelt stream	4	5	5	14	secure	H
Alpine stream	4	5	5	14	secure	H
Spring	4	4	5	13	secure	M
Forest stream	3	4	4	11	secure	M
Meadow stream	1	3	5	9	sp. concern	L
Trout headwater stream	5	4	4	13	secure	H
Stream with trout	4	2	4	10	sp. concern	M
Mainstem river	-	-	-	-	N/A	-

Lake Tahoe Basin-Entire					
Ecosystem	**Rarity**	**Disturbance**	**Protection**	**Status/ Score**	**Rating**
Lentic ecosystems					
Mountain pond	3.3	2.8	3.3	9.3	sp. concern
Alpine lake w/o native fish	3.3	2.3	2.8	8.4	sp. concern
Fen	1.3	2.0	2.5	5.8	threatened
Sphagnum bog	1.3	2.3	3.3	6.9	threatened
Alpine lake w/ native fish	0.3	2.0	4.0	6.3	threatened
Lake Tahoe	1.0	3.0	3.0	7.0	threatened
Marsh	0.5	1.5	3.0	5.0	threatened
Wet meadow	3.8	3.0	3.3	10.1	sp. concern
Lotic ecosystems					
Alpine snowmelt stream	3.3	3.7	4.3	11.3	secure
Cnfr forest snowmelt stream	4.3	3.5	4.3	12.1	secure
Alpine stream	2.5	3.7	4.3	10.5	sp. concern
Spring	3.5	2.8	3.0	9.3	sp. concern
Forest stream	3.0	2.8	2.8	8.6	sp. concern
Meadow stream	1.8	2.5	3.3	7.6	threatened
Trout headwater stream	5.0	3.0	3.5	11.5	secure
Stream with trout	4.0	2.5	3.5	10.0	sp. concern
Mainstem river	0.3	1.0	1.0	2.3	imperiled

APPENDIX C

ACCOUNTS OF FOCAL AQUATIC ECOSYSTEMS AND ECOLOGICALLY SIGNIFICANT AREAS

APPENDIX C

ACCOUNTS OF FOCAL AQUATIC ECOSYSTEMS AND ECOLOGICALLY SIGNIFICANT AREAS

Matthew D. Schlesinger and Erik M. Holst, editors

Focal Aquatic Ecosystem: Upper Truckee River
By Erik M. Holst

General

From its headwaters at approximately 2,804 m (9,200 ft), near Red Lake Peak, the Upper Truckee River flows north for a distance of 34.6 km (21.5 mi) into Lake Tahoe (CDFG 1987). Within the 146.6 km^2 (56.6 mi^2) drainage, 24 tributaries flow into the Upper Truckee River (CDFG 1987). The Upper Truckee River and the tributaries which make up the Upper Truckee River Watershed comprise the largest contribution to the waters of Lake Tahoe (CWQCB 1999).

Using Moyle's (1996) aquatic habitat classification, the Upper Truckee River can be divided into two aquatic habitat types: alpine streams and mainstem rivers and their larger tributaries. (See Issue 5, Chapter 5 for further discussion of this classification.) Mainstem rivers and their larger tributaries are widespread and of special concern in the Great Basin Province. That is, they are "declining in abundance and quality but many examples still exist" (Moyle 1996, p. 946). However, as noted in Issue 5, Chapter 5, only mainstem rivers received the highest concern rating of "imperiled" in the Lake Tahoe Basin; the lower reaches of the Upper Truckee River comprise the only representative of a mainstem river in the basin.

History

Between 1852 and 1857 emigrants moved thousands of sheep and cattle through the Lake Tahoe basin on their way to the gold fields of California (Supernowicz 1999). Transient grazing patterns persisted until the later part of the 1850s at which time more defined, less transient, patterns of grazing evolved along with human settlement patterns (Supernowicz pers. comm.). By the late nineteenth century in the Lake Valley area of the Upper Truckee River watershed, harvested land was being grazed by dairy cattle, and indiscriminate, unregulated sheep grazing was occurring in those areas not suitable for cattle (see Chapter 2; Supernowicz pers. comm.). During this same period, land use activities in the headwaters of the Upper Truckee River were primarily limited to grazing; no commercial logging occurred. By the 1910s, the development of a seasonal grazing allotment system throughout the watershed dedicated land to specific uses and limitations. The allotment system attempted to reduce the previous levels of resource damage and essentially eliminated indiscriminate sheep grazing (Supernowicz pers. comm.). However, four decades later the California Department of Fish and Game noted the Upper Truckee River was experiencing erosion problems due to past cattle grazing (CDFG 1957).

Commercial logging first occurred in the Lake Valley portions of the Upper Truckee River watershed in the 1860s (Supernowicz pers. comm.). Harvest data from 1887 to 1890 in T.12N., R.18E indicate a stand composition of Jeffrey pine (*Pinus jeffreyi*), sugar pine (*Pinus lambertiana*), and incense cedar (*Calocedrus* decrurrens) with an average diameter of 67 cm (26.4 in) (see Chapter 2). By 1897 the aforementioned township, and Lake Valley in general, was almost entirely cut over (see Chapter 2; Supernowicz pers. comm.). In 1936, parcels of this township were acquired by the USDA Forest Service from the Carson and Tahoe Timber and Flume Company; this acquisition included both harvested and unharvested lands. The harvested areas included stands or portions of stands that were clearcut as early as 1860, along with other areas that were selectively logged in the 1900s (USDA 1935). Most of the timber harvest occurred on flatter ground, and stands within the same land survey section in which clearcuts occurred were noted to contain trees between 75 and 300 years of age (USDA 1935). The acquisition included two main areas of 'virgin timber.' The 227 ha (560 ac) tract of late seral timber adjacent to the sawmill operated by C. G. Celio and Sons was described as having Jeffrey pine averaging 122 cm (48 in) in diameter at breast height in some areas (USDA 1935). All age classes were represented in this stand with 95 percent of the volume being classified as 'mature and overmature'; the species characteristics for the entire 227 ha (560 ac) tract are described in Table C-1.

By 1996 the stand composition in this area had shifted to Jeffrey pine, lodgepole, white fir, and incense cedar with average diameters of 35.5 to 40.5 cm (14 to 16 in) with the largest diameter being about 76 cm (30 in) (see Chapter 2). (For further discussion of historical land uses, see Chapter 2.)

In general, land use along the Upper Truckee River in the Lake Valley area from the 1850s to the 1920s/1930s was expansive and intensive in nature insofar as logging, ranching, and grazing created openings and meadows where they had not previously existed (Supernowicz pers. comm.). However, after the 1920s/1930s land use patterns changed, and vegetation began to encroach into the openings created during the Comstock Era (Supernowicz pers. comm.). In addition, during the Comstock Era and shortly thereafter, impoundments were placed along the Upper Truckee River and its tributaries to provide water for domestic and/or agricultural use (Supernowicz pers. comm.). Sanders, in his 1932 'Field Correspondence' to Chief Macaulay of the California Department of Natural Resources, Division of Fish and Game, notes the existence of dams along the Upper Truckee River that were used to irrigate cattle pastures in the summer months; during the fall, winter, and spring, gates on these dams were opened to facilitate fish passage (CDFG 1932). Celio (1930) notes the existence of a fish trap built by the Fish Commission on the Upper Truckee. Effects of these impoundments and fish traps on water flows and the aquatic biota are unknown. However, it should be noted that during this same time period, the Mt. Ralston Fish Planting Club was introducing exotic species such as water lilies, water hyacinth, and parrot feather into numerous high elevation lakes (Pierce 1932). They also introduced *Gammarus* (a fresh water shrimp) in shallow lakes and streams in the Lake Tahoe basin area (Pierce 1932). Similarly, during the late 1920s, private individuals were stocking sections of the Upper Truckee River with brook trout (*Salvelinus fontinalis*) supplied by the Fish Commission[1] (Celio 1930). At the urging of the Mt. Ralston Fish Planting Club, the California Division of Fish and Game (which was to become the California Department of Fish and Game) closed the Upper Truckee to fishing in the late 1920s for a period of two to three years (Supernowicz pers. comm., Celio 1930). This closure precipitated a disagreement during the late 1920s and early 1930s between the fish planting club, the California Division of Fish and Game, and private interests in the basin. Neither the extent nor the effect of such introductions and closures is well documented (Supernowicz pers. comm.).

Ecology

The California Department of Fish and Game evaluates water management strategies and manages fish resources in the Upper Truckee River based, in part, on instream fish flow requirements (CDFG 1987). Based on channel morphology, substrate, water flows, and habitat type, the Department has divided the entire 34.6 km (21.5 mi) Upper Truckee River into five segments (Table C-2) (CDFG 1987).

Native fish species presently occurring in the Upper Truckee River include Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*), Lahontan redside

[1]The California Fish and Game Commission and the California Department of Fish and Game are different entities; the California Fish and Game Commission has been in existence since 1870 (CDFG 1999a). Ms. Celio's letter does not clarify the agency affiliation of the 'Fish Commission.'

Table C-1—Timber species characteristics and estimated volume for a timber stand within lands acquired from Carson and Tahoe Timber and Flume Company (USDA 1936).

		DBH				
		Av.		Max.		Estimated Percent cut
Common Name	**Scientific Name**	cm	(in)	cm	(in)	by Species
Jeffrey pine	*Pinus jeffreyi*	76	(30)	127	(50)	66.2
Sugar pine	*Pinus lambertiana*	107	(42)	152	(60)	12.3
White fir	*Abies concolor*	91	(36)	137	(54)	11.3
Red fir	*Abies magnifica*	66	(26)	76	(30)	6.6
Incense cedar	*Calocedrus decurrens*	99	(39)	152	(60)	3.6

Table C-2—Segment lengths and substrate characteristics of the Upper Truckee River as delineated by the California Department of Fish and Game (CDFG 1987).

Segment	Length		Location	Characteristics
1	10.5 km	(6.5 mi)	Lake Tahoe to Angora Creek	silt, sand and mud substrate
2	3.2 km	(2.0 mi)	Angora Creek to Echo Creek	cobble and gravel riffles; sandy pools
3	4.5 km	(2.8 mi)	Echo Creek to Benwood Creek	silt, sand, gravel, and boulder
4	1.8 km	(1.1 mi)	Benwood Creek to the end of Christmas Valley (base of Hawley Grade)	low gradient of approximately 0.7 percent
5	14.6 km	(9.1 mi)	Benwood Creek to the headwaters near Red Lake Peak	5 to 6 percent gradient with interspersed flat meadows

(*Richardsonius egregius*), Paiute sculpin (*Cottus beldingii*), and Tahoe sucker (*Catostomus tahoensis*) (CDFG 1987). Introduced species include brook trout (*Salvelinus fontinalis*), brown bullhead (*Ameiurus nebulosus*), brown trout (*Salmo trutta*), and rainbow trout (*Oncorhynchus mykiss*).

Rainbow trout and Paiute sculpin occur throughout most of the drainage. With the exception of Lahontan cutthroat trout which are stocked in the Upper Truckee River's headwaters, the remaining species generally occur in the lower gradient reaches downstream of the base of Hawley Grade (Segment 4) (CDFG 1987). Spawning and rearing of lake run rainbow trout, brown trout, Lahontan redside, and Tahoe sucker also occur in the lower gradient reaches downstream of the base of Hawley Grade (CDFG 1987). Table C-3 notes the California Department of Fish and Game optimum flow regimes for each of the segments of the Upper Truckee River; these regimes were determined independently for each segment (CDFG 1987).

Adult Lahontan cutthroat of the Heenan Lake strain were introduced annually in Taylor Creek and the Upper Truckee River from 1956 through 1964. However, it is believed that competition from, and to a lesser extent predation by brook trout and other non-native species prevented the establishment of a self-sustaining cutthroat population (Elliott pers. comm.). After the removal of brook trout in 1989, the California Department of Fish and Game restored Lahontan cutthroat trout to 6.4 km (4 mi) of the Upper Truckee River and its tributaries, upstream (south) of the confluence of

Table C-3—California Department of Fish and Game optimum flow regimes for each of the segments of the Upper Truckee River (CDFG 1987).

Segment	Optimization strategy
1	Optimize flows for brown trout spawning and incubation habitat from October 1 to March 31; optimize for rainbow trout spawning and incubation habitat April 1 to July 15; and, optimize for brown trout rearing habitat July 16 to October 1.
2	Optimize flows for lake run rainbow habitat from April 1 and July 15; optimize for rainbow trout rearing habitat July 16 to September 30; and, optimize for brown trout spawning and rainbow trout rearing habitat October 1 to March 30.
3	Optimize flows for rainbow trout spawning and incubation habitat from April 1 to July 15; optimize for rainbow trout rearing habitat from July 16 to September 30; and, optimize for brown trout spawning and rainbow trout rearing habitat October 1 to March 30.
4	Optimize flows for lake run rainbow trout habitat†.
5	The California Department of Fish and Game noted no specific flow objective for Segment 5 in their "Stream Evaluation Report 87-1" (CDFG 1987); however, the California Heritage Trout Program notes that Lahontan cutthroat trout have been restored to the Upper Truckee River, including tributaries, upstream of the confluence with Showers Creek (CDFG 1999b).

† Segment 4 requires maintenance of natural flow conditions all year long.

Showers Creek (CDFG 1987). Since 1989 annual removal efforts have continued and will continue as long as this effort indicates brook trout are present in this portion of the Upper Truckee River (Reiner pers. comm).

Grass Lake Natural Research Area and Osgood Swamp are two *Sphagnum* bogs located with in the Upper Truckee River watershed. For further discussion on these areas, see the account for bogs and fens in this appendix.

Effects of Human Activities

Aquatic communities of the Lake Tahoe basin have undergone a significant transformation since the arrival of Euro-American settlers. Grazing, logging, and development have affected virtually all aquatic ecosystems in the basin, and the stocking of exotic fish in waters in the Lake Tahoe basin (including naturally fishless lakes and drainages) has changed the character of the basin's fishery. Similarly, the Upper Truckee River has undergone notable change during this time period. Construction of the Tahoe Keys subdivision displaced Rowland's Marsh at the river's mouth, and the lower reaches of the Upper Truckee River were channelized and hydrologically modified by the construction of the South Lake Tahoe Airport (CDFG 1963, CWQCB 1999). Additionally, lower portions of the Upper Truckee River watershed have been adversely affected by the urbanization of Tahoe Valley. Activities such as the construction of housing developments, the construction and maintenance of two golf courses and Highway 50 have altered landscape features, changed surface run-off patterns, contributed to degraded water quality and introduced exotic plant species.

Effects from recreational activities to the Upper Truckee River watershed are somewhat difficult to quantify. Some lands in the drainage have been, and are being adversely affected to varying degrees by a variety of uses including dispersed motorized and nonmotorized recreation (USDA 1988). Additionally, concentrated recreation may trample vegetation, adversely affect streambank stability, and degrade water quality. In the past there was expressed concern regarding public access to certain portions of the river. However, recent land acquisitions such as the December 1998 purchase of Sunset Ranch by the California Tahoe Conservancy, will provide for future access (O'Daly pers. comm.). Specific impacts to aquatic and terrestrial components of the watershed from such stream-oriented recreation are difficult to predict, but could be expected to correlate roughly with the degree of development of recreational facilities.

Increasing human population levels in the basin also create other problems. To avoid eutrophication of Lake Tahoe, sewage is currently pumped out of the basin. Treated sewage has spilled several times in recent years along the Luther Pass pipeline that generally runs parallel to the Upper Truckee River, and on November 7, 1996 a spill of 5,000 gallons of treated wastewater went directly into the Upper Truckee (NDWP 1997). In an aquatic environment, wastewater spills have the potential to introduce viral and/or parasitic pathogens, raise bacteria levels, reduce dissolved oxygen, increase suspended solids, and/or stimulate algal blooms (EPA 1996, USGS 1997, USGS 1999). However, wastewater treated at the South Tahoe Public Utility District (STPUD) facility receives secondary treatment[2] and is pressure filtered before transport (Solbrig pers. comm.). Thus, the STPUD treatment facility is considered 'filter secondary' or 'advanced secondary' (Johnson pers. comm). Because such secondary wastewater treatment removes dissolved organic matter, is chlorinated, but does not appreciably reduce nitrates or phosphates, any impacts to the aquatic environment from wastewater spills would be expected to be related to ammonia (20 mg/l) and various chlorine compounds (3 mg/l), as opposed to pathogens (Johnson pers. comm, Solbrig pers. comm.). Given the degree of treatment and considering dilution rates, impacts from small wastewater spills from the STPUD sewage transport line would be expected to be minimal. (To reduce the potential for wastewater spills, the South Tahoe Public Utility District is actively replacing older segments of the sewage transport line [O'Daly pers. comm.].)

Conservation

For approximately the last 15 years, the water quality of tributaries to Lake Tahoe has been monitored to varying degrees by the following agencies and groups: Environmental Protection Agency, Joint Studies Group, Lahontan Region Water Quality Control Board, University of Nevada Reno, Nevada Division of Environmental Protection, Tahoe Research Group, USDA Forest Service, and US Geological Survey (TRPA 1996). Currently such monitoring is carried out by the latter 4 agencies and groups (TRPA 1996). Continuous monitoring data for an array of water quality components are lacking (e.g., pH, turbidity, fecal coliform bacteria). However, data compiled by Tahoe Regional Planning Agency indicate that the Upper Truckee River has exceeded the State of California's acceptable total nitrogen and biologically available iron levels for water years 1989 through 1993 and 1995; California total phosphorus concentrations were exceeded in water years 1981 through 1995 (TRPA 1996).

Pursuant to section 303(d) of the Clean Water Act, the Lake Tahoe watershed (ref. no. 16050101), has been listed by the State of California as a Category I (Impaired) Priority Watershed (CWRCB 1998). As such, it is subject to the Total Maximum Daily Load (TMDL) program. In accordance with section 303(d) criteria, TMDL monitoring levels for sediments and nutrients in the Lake Tahoe watershed are being developed by the Lahontan Region of the California Regional Water Quality Control Board. The Upper Truckee River is not noted on the 303(d) list; however, because of its contribution to the surface inflow to Lake Tahoe, restoration measures are needed to improve lake clarity (CWQCB 1999).

Although many of the water quality issues in the Upper Truckee River watershed are being coordinated at state and local levels, the majority of the watershed is presently managed by the USDA Forest Service, and while there is private ownership, both the USDA Forest Service and the State of California manage a significant portion of those lands immediately adjacent to the river. The

[2] Prior to 1989 wastewater from South Lake Tahoe received tertiary treatment and would meet potable drinking water standards (Solbrig pers. comm.).

California Department of Parks and Recreation manages the majority of state lands; however, several state agencies have agency-specific management priorities for the Upper Truckee River. As noted above, the California Department of Fish and Game manages fish resources based on optimum flow regimes. The Watershed Management Initiative of the California Department of Water Resources has directed their efforts in the Upper Truckee River to reduce sedimentation and nutrification, to restore wetland function, and to restore riparian areas and/or river morphology and function (CDWR 1998). The California Regional Water Quality Control Board is responsible for prioritizing activities in individual watersheds. They have established the following objectives: 1) "to enhance water quality in the Upper Truckee watershed of Lake Tahoe, through a concerted effort of implementing watershed projects improvement"; 2) "Use the Upper Truckee River Focused Watershed Group[3] as a clearinghouse for existing information"; 3) "Implement solutions for restoration of watershed function (related to water quality), as well as a reduction of sediment and nutrient inputs"; 4) "Upper Truckee River Focus Watershed Group, in coordination with Tahoe Citizen Environmental Action network, implements a proactive program of community outreach;" and, 5) "Evaluate water quality response to watershed management efforts to develop more effective implementation strategies" (CWQCB 1999, p. 5-6).

Management direction for those federal lands administered by the Lake Tahoe Basin Management Unit (LTBMU) is guided by the Unit's Land and Resource Management Plan (USDA 1988). The majority of the Upper Truckee watershed lands administered by the LTBMU are included in the Tahoe Valley and Meiss Management Areas. The Tahoe Valley Management Area includes the lower gradient reaches of the Upper Truckee River downstream of the base of Hawley Grade; the Meiss Management Area encompasses those reaches of the Upper Truckee from that point south to the headwaters.

Issues and concerns for the two management areas are quite different. In the Tahoe Valley Management Unit, most of the national forest system land is at the urban interface. As such, many of the management issues involve concerns such as dispersed motorized and nonmotorized recreation, stream-oriented recreation, forest health, and risk of fire (USDA 1988). By contrast, the concerns for Meiss Management Area focus on wildlife management issues; the area is closed to all vehicles and grazing is permitted (USDA 1988). Currently Management Standards for the Meiss Grazing Allotment are being analyzed; the environmental analysis will consider water quality tests on the Upper Truckee River that indicate California standards for fecal coliform bacteria levels were exceeded several times in 1999 due to grazing allotment utilization (O'Daly 1999).

The primary resource management emphasis for the Tahoe Valley Management Area is meeting recreational, scenic and special use demands (USDA 1988). The primary resource management emphasis for the Meiss Management Area is to "…provide a variety of unroaded non-motorized recreation experiences and to protect scenic conditions" (USDA 1988, p. IV-140). Management Practices for both areas include 'nonstructural' and 'structural' fish habitat management strategies. However, the 'Standards and Guidelines' differ as noted in Table C-4. Differences in wildlife management habitat strategies are also noted in Table C-4.

Further protection may lie in the future for the Upper Truckee and its watershed. In February of 1999, the LTBMU Forest Supervisor recommended the National Forest portion of the Upper Truckee River, south of Christmas Valley, for Wild River designation under the Wild and Scenic Rivers Act authority. This recommendation has been forwarded to higher Forest Service levels, and planning direction is in place to protect the river corridor from changes that could adversely affect Congressional Wild River designation. (O'Daly pers. comm.)

[3] To coordinate and focus watershed improvement activities, the California Regional Water Quality Control Board, in cooperation with TRPA, established the Upper Truckee River Focused Watershed Group (UTRFWG) in 1995; the Regional Water Quality Control board serves as the group's facilitator (CWQCB 1999). UTRFWG "…is currently collaborating with the U.S. Army Corps of Engineers (Corps) to develop a comprehensive watershed plan…" (Adair pers. comm).

Table C-4—Lake Tahoe Basin Land and Resource Management Plan Practices, Standards and Guidelines for the Meiss and Tahoe Valley Management Areas† (USDA 1988).

Management Area	Practice	Standard and Guideline
Meiss	Nonstructural Wildlife Habitat Management	Protect or improve wildlife in meadow areas
	Nonstructural Fish Habitat Management	Assist the California Department of Fish and Game in the reintroduction of Lahontan cutthroat trout
	Structural Fish Habitat Management	Improve fish habitat in meadow areas.
Tahoe Valley	Structural Wildlife Habitat Management	Waterfowl nesting islands and tubs at Pope Marsh will be maintained. Tubs will be replaced by nesting islands in cooperation with the California Department of Fish and Game
	Nonstructural and Structural Fish Habitat Management	Improve conditions on the Upper Truckee River for migratory and resident trout.

† For a complete list of Practices, Standards and Guidelines for these areas, please consult the LTBMU Land and Resource Management Plan (USDA 1988).

Additionally, an executive order issued by President Clinton recently directed the Forest Service to prepare an Environmental Impact Statement affording roadless areas, including portions of the Upper Truckee watershed, protection from logging, road building, and other activities. This designation would not change the way the area is currently managed, as those activities are already prohibited (O'Daly pers. comm.).

While the aforementioned management directions provide for general conservation and management strategies, consideration should be given to developing a specific management plan for the Upper Truckee River in the context of how the biological integrity of aquatic ecosystems in the basin would be maintained and improved. Due to the diversity of issues and interests, such a plan should include a concerted effort to involve various local, state, and federal agencies, along with residents and special interest groups.

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Focal Aquatic Ecosystem and Ecologically Significant Area: Bogs and Fens
By Erik M. Holst

Distribution

Bogs

Moyle (1996) classified bogs as 'unique' in the Great Basin Province of the Sierra Nevada, i.e., only one or two examples exist. Burke (1987) noted that bogs were rare in Northern California, occurring in El Dorado, Nevada, Placer, Plumas, and Sierra counties. The following bogs have been noted in the Lake Tahoe basin (see Issue 5, Chapter 5):

Grass Lake (Grass Lake Moss Bog), a true quaking bog, comprises part of the 146 ha (360 acre) Grass Lake Research Natural Area (RNA) and is the largest quaking bog in California; it is located southeast of Lake Tahoe near Luther Pass (Burke 1987).

Osgood Swamp (Osgood Bog), with an area of approximately 6 ha (15 ac), is located south of Lake Tahoe near the bottom of Meyers Grade.

Hell Hole, with an area of approximately 4 to 6 ha (10 to 15 ac) at 2,560 m (8,400 ft) in elevation, is located south of Lake Tahoe and north northeast of Grass Lake.

No studies have been done to confirm the classification of the latter two sites as bogs.

Fens

Moyle (1996) considered fens 'unusual' in the Great Basin Province of the Sierra Nevada. The literature (Burke 1987, USDA 1988) suggests that there are no fens in the basin, a hypothesis supported by Smith (pers. comm.) and Allessio (pers. comm.). However, Sawyer and Keeler-Wolf (1995) note that bogs and fens are often quite difficult to distinguish from one another, and Burke (1987) notes that fens and bogs intergrade with each other. Thus, although the potential for fens exists in the Lake Tahoe basin, none are noted in this account.

Ecology

Bogs

Bogs are ombrotrophic (rain-fed) peat-containing wetland communities typically composed of species of bryophytes such as *Sphagnum* that form in areas with little or no drainage (Hale 1999). Because bogs primarily derive their nutrients directly from precipitation, they are oligotrophic (nutrient poor) (Purdue University 1997, Dennison and Berry 1993). Additionally, the accumulation of dead plant material (peat) and the nutrient poor water makes bogs highly acidic, with a pH between 3.0 and 4.5 (Burke 1987, Gore 1983).

In general, because bogs lack nutrients and mineral soil and are highly acidic, they have a low plant diversity relative to other wetland communities (Dennison and Berry 1993). However, they provide the only suitable habitat for some species in the Lake Tahoe basin. Various species of bryophytes and lichens may be present in bogs; however, *Sphagnum,* with a low mineral nutritional requirement and tolerance for acidic water, tends to dominate, growing in dense mats (UOP 1995). Acidic water is not required by *Sphagnum* (Dennison and Berry 1993), but "*Sphagnum* is capable of altering the chemistry of its environment in the direction of its own optimal growth conditions by releasing hydrogen ions and increasing the acidity of the surrounding water" (UOP 1995).

Dennison and Berry (1993) identify three types of bogs: basin bogs, blanket bogs, and string bogs. *Basin bogs* (also called raised bogs) occupy depressions in the landscape such as former ponds and shallow lakes. Peat develops in these depressions building up layers and emerging above the surrounding landscape, creating a domed profile. Peat can also grow out across the bodies of water forming a floating island of dense *Sphagnum* moss called a quaking bog (Dennison and Berry 1993). *Blanket bogs* grow across the landscape. Generally starting out in shallow depressions, blanket bogs are created as peat spreads out in a layer across the landscape on gentle slopes in association with a water source (Dennison and Berry 1993, Johnson 1985). *String bogs* develop on slopes on undulating topography; they are essentially a series of bogs broken up by pools (Dennison and Berry 1993). In each of these bog types, the final landform is created as peat layers accumulate, divorcing the surface vegetation from the underlying substrate (Dennison and Berry 1993).

The classification of the three bogs noted in this account is in doubt. Of the three bogs noted in this report, the Lake Tahoe Basin Management Unit only has water chemistry data for Grass Lake. With a pH of 5.5 to 6.0 (Stewart 1978), Grass Lake appears less acidic than most bogs (Burke 1987, Gore 1983). However, other chemical characteristics and an analysis of the Grass Lake phytoplankton and zooplankton indicate that it is basically consistent with Midwestern United States bog characteristics (Stewart 1978). No studies examining the water chemistry, physiography, or vegetation of the latter two sites have been done.

Grass Lake (Grass Lake Moss Bog)--Grass Lake has been described as a transition between a fen and a bog, and although water is derived from three permanent streams and several seeps, Grass Lake is considered a *Sphagnum* bog (Burke 1987). It is the largest *Sphagnum* bog in California, and at an elevation of 2,347 m (7,700 ft), it exceeds the characteristic elevational range for Sierran peatlands (Burke 1987).

Grass Lake hosts several bog associated orchids and carnivorous plants. Three species of orchids that occur in the Grass Lake bog are: *Platanthera leucostachys* (white-flowered bog-orchid), *Platanthera sparsiflora* (sparse-flowered bog-orchid), and *Spiranthes romanzoffiana* (Burke 1987). Carnivorous plants include *Dosera rotundifolia* (sundew), *Utricularia minor*, and *Utricularia vulgaris* (common bladderwort) (Burke 1987).

Burke (1987) notes that the bog and associated meadow plant communities of Grass Lake Research Natural Area (RNA) are diverse. Based on the work of Beguin and Major (1975), Burke (1987) noted five wetland plant associations of Grass Lake (Table C-5).

Millar et al. (1996) recognized Grass Lake as a Significant Natural Area.

Osgood Swamp (Osgood Bog)--Osgood Swamp is located near Highway 50 at the base of Flag Pole Peak near the bottom of Meyers grade. Under private ownership in the 1960s, Osgood Swamp was drained; however, after it was acquired by the Forest Service in the 1970s, the natural moraine dam was restored with gabion structures, bringing the water level back to approximately its natural depth (Allessio pers. comm.).

During the early 1990s, the water level in Osgood Swamp lowered allowing lodgepole pine (*Pinus contorta*) to encroach into the meadow area (Derrig pers. comm.). However, by 1997, beaver (*Castor* canadensis) activity reinforced the man-made gabion dams raising the water level and forming a year-round lake (Derrig pers. comm.). Prior to the water level receding in the early 1990s, Derrig (pers. comm.) noted brook trout in Osgood Swamp; however, the lake is presently fishless.

The lake at Osgood is fed by several sources and has one outlet stream. Derrig (pers. comm.) estimated the flow out of Osgood Swamp to vary between 0.06 and 0.34 cubic meters per second (2 and 12 cubic feet per second), depending on the season.

Millar et al. (1996) recognized Osgood Swamp as a Significant Natural Area.

Osgood Swamp is an area of interest to wildflower enthusiasts and botanists. Barbour and Major (1977, p. 620) describe the flora of Osgood Swamp as “similar to that at Grass Lake, but richer in uncommon species." Over 140 species of wildflowers can be found in Osgood Swamp and its environs (Carville 1997). Carville (1997) noted several “highlighted flowers” (flowers of particular appeal) at Osgood Swamp (Table C-6).

Hell Hole--Hell Hole is a boreal bog in a cirque basin with steep granitic walls. Ponds, up to one-quarter acre in size, are scattered throughout the bog. Hell Hole is the location of the only known population of mountain yellow-legged frogs (*Rana muscosa*) in the basin (Manley and Schlesinger in preparation). It is likely that the frogs are able to persist there because the drainage is fishless (Reiner pers. comm) and Hell Hole contains several deep sinkholes that allow frogs and tadpoles to overwinter (Schlesinger pers. comm.). Hell Hole has never been logged, and although it has been grazed, impacts are minimal to moderate (Reiner pers. comm). Although the Hell Hole area has been inventoried and the streams classified, no scientific studies aimed at

Table C-5—Wetland plant associations of Grass Lake (Burke 1987).

Association	Association name	Common name	Primary species
Moss and *Sphagnum*	Drepanoclado-Utricularietum	Brown Moss-Bladderwort	*Drepanocladus fluitans, Utricularia vulgaris*
	Mimulo-Caricetum limnosae	Monkeyflower-Shoresedge	*Carex limosa, Menyanthes trifoliata, Drepanocladus fluitans, Sphagnum squarrosum*
Large Sedge	Caricetum simulato-rostratate	Long & Short-beaked Sedges	*Carex utriculata, Carex simulata,*
	Caricetum simulato-vesicariae	Shortbeak-Inflated Sedge	*Carex vesicaria*
	Caricetum nebraskesis	Nebraska Sedge	*Deschampsia caespitosa, Muhlenbergia filiformis, Aster alpigenus var. andersonii*
Meadow	Junco-nev.-Welecharitetum	Nevada Rush-Spikerush	*Juncus nevadensis, Eleocharis pauciflora, Carex simlata*
	Poa-Caricetum intefrae	Mountain Bluegrass-Smooth Beaked Sedge	*Carex integra, Poa cusicka ssp. epilis, Penstemon oreocharis var. rydbergii, Erigeron penegrinus.*
Shrubby	Kalmino-Pinetum	Alpine Laurel-Lodgepole Pine	*Pinus contorta, Kalmia polifolia ssp. microphylla, Vaccinium uliginosum ssp. occidentale, Salix orestera, Lonicera cauriana, Ledum glandulosa*
	Salicetum rigidae	Willow Thicket	*Salix rigida**
Streamside Ephemeral	Sagino-Gnaphalietum		*Sagina saginoides, Gnaphalium palustre, Rorippa curvisiliqua, Tofieldia occidentalis ssp. occidentalis, Mimulus suksdorfii*
	Torreyochloetum pauciflorae		*Torreyochloea pauciflorae*

*Taxonomy as stated in Burke (1987); not found in other sources.

Table C-6—Highlighted flowers of Osgood Swamp Botanical Preserve (Carville 1997).

Scientific name	Common name
Aconitum columbianum	Monkshood
Triteleia hyacinthina	White brodiaea
Gentianopsis simlex	Hiker's Gentain
Lupinus fulcratus	Green-stipuled lupine
Nuphar luteum ssp. polysepalum	Yellow pond lily
Pyrola minor	Common wintergreen
Sisyrinchium elmeri	Mountain yellow-eyed grass
Sisyrinchium idahoense	Blue-eyed grass

classifying the site have been undertaken (Reiner pers. comm).

Fens

Fens, in contrast to bogs, are minerotrophic peatlands (receiving nutrients from the rock substrate via water flow); they receive nutrients from groundwater as well as precipitation (Sawyer and Keeler-Wolf 1995). The water in fens is less acidic than that of bogs; the pH in fens ranges between 5.0 and 8.0 (Burke 1987, Gore 1983). No fens have been identified in the Lake Tahoe Basin.

Effects of Human Activities

As an RNA, Grass Lake is managed according to the established "Protection and Management Standards" for RNAs (USDA 1994); it is managed to maintain natural processes and biodiversity. It is worth noting that prior to the establishment of Grass Lake as a RNA in 1991, Burke (1987) cited camping and firewood collection as having damaging impacts to the Grass Lake bog. Under present RNA management direction, camping and firewood collection are not permitted; cross country skiing is permitted (USDA 1988). Additionally, the RNA has been withdrawn from mineral entry and excluded from grazing allotments (USDA 1991).

Burke (1987) considered salt run-off from the deicing of Highway 89 to be the most serious impact to the Grass Lake bog. The "Establishment Record for Grass Lake RNA" similarly notes salting to de-ice as a concern and indicates coordination efforts to develop a 'highway maintenance prescription' (USDA 1991); however, the California Department of Transportation states that road salt continues to be used to de-ice Highway 89 adjacent to Grass Lake RNA (Brannon pers. comm.).

Recently it was discovered that a sewer line belonging to the South Tahoe Public Utility District runs through the Grass Lake RNA. The sewer line needs replacing, and although the District has an easement that includes the right to replace it in the present alignment (through the RNA), they have agreed to place the new sewer line along the shoulder of Highway 89 (O'Daly pers. comm.).

Osgood Swamp is included in the Tahoe Valley Management Area of the Lake Tahoe Basin Management Unit Land and Resource Management Plan (USDA 1988). It is managed as a wetland under 'Management Prescription #8,' which states, "Manage wetlands for their watershed, wildlife, fish, and scenic values. The prescription recognizes the critical importance of wetlands in filtering sediment and nutrients before they reach Lake Tahoe. In most situations, protection from disturbance or unnatural encroachment would be the principal action" (USDA 1988, p. IV-48). 'Management Practice 35' of the Lake Tahoe Basin Management Unit Land and Resource Management Plan provides for monitoring and management of Osgood Swamp to protect its special features for possible future evaluation as a special study area such as a RNA (USDA 1988).

Hell Hole is included in the Freel Peak Management Area of the Lake Tahoe Basin Management Unit Land and Resource Management Plan and is recognized as a recreational attraction (USDA 1988). Like Osgood Swamp, Hell Hole is included in 'Management Prescription #8' and 'Management Practice 35' and is being managed and monitored to protect its special features (USDA 1988). Unlike at Osgood Swamp, grazing is permitted in the Hell Hole area (O'Daly pers. comm.). The effects of grazing at Hell Hole have not been quantified, but could include removing riparian vegetation, degrading water quality, trampling vegetation, and eroding stream banks (Moyle et al. 1996).

In general, any human activities that change water flow into or out of bog areas have the potential to seriously degrade or destroy the bog environment. Similarly, activities that change the water chemistry of bogs may adversely affect these wetland communities. At present, management considerations of the above described *Sphagnum* bogs in the Lake Tahoe basin essentially preclude such potentially damaging land use activities. However, other human activities that could potentially degrade bogs in the Lake Tahoe basin include introduction of exotic species, grazing, off-highway vehicle use, mountain biking, equestrian use, firewood collection, and trampling by recreationists.

Conservation

Wetland areas across the lower 48 states have declined 53 percent over approximately the last 200 years (Doyle 1998). Although this overall percentage includes wetlands and riparian areas that were lost to agriculture along mainstem rivers and floodplains, Kondolf et al. (1996) noted that riparian areas in the Sierra Nevada have also been impacted by human activities. Similarly, Moyle (1996, p. 948) noted, "The diversity of natural aquatic habitat types in the Sierra Nevada is in the process of being diminished."

In the Great Basin Province of the Sierra Nevada, *Sphagnum* bogs were found to be 'unique' and of 'special concern' (Moyle 1996) and as such, merit a high degree of conservation. However, as previously noted in this chapter, the first step in the monitoring and conservation of an aquatic system is to have an accurate inventory of their number and locations within the Lake Tahoe basin. The location of three bogs is known, but others, particularly those of smaller size, potentially exist. Thus, it is apparent that while protecting the known *Sphagnum* bogs, additional conservation efforts should include inventory. If other *Sphagnum* bogs are noted in an inventory process, conservation efforts similar to those in place for Grass Lake could be considered.

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Ecologically Significant Area: Deep-water Plant Beds

By Erik M. Holst

Distribution

The deep-water plant bed (macrohydrophyte) assemblage was first documented in Lake Tahoe by Frantz and Cordone (1966) while taking benthic samples using an Ekman grab. They noted deep-water plant beds to a depth of 100 m (328 ft), at which point plant densities decreased, apparently due to the reduction in light. Further analysis by Frantz and Cordone (1967) indicated macrohydrophytes were most dense between approximately 45 m and 105 m (150 and 350 ft) in depth. Beauchamp et al. (1992) noted that each of the two deep water plant beds in the southeast part of Lake Tahoe occupied an area of approximately 2,000 m².

Only two occurrences of deep-water plant beds in Lake Tahoe have been confirmed (see Issue 6, Chapter 5). Complete surveys for these plant beds have not been conducted, but Hall (in preparation) has developed a model of potential locations of deep-water plant beds (see Issue 6, Chapter 5). The model used depth and substrate information from Frantz and Cordone (1967) and Loeb and Hackley (1988) as well as Lake Tahoe bathymetry data (Gardner et al. 1998) to predict the occurrence of deep-water macrophytes in the lake. Preliminary surveys to confirm the presence of these deep-water plant beds are planned (K. Johnson, pers. comm.).

Ecology

Frantz and Cordone (1967) described 6 species of algae, 10 mosses, and 2 liverworts as components of Tahoe's deep-water plant bed assemblage (Table C-7); however, several moss identifications have recently been questioned (Shevock pers. comm.). Macrohydrophyte composition varied with depth. *Chara* was frequent at depths less than 30.5 m (100 ft); bryophytes were prevalent between approximately 31—137 m (100—450 ft), and algae generally occurred at depths of 61—137 m (200—450 ft), (Frantz and Cordone 1967).

The overall distribution of these deep-water macrohydrophytes appears to be controlled by light penetration and substrate type (Frantz and Cordone 1967). This hypothesis is based on plant density, depth, and substrate distribution data. Plants were most abundant under reduced light and did not appear to tolerate light intensities of shallower depths. Deep-water macrohydrophyte densities were low at depths less than 30 m (100 ft) and declined rapidly after approximately 100 m (328 ft) (Frantz and Cordone 1967). Deep-water plant bed distribution appeared to be restricted to substrates consisting of mud and silt (Frantz and Cordone 1967).

Distribution of the plant beds across Lake Tahoe was fairly consistent with the above criteria, the only exception being the presence of *Chara* at a depth of approximately 6 m (20 ft) at the south end of the lake. The presence of this associate of deep-water plant beds was attributed to a substrate formed by deposition of fine sediment by the Upper Truckee River (Frantz and Cordone 1967). Additionally, carbon dioxide levels and thermal considerations resulting from strong currents in shallower depths of Tahoe may influence deep-water plant bed distribution (Frantz and Cordone 1967).

Frantz and Cordone (1996) noted that deep-water plant beds provided habitat for invertebrates, including several species endemic to Lake Tahoe. Further, they noted that the depth distribution of gastropods, plecopterans, and pelecypods essentially correlated with that of the deep-water plant beds. *Capnia lacustra* is a small wingless stonefly that is endemic to Lake Tahoe and is associated with the deep-water macrohydrophyte assemblage (Frantz and Cordone 1996). This unique stonefly spends its entire life cycle at depths ranging from 60 to almost 275 m (200 to 900 ft) in Lake Tahoe (Frantz and Cordone 1996). (For further discussion, see the focal species account for the Lake Tahoe benthic stonefly, Issue 7, Chapter 5.)

Data on the potential impacts to Tahoe's deep-water plant beds by the nonnative crayfish (*Pacifastacus leniusculus*) are incomplete and somewhat conflicting. Frantz and Cordone (1967, p. 713) suggested, "Crayfish may exert some influence on the distribution of exotic plants. They (crayfish) are

Table C-7—Deep-water plants found in Lake Tahoe (Frantz and Cordone 1967)

Category	Family	Taxon	Depth in meters
Chlorophyta	Charophyceae	*Chara contraria*	38.7
	(stoneworts)	*Chara delicatula var. annulata*	7.0—45.7
		Chara delicatula var. barbata	61.0
	Chlorophyceae	*Cladophora glomerata*	59.1—125.3
	(grass-green algae)	*Zoochlorella parasitira*	38.7
Chrysophyta	Xanthophyceae (yellow-green algae)	*Vaucheria sp.*	53.3—110.3
Cyanophyta (blue-green algae)	Myxophyceae	*Schizothrix calcicola*	30.5
Bryophyta	Amblystegiaceae	*Hygrohypnum sp.**	121.9
(mosses)		*Hygrohypnum molle*	68.6—91.1
		Hygrohypnum palustre	88.4
		Leptodictyum riparium	30.5—121.9
		Leptodictyum riparium forma fruitans	76.5
	Brachytheciaceae	*Brachythecium sp.*	104.2
		Eurhynchium sp.	100.3—121.9
	Fissidentaceae	*Fissidens adiantoides*	68.3
		Fissidens grandifrons	74.4—121.9
	Fontinalaceae	*Fontinalis nitida*	121.9
	Neckeraceae	*Porothamnium bigelovii*	100.3—119.5
Hepatophyta	Blepharostomataceae	*Blepharostoma arachnoideum*	100.3—110.3
(liverworts)	Geocalycaceae	*Chiloscyphus fragilis*	60.7—121.9

Species and depth information from Frantz and Cordone (1967). Taxonomy from Schuester (1979) and Vitt (1984).

*Identification not certain

very abundant in Lake Tahoe and are known to feed on vegetation." Beauchamp et al. (1992) documented crayfish to a depth of 40 m (131 ft) in autumn and winter in the vicinity of the macrohydrophytes in the southeast region of Lake Tahoe, but crayfish were not found in the beds of *Chara*. Further research is needed on the potential effects of crayfish grazing.

In addition to providing habitat for invertebrates, deep-water plant beds are used by nonnative fish. Beauchamp et al. (1992) noted lake trout (*Salvelinus namaycush*) spawning over beds of *Chara delicatula*. They further documented lake trout congregating around mounds of macrohydrophytes in the southeast region of Lake Tahoe at a depth of 45—55 m (147.6—180.0 ft) during the months of September, October and November. Given the significance of the introduced lake trout as a Tahoe game fish, this unusual spawning behavior has important fishery management implications; however, little is known of the potential ecological impacts of lake trout to the deep-water macrohydrophyte assemblage.

Frantz and Cordone (1966, 1967, and 1996) provide baseline information regarding the unique deep-water plant bed complex. However, given the decline in Lake Tahoe's clarity since these data were collected (see Chapter 4), changes in this assemblage have no doubt occurred. Detailed, long-term scientific research is needed to assess Tahoe's deep-water macrohydrophytes and their associations. Given the decline in lake clarity and increase in algal growth (discussed below), it is clear that such research and coordination should begin immediately. The contribution of universities toward this scientific research should not be overlooked; to the contrary, land management agencies and academic institutions should both encourage dialogue and coordinate research efforts.

Effects of Human Activities

Data on effects of human activities on Lake Tahoe's deep-water plant beds and their associated benthic invertebrate assemblages are sparse. However, various studies (e.g., Frantz and Cordone

1996, Jassby et al. 1999) have made clear that human activities that lead directly or indirectly to increases in phytoplankton and/or sediment transport will decrease lake clarity; such decreases in clarity will have an adverse impact on deep-water plant beds. As Frantz and Cordone stated (1966, p. 30) stated, "Should further significant enrichment occur, reduced light penetration might permanently eliminate this unique plant community." Recent Lake Tahoe clarity data indicate that the average annual Secchi depth has dropped approximately 7.5 m (24.8 feet) in the last 30 years (Jassby et al. 1999); the 1998 Secchi depth of approximately 20 m (66 ft) was the second worst year on record behind 1997 (UCD 1999). Correspondingly, data indicate that algal growth, which along with suspended fine sediments directly decrease lake clarity and light penetration, has been increasing at a rate of greater than 5 percent per year (Reuter et al. 1996).

Given the dependence of Lake Tahoe's unique deep-water macrohydrophyte assemblage on water clarity, management scenarios that directly or indirectly promote eutrophication or sediment transport should be approached cautiously. Actions such as prescribed fire should, at a minimum, employ Best Management Practices (BMPs) to prevent sediment transport into aquatic systems. Jassby et al. (1999 p. 294) note "[I]n deep lakes such as Tahoe, it is not enough to institute erosion control measures that target total suspended sediment discharge if the relevant-sized (light-attenuating) particles continue to get through unhampered. Indeed, the larger, less important particles are most likely to be removed by watershed management practices, and the resulting improvements to the lake may be far less than anticipated." Thus, there may be a need to reevaluate, redesign, and/or institute new BMPs in order prevent transport of these smaller size particles. Finally, atmospheric deposition or airborne pollutants is known to decrease lake clarity (see Chapters 3 and 4), so management scenarios should also consider impacts to air quality (Jassby et al. 1999, Reuter et al. 1996).

Conservation

Efforts should be made to protect known and discovered deep-water plant beds from anthropogenic stresses. Additionally, management considerations might include actions targeted at improving lake clarity and reducing potentially damaging ecological impacts from introduced fauna and flora.

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Ecologically Significant Area: Aspen
By J. Shane Romsos

Distribution

Quaking aspen (*Populus tremuloides*) is the most widely distributed tree in North America (Howard and Tirmenstein 1996). In the Sierra Nevada, more than 80 percent of aspen is distributed north of the Middle Fork of the San Joaquin River (Potter 1994). In the Lake Tahoe Basin, aspen communities occur infrequently in relatively small and irregularly distributed patches that range from a few square meters to 23 hectares (57 acres) (USDA 1991). Aspen communities can be found at all elevations in the basin except alpine ridgelines, and are most common between 6,230 and 8,000 feet (1920 – 2468 m). The distribution of aspen communities in the basin appears to be related to the availability of a consistent source of moisture. In general, aspens are associated with climates with long and cold winters and a heavy snow pack (Verner 1988).

Potter (1994) identified two quaking aspen plant associations in the central and southern Sierra Nevada: the quaking aspen/California corn lily (*Veratrum californicum*) association (POTR/VECA) and the quaking aspen/mountain pennyroyal (*Monardella odoratissima*) association (POTR/MOOD). The POTR/MOOD association differs from the POTR/VECA association in that it typically occurs on relatively dryer upland sites (Potter 1994). In the Lake Tahoe Basin, both quaking aspen plant associations occur.

Ecology

Key Physical and Biological Characteristics

Aspen communities are good indicators of mesic soil conditions as a high water table during the early part of the growing season is necessary for aspens' establishment and productivity (Verner 1988). Soils that support aspen are derived from volcanic and granitic parent material and stands are typically situated on alluvial and colluvial deposits or glacial outwash deposits (Potter 1994). Topsoils that support aspen range from 5 to 94 cm (2 – 38 inches) deep (average topsoil depth = 30 cm [12 inches]) (Potter 1994) and most productive stands are established on well drained sandy to silt loam soils (Debyle and Zasada 1980). In general, deep soils, finer soil textures, and a low amount of coarse fragments throughout the soil profile support a high water holding capacity thought to be ideal for supporting aspen (Potter 1994). Soils typically lie over fractured parent material, which allows rooting and supplies additional moisture (Potter 1994).

Aspen communities are typically found on gentle to moderate slopes (< 33 percent, averaging 12 to 18 percent), occupy toeslopes, benches and valley-like situations, and do not require a specific aspect as long as solar radiation is moderately high to high (Potter 1994). Streams, creeks, seeps, lake shores, and meadows typify ideal growing conditions for aspen (Verner 1988, Potter 1994). Aspen communities are located within red fir (*Abies magnifica*), Jeffrey pine (*Pinus jeffreyii*), white fir (*Abies concolor*), lodgepole pine (*Pinus contorta*), western juniper (*Juniperus occidentalis*) and mixed conifer zones (Verner 1988, Potter 1994). High aspen cover, with relatively little hardwood and conifer tree species co-dominating, is characteristic of the upper tree canopy in aspen communities (Potter 1994). Aspen can also occur as an understory layer beneath a scattered overstory layer of conifers. Canopy cover is lower in mature aspen stands (25 to 60 percent) than in young and intermediate aged stands (60 to 100 percent) (Verner 1988). Aspens can reach a height of 18 m (60 feet) and a diameter of 0.6 m (2 feet) with extreme tree heights of up to 30 m (100 feet) and diameters of up to 1 m (3 feet) (Verner 1988). Trees within an aspen stand are genetically similar as new individuals are cloned from a few pioneer trees (Verner 1988). Aspens most commonly spread by root suckering (Verner 1988, Howard and Tirmenstein 1996), where stems sprout from roots, and to a lesser extent from seed (Howard and Tirmenstein 1996). Stands are composed of a few to thousands of stems usually in a mosaic of clones of different ages and sizes (Verner 1988).

A shrub layer is generally not predominant in aspen communities. However, creeping snowberry (*Symphoricarpos acutus*), sagebrush (*Artemisia tridentata*), squaw currant (*Ribes cereum*), and Sierra gooseberry (*Ribes roezlii*) are known as shrub associates (Potter 1994).

A rich variety of ground cover plants known as moist site indicators is common in aspen communites (Potter 1994). Ground cover is generally dominated by a mix of mountain sweet-cicely (*Osmorhiza chilensis*), Fendler's meadow rue (*Thalictrum californicum*), arrowhead butterweed (*Senecio triangularis*), California corn lily, Kellogg's bedstraw (*Kelloggia galioides*), Gray's lovage (*Ligusticum grayi*), common yarrow (*Achillea lanuosa*), yellow brodiaea (*Brodiaea lutea*), wandering daisy (*Erigeron peregrinus angustiflolius*), white-flowered *hawkweed (Hieracium albiflorum*), pine-woods lousewort

(*Pedicularis semibarbata*), Parish's yampa (*Perideridia parishii*), western bracken fern (*Pteridium aquilinum*), mountain violet (*Viola purpurea*), Wright's blue-eyed mary (*Collinsia torreyi wrightii*), mountain tansy mustard (*Descurainia richardsonii incisa*), mountain pennyroyal, Anderson's thistle (*Cirsium andersonii*), narrow-leaved collomia (*Collomia linearis*), Jessica's stickseed (*Hackelia jessicae*), Coville's gayophytum (*Gayophytum eriospermum*), California butterweed (*Senecio aroniciodes*), Brewer's angelica (*Angelica breweri*), Sierra wallflower (*Erysimum perenne*), Douglas' knotweed (*Polygonum douglasii*), and mountain mule-ears (*Wyethia mollis*) (Potter 1994).

Successional Stages

Succession proceeds rapidly following natural disturbances such as fire. Typically an herbaceous layer is the first to establish followed by shrub and tree seedlings approximately 5 years after disturbance, given ideal conditions and an absence of grazing (Verner 1988, Howard and Tirmenstein 1996). Within 10 to 15 years, a pole-stage develops and matures within 30 years (Verner 1988). Because aspens are intolerant of shade, shade tolerant conifer species may eventually replace an aspen community (Verner 1988). However, conifer tree invasion into aspen stands is very slow (Verner 1988). Intact stands of aspen have been reported to reach ages of 200 years (Debyle and Zasada 1980).

Contribution to Biological Diversity

Maintaining aspen communities in the Lake Tahoe Basin is critical because they provide important landscape features used by a diversity of wildlife (Manley and Schlesinger in prep.), invertebrates, fungi, and plants (Debyle and Zasada 1980, Verner 1988, Potter 1994). Birds and mammals use aspen for hiding, nesting, thermal cover, and foraging, though they are not entirely dependent on aspen communities (Verner 1988). Young stands of aspen, especially during fall and winter when protein content of aspen is high relative to other shrub species, provides forage for deer (Tew 1970, Bartos and Johnson 1978). Black bears (*Ursus americanus*) forage on berry-producing plants and forbs that establish in the understory of aspen stands and can provide suitable denning sites (DeByle 1985). Lagomorphs eat quaking aspen buds, twigs, and bark year-round (Brinkman and Roe 1975, DeByle 1985). Aspen is an important plant species for beavers (*Castor canadensis*) as stems are used to construct dens and lodges, and leaves, twigs, and bark provide food. Small rodents, including squirrels, pocket gophers, mice and voles, feed on aspen during at least part of the year (Jones and DeByle 1985). The highest densities of rodents in aspen communities are generally found in mature stands (Probst and Rakstad 1987).

Aspen communities attract a variety of bird species due to microclimatic features and physical characteristics. Because aspen communities occur on mesic sites, insect production compared to dryer and adjacent forest and shrubland is greater, making aspen communities more attractive to insectivorous birds (Verner 1988). Brinkman and Roe (1975) reported that aspen were also important for herbivorous birds, such as Ruffed Grouse (*Bonasa umbellus*), because aspen catkins, buds, and leaves provided a substantial and nutritious food source. Not only do aspen communities provide opportunities to forage, they also are suitable for cover and nesting. DeByle (1981) estimated bird densities of 22 to 65 breeding pairs in aspen stands measuring 4 hectares (9.8 acres). Because aspen is a relatively soft wood, and often times is infected with a variety of fungi, many cavity excavating and cavity nesting birds commonly occur in aspen stands during the nesting season. Other birds, such as Dark-eyed Juncos (*Junco hyemalis*) and White-crowned Sparrows (*Zonotrichia leucophrys*), find suitable ground nesting habitat in the leaf litter of aspen. Canopy nesting birds, such as Northern Goshawk (*Accipiter gentilis*), Western Wood-pewee (*Contopus sordidulus*), Western Tanager (*Piranga ludoviciana*), and vireos (*Vireo spp.*) will also nest in aspen groves (DeByle 1985).

Response to Disturbance

Soil type, solar exposure, and disturbance appear to be important for the stability of aspen communities (Verner 1988, Cryer and Murray 1992, Potter 1994). As an aspen stand matures, a nutrient rich mollic soil layer develops. Aspens thrive in this rich humus layer, but over time stands will degenerate without disturbance. As a stand deteriorates, amendments to and nutrients in the organic layer are reduced, and in turn the demise of the stand is perpetuated. Low to moderate intensity burning tends to maintain productive aspen stands on ideal soil types (Schier and Campbell 1978, Howard and Tirmenstein 1996). A deteriorating aspen stand that is burned may be more likely to revert back to a more productive stand because burning increases soil pH and adds organic carbon and nutrients to the soil (Cryer and Murray 1992). Potter (1994) recommends that treatments involving the mechanical pushing of aspen followed by broadcast burning may rejuvenate aspen stands showing stagnation. Heavy grazing by domestic livestock, such as sheep and cattle, and intense overbrowsing by wildlife of young aspen sprouts can retard aspen growth and reproduction (Verner 1988, Greenway 1990, Potter 1994).

Research Needs

We used remotely sensed data to describe the distribution of aspen communities in the Lake Tahoe Basin (Issue 6, Chapter 5). A more intensive effort is needed to map aspen communities and record stand conditions. A modeling exercise might be able to predict the occurrence of aspen communities, which could then be field validated. Opportunities for restoration and regeneration may be highlighted by these exercises. In terms of biological diversity, research is needed to identify what minimum size of aspen community is needed to support a diverse assemblage of taxa.

Effects of Human Activities

Human activity may directly and indirectly affect the integrity of aspen communities. Trail and road development through aspen stands may interrupt natural water and moisture (evapotranspiration) balances, cause fragmentation, cause soil compaction, interrupt soil development, disturb native wildlife, and serve as an import route of non-native plant and animal species. Domestic animal grazing can also significantly retard the regeneration of aspen communities (Verner 1988, Greenway 1990, Potter 1994).

Conservation

According to the TRPA (1986), riparian plant communities are to be restored or expanded whenever and wherever possible to promote habitat for wildlife and improve water quality. The aspen community, because of its association with moist soil conditions, is considered a type of riparian community (Sinclair 1999) and thus is afforded protection under Chapter 74 of the TRPA Code of Ordinances (1987). Chapter 74 of TRPA (1987) does not allow projects or activities that convert riparian communities to urban environments unless such projects or activities are needed to improve vegetation health or fish and/or wildlife habitat improvements.

A conservation strategy that provides for the long-term maintenance of aspen communities will ensure the persistence of the diversity of aspen associated species. Several management strategies can be implemented to improve the quality and longevity of aspen communities, including burning, bulldozing, removing conifers, and clearcutting. In general, prescribed burning can result in vigorous sprouting of aspen although the long-term growth and survival of sprouts depends on the pre-fire carbohydrate level in roots, genetic variation in sprouting ability of clones, fire severity, and season of fire (Bartos and Mueggler 1981, Brown and Simmerman 1986). When carefully done, whole tree bulldozing (or tree pushing) exposes root-wads and can stimulate aspen sprouting (Shepperd 1996). However, when bulldozing operations cause deep cutting of soil and/or compaction, sprouting can be retarded. A rubber-tire skidder with the blade positioned so as not to disturb the soil provided the best results according to Shepperd (1996). Removing invading conifer trees can improve aspen stand vigor by reducing competition for water, nutrients and sunlight. Clearcutting aspen stands has resulted in increased suckering in degenerating aspen stands (Crouch 1981). However, for most vigorous sprouting, clearcutting a large proportion of an aspen stand is required because apical dominance is retained in standing stems.

An assessment of aspen stand quality is an important consideration when implementing a prescription to manage for long-term persistence of aspen communities. A simple prescription of clearcutting or burning a site to meet conservation goals of maintaining the vigor of an aspen community may not be enough. Careful forethought should be given to the treatment sites' characteristics. For example, Schier and Campbell (1978) found that concentrations of phosphorous and percent silt were significantly lower on soils with deteriorating stands than on soils with healthy stands. Thus, soil quality, availability of moisture, stand genetic variation, stand age (size) structure, impacts from grazing and browsing, solar exposure, disease and the effect of conifer encroachment should be considered prior to implementing a plan to manage or restore aspen communities.

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APPENDIX D

DETAILS OF MODELS OF RIPARIAN BIODIVERSITY AND COMMUNITY DIVERSITY

APPENDIX D

DETAILS OF MODELS OF RIPARIAN BIODIVERSITY AND COMMUNITY DIVERSITY

Matthew D. Schlesinger and J. Shane Romsos

Lentic Riparian Areas with High Biodiversity

Aquatic/Riparian Bird Species Richness

Manley and Schlesinger (in prep) detected 41 aquatic/riparian bird species. The best model predicting species richness of aquatic/riparian birds consisted of 9 variables ($F_{9,78} = 24.07$, $P < 0.0001$, adj. $R^2 = 0.70$) (Table D-1).

Table D-1—The best multiple linear regression model used to predict aquatic/riparian/meadow bird species richness around lentic systems in the Lake Tahoe basin. All variables were measured within 200 m of each site, except elevation, measured at the lake or meadow surface, and lentic area.

Variable	B	SE B	Beta	T	Sig T
Elevation (m)	-0.005	0.001	-0.506	-4.955	< 0.0001
Lentic area[a]	0.249	0.087	0.182	2.870	0.0053
Slope	-0.052	0.019	-0.209	-2.826	0.0060
Wooded riparian[b]	2.820	1.180	0.150	2.389	0.0193
Mixed conifer[a]	-1.257	1.257	-0.106	-1.000	0.3202
Meadow[b]	5.307	0.973	0.351	5.453	< 0.0001
Precipitation (cm)	-0.015	0.006	-0.187	-2.342	0.0217
Shrubs[b]	-2.031	0.744	-0.172	-2.731	0.0078
Canopy cover	-0.039	0.013	-0.252	-2.954	0.0041
Intercept	17.910	2.256		7.938	< 0.0001

Notes:
[a] ln (x) or ln (x + 1) transformation applied
[b] Square root transformation applied

The following equation was used to predict aquatic/riparian/meadow bird species richness:

$$ABR' = 17.910 + (-0.005 * \textit{elevation [m]}) + (0.249 * \ln[\textit{lentic area (ha)}]) + (-0.052 * \textit{slope}) + (2.820 * \sqrt{woodedriparian}) + (-1.257 * \ln[\textit{mixed conifer}]) + (5.307 * \sqrt{meadow}) + (-0.015 * \textit{precipitation [cm]}) + (-2.031 * \sqrt{shrubs}) + (-0.039 * \textit{canopy cover}) - (1.282 * \sqrt{2.111})$$

where:

1) ABR' = predicted aquatic/riparian/meadow bird species richness
2) * = multiplied by
3) $\sqrt{\ }$ = square root
4) $\sqrt{2.111}$ = square root of the model's MSE
5) all variables except elevation and area were measured as proportions of land area within 200 m of each lentic unit

ABR' ranged from -4.49 to 10.08 ($\bar{x}$ = 0.55, s.e. = 0.105). The rescaled values ranged from 0 to 1 ($\bar{x}$ = 0.35, s.e. = 0.007) (Figure D-1).

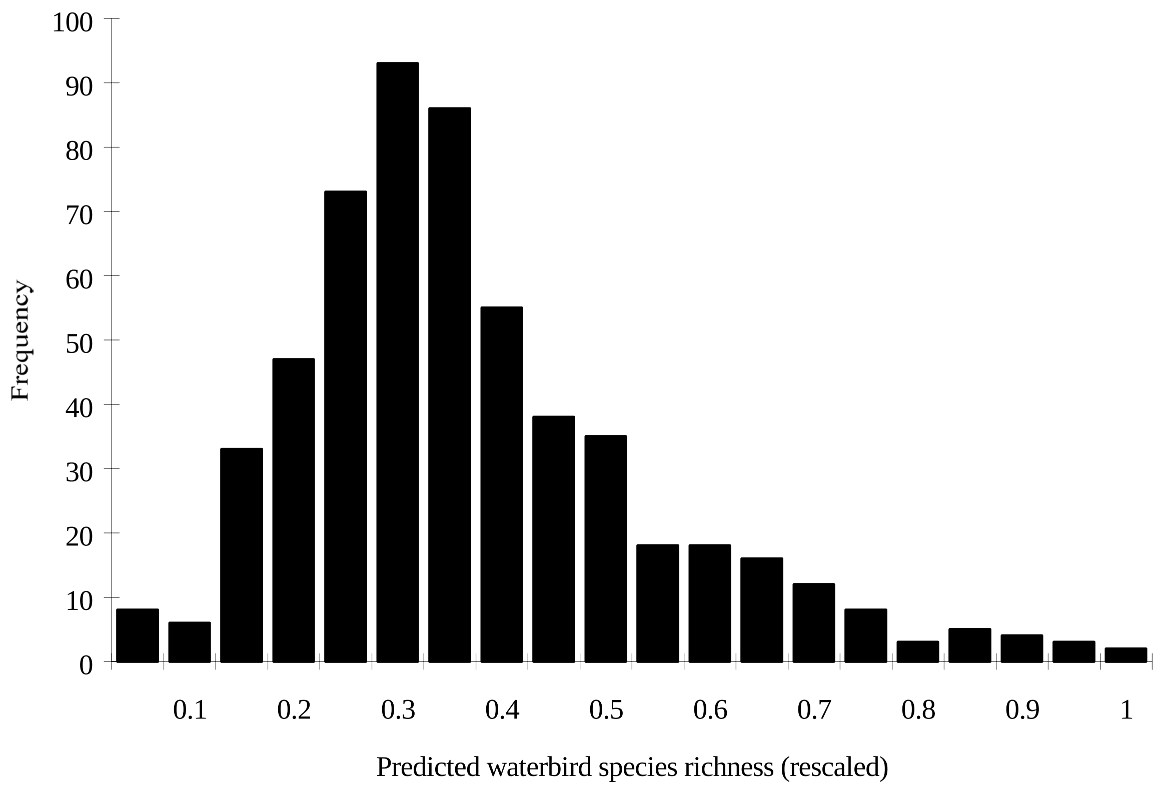

Figure D-1—Distribution of predicted waterbird species richness (rescaled from 0 to 1) around lakes and wet meadows in the Lake Tahoe basin.

Total Bird Species Richness

Manley and Schlesinger (in prep) detected 95 native bird species around lakes and wet meadows (Appendix H). The best model predicting total bird species richness consisted of 6 variables ($F_{6,81}$ = 14.26, P < 0.0001, adj. R^2 = 0.48) (Table D-2).

Table D-2—The best multiple linear regression model in predicting total bird species richness around lentic systems in the Lake Tahoe basin. All variables were measured within 200 m of each site, except elevation, measured at the lake or meadow surface, and lentic area.

Variable	B	SE B	Beta	T	Sig T
Elevation (m)	-0.004	0.002	-0.301	-2.599	0.0111
Lentic area (ha) [a]	0.229	0.159	0.121	1.445	0.1523
Slope	-0.059	0.033	-0.172	-1.795	0.0763
Wooded riparian[b]	6.613	2.083	0.254	3.175	0.0021
Mixed conifer[a]	3.698	1.820	0.225	2.032	0.0455
Meadow[b]	5.999	1.791	0.287	3.349	0.0012
Constant	18.929	3.985		4.750	< 0.0001

Notes:
[a] ln (x+1) transformation applied
[b] Square root transformation applied

The following equation was used to predict total bird species richness:

TBR' = 18.929 + (-0.004 * *elevation* [m]) + (0.229 * ln [*lentic area (ha)*]) + (-0.059 * *slope*) + (6.613 * $\sqrt{woodedriparian}$) + (3.698 * ln [*mixed conifer* + 1]) + (5.999 * $\sqrt{meadow}$) - (1.282 * [$\sqrt{7.158}$])

where:

1) TBR' = predicted total bird species richness
2) * = multiplied by
3) $\sqrt{\ }$ = square root
4) $\sqrt{7.158}$ = square root of the model's MSE
5) all variables except elevation and area were measured as proportions of land area within 200 m of each lentic unit

TBR' ranged from 0.28 to 14.59 ($\bar{x}$ = 7.31, s.e. = 0.126). The rescaled values ranged from 0 to 1 ($\bar{x}$ = 0.49, s.e. = 0.009) (Figure D-2).

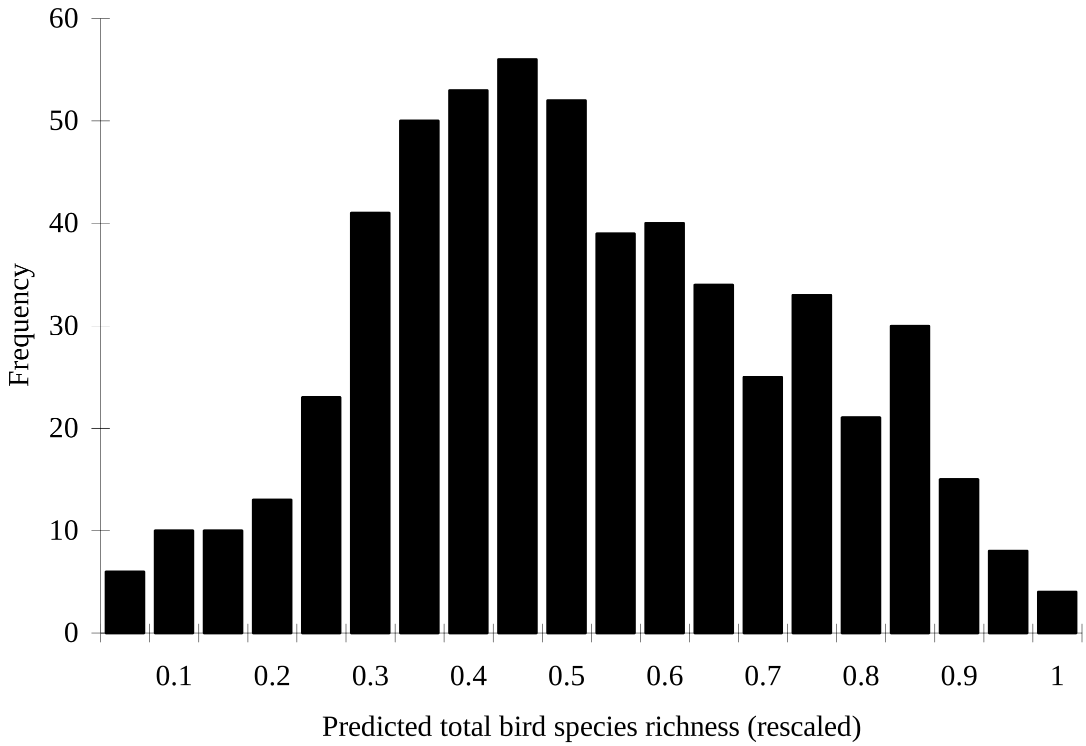

Figure D-2—Distribution of rescaled predicted total bird species richness around lakes and wet meadows in the Lake Tahoe basin.

Lotic Riparian Areas with High Biodiversity

Aquatic/Riparian Bird Species Richness

Manley and Schlesinger (in preparation) detected 39 aquatic/riparian bird species in surveys of lotic riparian areas. The best model predicted total bird species richness consisted of six variables ($F_{6,73} = 15.21$, $P < 0.0001$, adj. $R^2 = 0.52$) (Table D-3).

Table D-3—Multiple linear regression model used to predict bird species richness within lotic corridors (within 300 meters of each side of streams) in the Lake Tahoe basin.

Variables	B	SE B	Beta	T	Sig T
Subalpine conifer	-2.744	2.510	-0.113	-1.093	0.278
Elevation[a]	-10.430	6.189	-0.215	-1.685	0.096
Precipitation[a]	-2.029	1.356	-0.158	-1.497	0.139
Wooded riparian[b]	8.014	3.130	0.227	2.560	0.013
Meadow[b]	12.468	1.944	0.529	6.415	< 0.000
Shrubs[b]	1.861	1.513	0.111	1.230	0.223
Constant	92.516	44.674		2.071	0.042

Notes:
[a] Log-normal transformed
[b] Square-root transformed

The following equation was used to predict aquatic/riparian bird species richness:

$$ABR' = (-2.744 * \textit{subalpine conifer}) + (-10.430 * \ln[\textit{elevation (m)}]) + (-2.029 * \ln[\textit{precipitation (cm)}]) + (8.014 * \sqrt{woodedriparian}) + (12.468 * \sqrt{meadow}) + (1.861 * \sqrt{shrubs}) + 92.516 - (1.282 * \sqrt{7.001})$$

where:

1) ABR' = predicted species richness of aquatic/riparian birds
2) * = multiplied by
3) $\sqrt{\ }$ = square root
4) $\sqrt{7.001}$ = square root of the model's MSE
5) all variables were summarized within 300 m of each stream

ABR' ranged from –4.89 to 16.78 ($\bar{x}$ = 4.03, s.e. = 0.08). The rescaled values ranged from 0 to 1 ($\bar{x}$ = 0.41, s.e. = 0.004; Figure D-3).

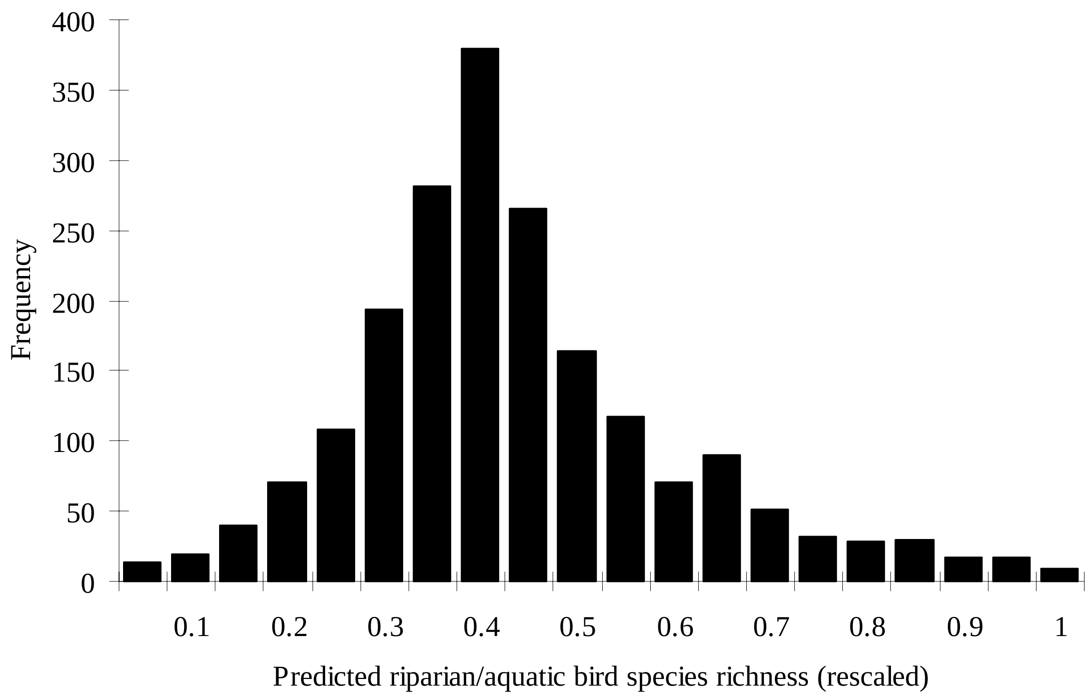

Figure D-3—Distribution of rescaled predicted species richness of riparian/aquatic birds in lotic riparian areas in the Lake Tahoe Basin.

Total Bird Species Richness

Manley and Schlesinger (in prep) detected 101 bird species in surveys of lotic riparian areas (Appendix G). The best model predicting total bird species richness consisted of 5 variables ($F_{5,74} = 6.52$, $P < 0.0001$, adj. $R^2 = 0.26$) (Table D-4).

Table D-4—Multiple linear regression model used to predict total bird species richness within lotic corridors (within 300 meters of each side of streams) in the Lake Tahoe basin.

Variables	B	SE B	Beta	T	Sig T
Precipitation[a]	-7.305	2.902	-0.302	-2.518	0.0140
Wooded riparian[b]	12.408	6.974	0.186	1.779	0.0793
Meadow[b]	12.952	4.988	0.292	2.596	0.0114
Mixed conifer	9.237	4.744	0.322	1.947	0.0553
Canopy cover	-0.128	0.069	0.270	-1.846	0.0689
Constant	62.346	13.795		4.519	< 0.0001

Notes:
[a] Log-normal transformed
[b] Square-root transformed

The following equation was used to predict bird species richness:

$$BR' = (-7.305 * \ln [\textit{precipitation (cm)}]) + (12.408 * \sqrt{woodedriparian}) + (12.952 * \sqrt{meadow}) + (9.237 * \textit{mixed conifer}) + (-0.128 * \textit{canopy cover}) + 62.346 - (1.282 * \sqrt{38.257})$$

where:

1) BR' = predicted bird species richness
2) * = multiplied by
3) $\sqrt{\ }$ = square root
4) $\sqrt{38.257}$ = square root of the model's MSE
5) all variables were summarized within 300 m of each stream

BR' ranged from 12.13 – 42.66 ($\bar{x}$ = 26.68, s.e. = 0.11). The rescaled values ranged from 0 to 1 ($\bar{x}$ = 0.48, s.e. = 0.004; Figure D-4).

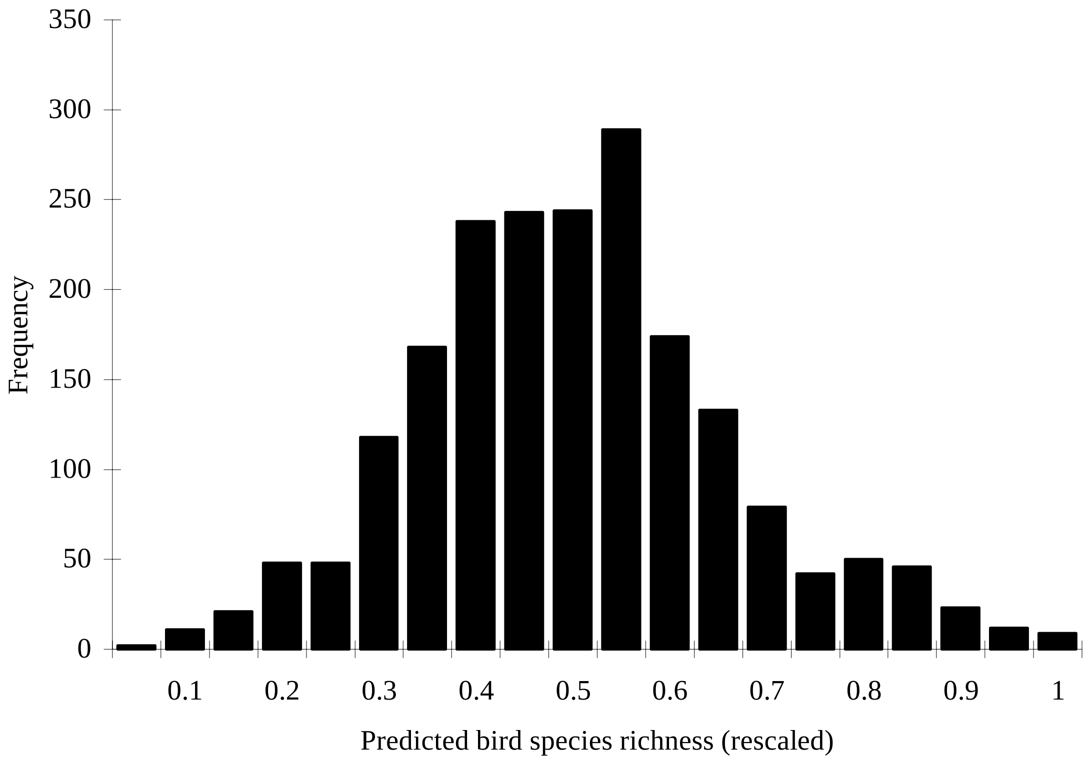

Figure D-4—Frequency distribution of predicted bird species richness (rescaled from 0-1) within 300 m of lotic systems in the Lake Tahoe basin.

Mammal Species Richness

Manley and Schlesinger (in prep) detected 35 mammal species in lotic riparian areas (Appendix G). The best model predicting mammal species richness consisted of seven variables ($F_{7,72}$ = 3.04, P = 0.0075, adj. R^2 = 0.15) (Table D-5).

Table D-5—Multiple linear regression model used to predict mammal species richness in lotic riparian areas (within 100 meters of each side of streams) in the Lake Tahoe basin.

Variables	B	SE B	Beta	T	Sig T
Elevation[a]	0.925	0.225	0.622	4.117	0.0001
Slope[a]	-0.339	0.312	-0.147	-1.086	0.2811
Wooded riparian[a]	3.723	2.407	0.222	1.547	0.1263
Decid/conif riparian[a]	4.200	1.905	0.286	2.205	0.0307
Shrubs[a]	2.732	1.532	0.260	1.784	0.0787
Mixed conifer[b]	4.259	1.749	0.492	2.435	0.0174
Meadow	5.172	2.937	0.326	1.761	0.0825
Constant	-39.473	11.804		-3.344	0.0013

Notes:
[a] Square-root transformed
[b] Arcsine of square-root transformed

The following equation was used to predict mammal species richness within lotic corridors:

$$MR' = (0.925 * \sqrt{elevation}) + (-0.339 * \sqrt{slope}) + (3.723 * \sqrt{woodedriparian}) + (4.200 * \sqrt{dcriparian}) + (2.732 * \sqrt{shrubs}) + (4.259 * \text{arcsine}[\sqrt{mixedconifer}]) + (5.172 * meadow) - 39.473 - (1.282 * \sqrt{6.241})$$

where:

1) MR' = predicted species richness of mammals
2) * = multiplied by
3) $\sqrt{\ }$ = square root
4) $\sqrt{6.241}$ = square root of the model's MSE
5) all variables were summarized within 100 m of each stream

MR' ranged from –2.72 to 10.29 ($\bar{x}$ = 5.24, s.e. = 0.04). The rescaled values ranged from 0 to 1 ($\bar{x}$ = 0.61, s.e. = 0.003) (Figure D-5).

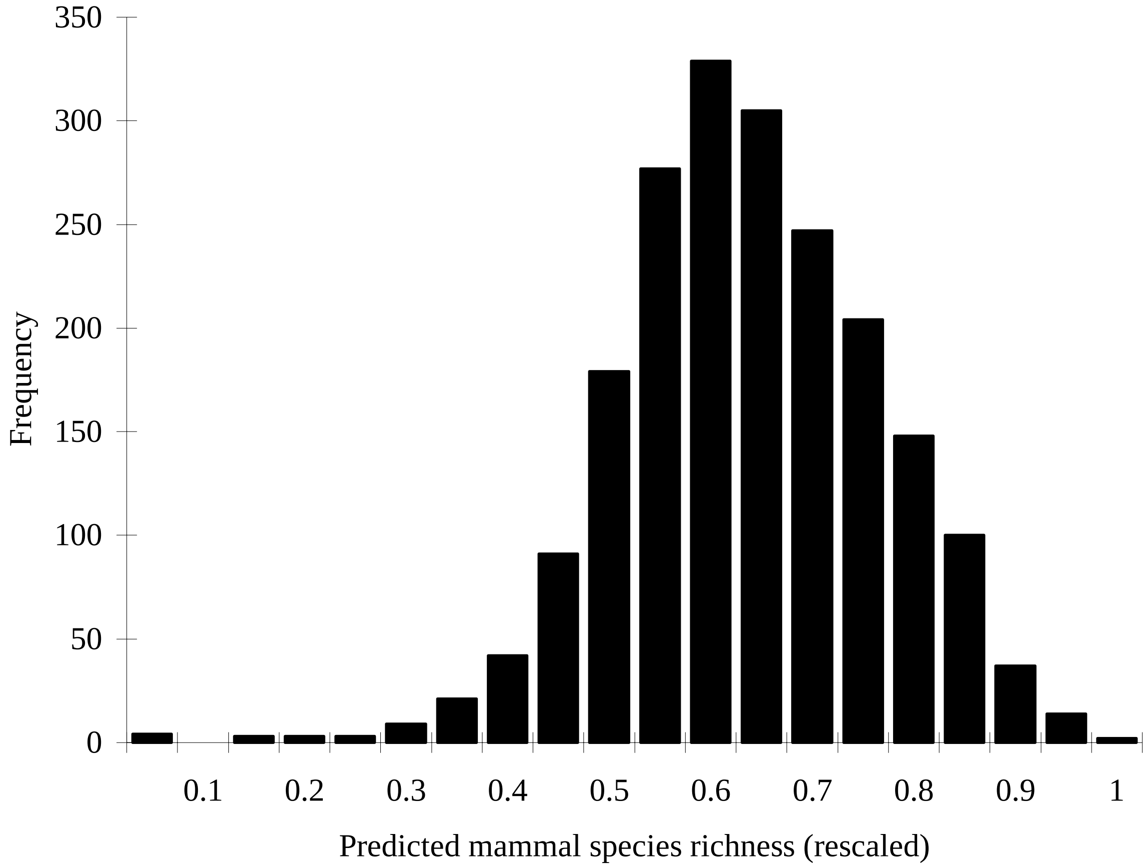

Figure D-5—Frequency distribution of predicted mammal species richness (rescaled from 0-1) within 100 m of lotic systems in the Lake Tahoe basin.

Vascular Plant Species Richness

Manley and Schlesinger (in prep) detected 471 vascular plant species in surveys of lotic riparian areas (see Appendix E). The best model predicting total bird species richness consisted of 10 variables ($F_{10,69}$ = 7.18, $P <$ 0.0001, adj. R^2 = 0.44) (Table D-6). Other variables might also be good predictors of vascular plant species richness, but were not available at the time of this analysis.

Table D-6—Multiple linear regression model used to predict vascular plant species richness within lotic corridors (within 30 m of each side of streams) in the Lake Tahoe basin.

Variables	B	SE B	Beta	T	Sig T
Wooded riparian	42.269	11.156	0.554	3.789	0.0003
Precipitation[a]	27.148	5.821	0.439	4.664	< 0.0001
Decid/conif riparian[b]	33.801	9.768	0.529	3.460	0.0009
Meadow[b]	25.259	12.901	0.348	1.958	0.0543
Shrubs[b]	20.984	9.804	0.246	2.140	0.0359
Mixed conifer[c]	23.799	9.339	0.413	2.548	0.0131
Gravelly alluvial land	14.145	7.190	0.171	1.967	0.0532
Inville soils	-41.395	13.887	-0.257	-2.981	0.0040
Meiss soils	-20.874	9.205	-0.200	-2.268	0.0265
Umpa soils	-9.880	6.134	-0.139	-1.611	0.1118
Constant	-93.255	30.554		-3.052	0.0032

Notes:
[a] log-normal transformed
[b] square-root transformed
[c] arcsine of square-root transformed

The following equation was used to predict vascular plant species richness:

$$VPR' = (42.269 * \text{wooded riparian}) + (27.148 * \ln[\textit{precipitation}]) + (33.801 * \sqrt{dcriparian}) + (25.259 * \sqrt{meadow}) + (20.984 * \sqrt{shrubs}) + (23.799 * \text{arcsine}[\sqrt{mixedconifer}]) + (14.145 * \textit{gravelly alluvial land}) + (-41.395 * \textit{Inville soils}) + (-20.874 * \textit{Meiss soils}) + (-9.880 * \textit{Umpa soils}) - 93.225 - (1.282 * \sqrt{190.617})$$

where:

1) VPR' = predicted vascular plant richness
2) * = multiplied by
3) $\sqrt{\ }$ = square root
4) $\sqrt{190.617}$ = square root of the model's MSE
5) all variables were summarized within 300 m of each stream

VPR' ranged from –18.22 to 92.69 ($\bar{x}$ = 49.42, s.e. = 0.351). The rescaled values ranged from 0 – 1 ($\bar{x}$ = 0.61, s.e. = 0.003) (Figure D-6).

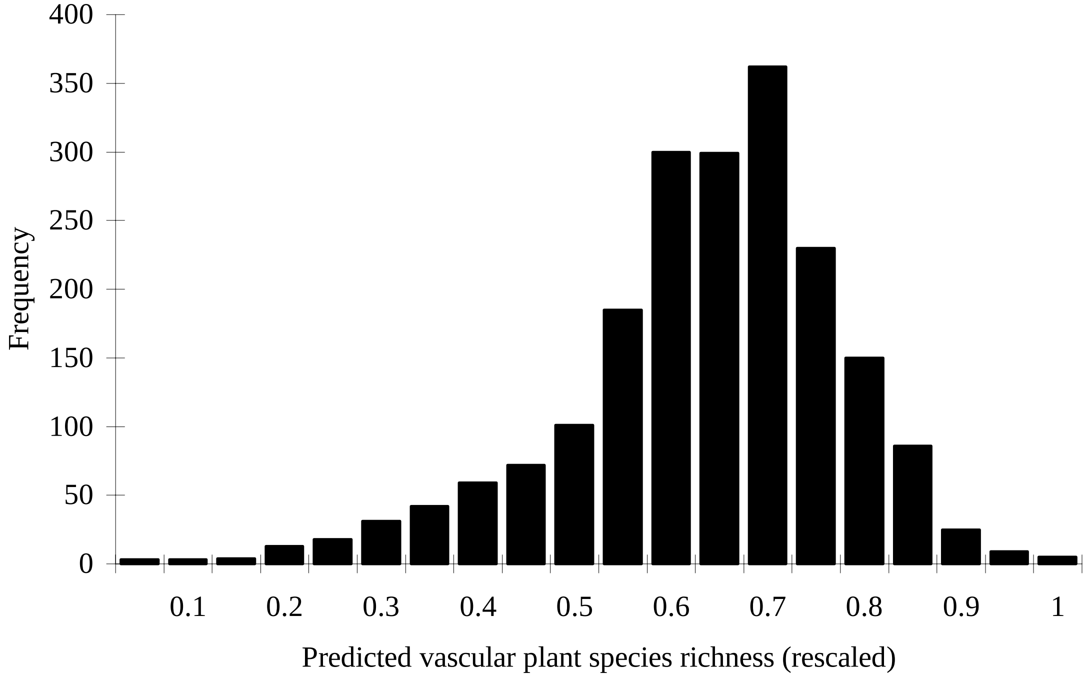

Figure D-6—Frequency distribution of predicted vascular plant species richness (rescaled from 0-1) within 30 m of lotic systems in the Lake Tahoe basin.

Community Diversity

The best regression model describing community diversity consisted of five variables (elevation, precipitation, slope, distance to stream, and distance to lake ($F_{5,129933}$ = 9938.36, $P < 0.0001$, adj. $R^2 = 0.28$) (Table D-7).

Table D-7—The best regression model describing plant community diversity in the Lake Tahoe Basin.

Variables	B	SE B	Beta	T	Sig T
Precipitation	0.0137	0.000309	0.177081	44.287	< 0.0001
Elevation	0.0004	0.000015	0.120597	27.136	< 0.0001
Distance to stream	-0.0001	0.000001	-0.280046	-94.085	< 0.0001
Distance to lake	-0.0001	0.000003	-0.066567	-21.367	< 0.0001
Percent slope	0.0537	0.001744	0.100100	30.766	< 0.0001
Constant	0.5799	0.025862		22.423	< 0.0001

Notes:
[a] log-normal transformed
[b] square-root transformed
[c] arcsine of square-root transformed

Appendix E

Vascular Plants of the Lake Tahoe Basin

APPENDIX E

VASCULAR PLANTS OF THE LAKE TAHOE BASIN

Erik M. Holst and Sheryl L. Ferguson

Table E-1—Documented and potential vascular plant species of the Lake Tahoe basin. Reliability codes: 1 = high--documented occurrence; 2 = moderate--potentially occurring based on at least 2 sources; and 3 = low--potentially occurring based on a single source. TESC = Federal or State threatened, endangered, or special concern. Rare = rare - highly restricted or rare - limited occurrence (Skinner and Pavlick 1994, Dennis 1995). Sierra Nevada endemic status is from Shevock (1996). Harvest codes: CH = commercial harvest, M = medicinal, WH = Washoe use. Agency emphasis = TRPA special interest or USDA Forest Service sensitive. Sources: Smith (1973, 1983), Manley and Schlesinger (in prep), and USDA (1995a). All taxa in Dennis (1995) except for those noted with a *.

			Ecological Criteria				Cultural Criteria		Source		
Scientific name	Common name	Reliability	T,E,SC	Rare	SN endemic	Exotic	Harvest	Agency emphasis	Smith	Manley Schlesinger	USDA
Abies concolor	White fir	1					CH, WH,M		X	X	
Abies magnifica	California red fir	1					CH		X	X	
Abies magnifica var. *magnifica*	California red fir	1					CH		X	X	
Abronia turbinata	Transmontane sand verbena	3					M				
Acer glabrum	Rocky Mountain maple	1					M		X	X	
Acer glabrum var. *torreyi*	Torrey's maple	1					M		X		
Achillea millefolium	Yarrow	1					WH, M		X	X	
Achnatherum hymenoides	Indian ricegrass	1							X		
Achnatherum lemmonii	Lemmon's needlegrass	3									
Achnatherum lettermanii	Formerly "Stipa lettermanii"	1							X	X	
*Achnatherum nelsonii**		3									
Achnatherum nelsonii ssp. *dorei*	Dore's needlegrass, Williams needlegrass	3									
Achnatherum nevadense	Nevada needlegrass	3									
Achnatherum occidentalis	Western needlegrass	1							X	X	

			Ecological Criteria				Cultural Criteria		Source		
Scientific name	**Common name**	**Reliability**	**T,E,SC**	**Rare**	**SN endemic**	**Exotic**	**Harvest**	**Agency emphasis**	**Smith**	**Manley Schlesinger**	**USDA**
Achnatherum occidentalis ssp. *californicum*	California needlegrass	1							X		
Achnatherum occidentalis ssp. *pubescens*	Elmer's needlegrass	1							X		
Achnatherum pinetorum	Pine stipa	1							X		
Achnatherum thurberianum	Thurber's needlegrass	3									
Achnatherum webberi	Webber's needlegrass	3									
Aconitum columbianum	Monkshood	1							X	X	
Actaea rubra	Baneberry	1					M		X	X	
Adenocaulon bicolor	American trailplant	1					M		X	X	
Adiantum aleuticum	Five-fingered fern	1					M		X	X	
Adiantum capillus-veneris	Southern maiden	1					M			X	
Agastache parvifolia	Small-leaved horsemint	1								X	
Agastache urticifolia	Nettleleaf giant hyssop	1							X	X	
Ageratina occidentalis	Western snakeroot	1							X	X	
Agoseris aurantiaca	Orange agoseris	1					M		X		
Agoseris elata	Tall agoseris	1							X	X	
Agoseris glauca	Glaucous mountain-dandelion	1							X	X	
Agoseris glauca var. *laciniata*	False agoseris	3									
Agoseris glauca var. *monticola*	Pale agoseris	3									
Agoseris grandiflora	Bigflower agoseris	1							X		
Agoseris heterophylla	Annual agoseris	1							X	X	
Agoseris retrorsa	Spearleaf agoseris	1							X	X	
Agropyron desertorum	Desert wheatgrass	1				X			X	X	
Agrostis exarata	Spike bentgrass	1							X	X	
Agrostis gigantea	Giant mountain-dandelion	1				X			X		
Agrostis humilis	Mountain bentgrass	1		X					X		
Agrostis idahoensis	Idaho bentgrass	1							X		
Agrostis oregonensis	Oregon bentgrass	1							X		
Agrostis pallens	Seashore bentgrass	1							X		
Agrostis scabra	Rough bentgrass	1							X		

			Ecological Criteria				Cultural Criteria		Source		
Scientific name	**Common name**	**Reliability**	**T,E,SC**	**Rare**	**SN endemic**	**Exotic**	**Harvest**	**Agency emphasis**	**Smith**	**Manley Schlesinger**	**USDA**
Agrostis stolonifera	Creeping bentgrass	1				X			X		
Agrostis thurberiana	Thurber's bentgrass	1							X		
Agrostis variabilis	Mountain bentgrass	1							X		
Allium anceps	Twinleaf onion	3									
*Allium bisceptrum**		3									
Allium bisceptrum var. *bisceptrum*	Twincrest onion	3					WH, M				
Allium campanulatum	Dusky onion	1							X	X	
Allium obtusum		1							X		
Allium parvum	Small onion	3									
Allium platycaule	Broadstemmed onion	1							X		
Allium validum	Pacific onion	1					WH		X	X	
Allophyllum gilioides	Dense false gilia	1							X		
Allophyllum gilioides ssp. *gilioides*	Dense false gilia	3									
Allophyllum gilioides ssp. *violaceum*	Dense false gilia	1							X		
Allophyllum integrifolium	White false gilia	1							X		
Allotropa virgata	Sugarstick	1							X	X	
*Alnus incana**		1							X	X	
Alnus incana ssp. *tenuifolia*	Mountain alder	1					M		X	X	
Alnus rhombifolia	White alder	1					M			X	
Alopecurus aequalis	Shortawn foxtail	1							X	X	
Amaranthus californicus	California amaranth	3									
Ambrosia acanthicarpa	Flatspine burr ragweed	1							X		
Amelanchier alnifolia	Service-berry	1					M, WH		X	X	
Amelanchier alnifolia var. *pumila*	Service-berry	1					M		X		
Amelanchier utahensis	Utah service-berry	1					M		X	X	
Amsinckia tessellata	Devil's lettuce	3									
Anaphalis margaritacea	Pearlyeverlasting	1					M		X	X	
*Androsace septentrionalis**		3									
Androsace septentrionalis ssp. *subumbellata*	Pygmyflower rockjasmine	3					M				

			Ecological Criteria				Cultural Criteria		Source		
Scientific name	**Common name**	**Reliability**	**T,E,SC**	**Rare**	**SN endemic**	**Exotic**	**Harvest**	**Agency emphasis**	**Smith**	**Manley Schlesinger**	**USDA**
Anelsonia eurycarpa	Daggerpod	1			X				X		
Anemone drummondii	Drummond's anemone	1							X		
Anemone occidentalis	White pasqueflower	1					M		X		
Angelica breweri	Brewer's angelica	1					WH		X	X	
Angelica californica	California angelica	1								X	
Antennaria argentea	Silver pussytoes	1							X	X	
Antennaria corymbosa	Flattop pussytoes	1							X		
Antennaria dimorpha	Low pussytoes	1							X		
Antennaria geyeri	Pussytoes	1							X	X	
Antennaria media	Rocky Mountain pussytoes	1							X		
Antennaria pulchella	Pussytoes	3		X							
Antennaria rosea	Rosy pussytoes	1					M		X	X	
Antennaria rosea ssp. *confinis*	Rosy pussytoes	3					M				
Antennaria umbrinella	Umber pussytoes	1							X		
Antirrhinum leptaleum	Spurred toadsmouth	3									
Antirrhinum vexillo-calyculatum		3									
Apocynum androsaemifolium	Mountain dogbane, smooth mountain dogbane	1					M		X	X	
Apocynum cannabinum	Indianhemp	3					M				
Aquilegia formosa	Western columbine	1					M		X	X	
Arabis davidsonii	Davidson's rockcress	3									
Arabis drummondii	Drummond's rockcress	1							X		
Arabis glabra	Tower rockcress	1					M		X	X	
Arabis glabra var. *glabra*	Tower rockcress	3					M				
Arabis hirsuta	Hairy rockcress	3									
Arabis hirsuta var. *glabrata*	Mountain rockcress	3									
Arabis hirsuta var. *pycnocarpa*	Hairy rockcress	3									
Arabis holboellii	Holboell's rockcress	1								X	
Arabis holboellii var. *pendulocarpa*	Dropseed rockcress	1							X		
Arabis holboellii var. *pinetorum*	Holboell's rockcress	1							X		

			Ecological Criteria				Cultural Criteria		Source		
Scientific name	**Common name**	**Reliability**	**T,E,SC**	**Rare**	**SN endemic**	**Exotic**	**Harvest**	**Agency emphasis**	**Smith**	**Manley Schlesinger**	**USDA**
Arabis holboellii var. *retrofracta*	Second rockcress	1							X		
Arabis lemmonii	Lemmon's rockcress	1							X		
Arabis lemmonii var. *depauperata*	Soldier rockcress	1							X		
Arabis lemmonii var. *lemmonii*	Lemmon's rockcress	1							X		
Arabis lyallii	Lyall's rockcress	1							X		
Arabis lyallii var. *lyallii*	Lyall's rockcress	3									
Arabis lyallii var. *nubigena*	Lyall's rockcress	3									
Arabis platysperma	Pioneer rockcress	1							X		
Arabis platysperma var. *howellii*	Howell's pioneer rockcress	1							X		
Arabis platysperma var. *platysperma*	Pioneer rockcress	1							X		
Arabis puberula	Silver rockcress	1							X		
Arabis pulchra	Beauty rockcress	3									
Arabis pulchra var. *pulchra*	Desert rockcress	3									
*Arabis rectissima**		1							X	X	
Arabis rectissima var. *rectissima*	Bristlyleaf rockcress	1							X	X	
Arabis repanda	Yosemite rockcress	1							X		
Arabis repanda var. *repanda*	Yosemite rockcress	3									
Arabis rigidissima	Trinity Mountain rockcress	3									
Arabis rigidissima var. *demota*	Galena Creek rockcress	3	X	X	X			X			
Arabis sparsiflora	Sicklepod rockcress	1							X		
Arabis sparsiflora var. *sparsiflora*	Sicklepod rockcress	3									
Arabis suffrutescens	Woody rockcress	1							X		
Arabis suffrutescens var. *suffrutescens*	Woody rockcress	3									
*Arabis Xdivaricarpa**	Spreadingpod rockcress	3									
Arceuthobium abietinum	Fir dwarf-mistletoe	3									
Arceuthobium americanum	American dwarf mistletoe	1					M		X		
Arceuthobium californicum	Sugar pine dwarf mistletoe	3									
Arceuthobium campylopodum	Western dwarf mistletoe	1					M		X	X	
Arctostaphylos nevadensis	Pinemat manzanita	1					WH, M		X	X	

			Ecological Criteria				Cultural Criteria		Source		
Scientific name	**Common name**	**Reliability**	**T,E,SC**	**Rare**	**SN endemic**	**Exotic**	**Harvest**	**Agency emphasis**	**Smith**	**Manley Schlesinger**	**USDA**
*Arctostaphylos nevadensis x patula**		1							X		
Arctostaphylos patula	Greenleaf manzanita	1					M, WH		X	X	
Arenaria aculeata	Prickly sandwort	1							X		
Arenaria congesta	Ballhead sandwort	1					M		X		
Arenaria congesta var. *congesta*	Ballhead sandwort	3					M				
Arenaria congesta var. *crassula*	Ballhead sandwort	3					M				
Arenaria congesta var. *subcongesta*	Subcongesta sandwort	1					M		X		
Arenaria congesta var. *suffrutescens*	Suffrutescent sandwort	1					M		X		
*Arenaria kingii**		1							X		
Arenaria kingii var. *glabrescens*	Prickly sandwort	1							X		
Argemone munita	Flatbud pricklypoppy	3					M				
Arnica amplexicaulis	Clasping arnica	3									
*Arnica chamissonis**		1							X	X	
Arnica chamissonis ssp. *foliosa*	Chamisso arnica	1							X	X	
Arnica cordifolia	Heartleaf arnica	1					M		X	X	
Arnica discoidea	Rayless arnica	1							X		
Arnica diversifolia	Rayless arnica	1							X		
Arnica latifolia	Broadleaf arnica	1					M		X		
Arnica longifolia	Spearleaf arnica	1							X	X	
Arnica mollis	Hairy arnica	1							X	X	
Arnica nevadensis	Nevada arnica	1							X		
Arnica parryi	Parry's arnica	1							X		
Arnica sororia	Twin arnica	1		X						X	
Arnica tomentella	Recondite arnica	1							X		
Artemisia arbuscula	Low sagebrush	1							X		
Artemisia arbuscula ssp. *arbuscula*	Gray low sagebrush	3									
*Artemisia cana**		3									
Artemisia cana ssp. *bolanderi*	Silver sagebrush	3					M				
Artemisia douglasiana	Douglas' sagewort	1					M		X	X	

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Artemisia dracunculus	Tarragon	1					M		X		
Artemisia ludoviciana	Louisiana sagewort	1					M		X		
Artemisia ludoviciana ssp. *candicans*	Gray sagewort	3					M				
Artemisia ludoviciana ssp. *incompta*	Mountain sagewort	1					M		X		
Artemisia ludoviciana ssp. *ludoviciana*	Foothill sagewort	3					M				
*Artemisia norvegica**		1							X		
Artemisia norvegica ssp. *saxatilis*	Boreal sagewort boreal sagebrush	1							X		
Artemisia nova	Black sagebrush	3					M				
Artemisia rothrockii	Timberline sagebrush	1							X		
Artemisia tridentata	Big sagebrush	1					M		X	X	
Artemisia tridentata ssp. *tridentata*	Basin big sagebrush	3					M				
Artemisia tridentata ssp. *vaseyana*	Mountain big sagebrush	3					M				
Artemisia tridentata ssp. *wyomingensis*	Wyoming big sagebrush	3					M				
Asarum hartwegii	Hartweg's wildginger	3									
Asclepias cordifolia	Heartleaf milkweed	1							X		
Asclepias eriocarpa	Woollypod milkweed	3					M				
Asclepias speciosa	Showy milkweed	1					M		X		
Aspidotis densa	Indian's dream	1							X	X	
Asplenium trichomanes-ramosum	Green spleenwort	1								X	
*Aster alpigenus**		1							X	X	
Aster alpigenus var. *andersonii*	Anderson's aster	1						X	X	X	
Aster ascendens	Chilean aster	1							X		
Aster breweri	Brewer's aster	1							X	X	
Aster campestris	Meadow aster	1							X		
Aster eatonii	Eaton's aster	1							X		
*Aster foliaceus**		1							X		
Aster foliaceus var. *lyallii*	Lyall aster	3					M				
Aster foliaceus var. *parryi*	Parry's Aster	1					M		X		
Aster frondosus	Leafy rayless aster short-rayed	3					M				

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	alkali aster										
Aster integrifolius	Thickstem aster	1							X	X	
Aster occidentalis	Western aster	1							X	X	
Aster occidentalis var. *occidentalis*	Western aster	1							X		
Aster occidentalis var. *yosemitanus*	Western bog aster	1							X		
Aster oregonensis	Oregon aster	1							X		
Aster peirsonii	Peirson's aster	1			X					X	
Aster scopulorum	Alpine ionactis	3									
Astragalus andersonii	Anderson's milkvetch	1							X		
Astragalus austiniae	Austin's milkvetch	1			X				X		
Astragalus bolanderi	Bolander's milkvetch	1							X		
*Astragalus canadensis**		3									
Astragalus canadensis var. *brevidens*	Shorttooth Canadian milkvetch	3					M				
*Astragalus curvicarpus**		3									
Astragalus curvicarpus var. *curvicarpus*	Curvepod milkvetch	3									
*Astragalus iodanthus**		3									
Astragalus iodanthus var. *iodanthus*	Humboldt River milkvetch	3									
Astragalus lemmonii	Lemmon's milkvetch	3									
Astragalus lentiginosus	Specklepod milkvetch	1					M		X		
Astragalus lentiginosus var. *ineptus*	Speckledpod milkvetch	3					M				
Astragalus malacus	Shaggy milkvetch	3									
Astragalus purshii	Woollypod milkvetch	1					M		X		
Astragalus purshii var. *lectulus*	Woollypod milkvetch	3					M				
Astragalus purshii var. *purshii*	Pursh's milkvetch	3					M				
Astragalus purshii var. *tinctus*	Woollypod milkvetch	3					M				
Astragalus whitneyi	Balloon pod milkvetch	1							X		
Astragalus whitneyi var. *confusus*	Conelike milkvetch	3									
Astragalus whitneyi var. *lenophyllus*	Balloon pod milkvetch	3			X						
Astragalus whitneyi var. *whitneyi*	Whitney's milkvetch	3									

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*Athyrium alpestre**		1							X	X	
Athyrium alpestre var. *americanum*	American alpine lady fern alpine lady-fern	1							X	X	
*Athyrium filix-femina**		1							X	X	
Athyrium filix-femina var. *cyclosorum*	Subarctic ladyfern	1					M		X	X	
Atriplex canescens	Fourwing saltbush	3					M				
Atriplex canescens ssp. *canescens*	Shadscale	3					M				
Atriplex truncata	Wedgescale saltbush	3									
Azolla mexicana	Mexican azolla	3		X							
Balsamorhiza sagittata	Arrowleaf balsamroot	1					M, WH		X	X	
Barbarea orthoceras	American yellowrocket	1					WH		X	X	
Bassia hyssopifolia	Fivehorn smotherweed	1							X		
Berberis aquifolium	Hollyleaved barberry	1					M			X	
Berberis aquifolium var. *aquifolium*	Oregon grape	3					M				
Betula occidentalis	Water birch	1							X		
Bolandra californica	Sierra false coolwort	1		X					X		
Boschniakia strobilacea	California groundcone	3									
Botrychium ascendens	Trianglelobe moonwort	3		X				X			
Botrychium multifidum	Leathery grapefern	1								X	
Botrychium simplex	Little grapefern	3									
Boykinia major	Large boykinia	1							X		
Brasenia schreberi	Watershield	1							X		
Brassica rapa	Field mustard	1				X	M		X	X	
Brickellia grandiflora	Tasselflower brickellbush	1					M		X		
Brickellia greenei	Greene brickellbush	1							X		
Brickellia microphylla	Littleleaf brickellbush	3									
Bromus anomalus	Nodding brome	1							X		
Bromus carinatus	California brome	1							X	X	
Bromus carinatus var. *carinatus*	California brome	1							X		
Bromus ciliatus	Fringed brome	1					M		X		

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Bromus hordeaceus	Soft chess	1				X			X		
*Bromus inermis**		1							X		
Bromus inermis ssp. *inermis*	Smooth brome	1							X		
Bromus laevipes	Chinook brome	1								X	
Bromus madritensis	Compact brome	3				X					
Bromus orcuttianus	Orcutt's brome	1							X	X	
Bromus suksdorfii	Suksdorf's brome	1							X	X	
Bromus tectorum	Cheatgrass	1				X	M		X	X	
Bromus vulgaris	Colombian brome	1							X	X	
Bulbostylis capillaris	Threadleaf beakseed	1								X	
Calamagrostis canadensis	Bluejoint	1							X	X	
*Calamagrostis stricta**		1							X		
Calamagrostis stricta ssp. *inexpansa*	Northern reedgrass	1							X		
Calamagrostis stricta ssp. *stricta*	Slimstem reedgrass	3									
Callitriche hermaphroditica	Northern waterstarwort	3									
Callitriche heterophylla	Larger waterstarwort	1							X		
Callitriche heterophylla var. *bolanderi*	Bolander's water-starwort	3									
Callitriche verna	Vernal waterstarwort	1							X		
Calocedrus decurrens	Incense cedar	1					CH, WH		X	X	
Calochortus leichtlinii	Smokey mariposa	1							X	X	
Calochortus minimus	Sierra Star Tulip	1							X		
Calochortus nudus	Naked mariposa lily	1							X		
*Caltha leptosepala**		1							X	X	
Caltha leptosepala var. *biflora*	Howell's marshmarigold marsh marigold	1							X	X	
Calyptridium monospermum	One-seeded pussypaws	1								X	
Calyptridium roseum	Rosy pussypaws	1							X		
Calyptridium umbellatum	Cistanthe	1							X	X	
Calystegia malacophylla	Sierra false bindweed	3									
Calystegia malacophylla ssp. *malacophylla*	Sierra false bindweed	3									

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Calystegia occidentalis	Chaparral false bindweed	3					M				
Camassia quamash	Small camas	1							X	X	
Camassia quamash ssp. *breviflora*	Small camas	3									
Camassia quamash ssp. *quamash*	Camas small camas	1							X		
Camissonia boothii	Booth's sun cup	3									
Camissonia claviformis	Clavate-fruited primrose	3									
Camissonia parvula	Lewis River suncup	3									
Camissonia pubens	Hairy suncup	3									
Camissonia pusilla	Little wiry suncup	1							X		
Camissonia subacaulis	Stemless sun cup	1							X		
Camissonia tanacetifolia	Tansyleaf eveningprimrose	3									
Capsella bursa-pastoris	Shepherd's purse	1				X	M		X		
Cardamine breweri	Brewer's bittercress	1							X	X	
*Cardamine cordifolia**		1							X	X	
Cardamine cordifolia var. *lyallii*	Lyall's bittercress	1							X	X	
Cardamine nuttallii	Nuttall's toothwort	3									
Cardamine occidentalis	Bitter-cress	1								X	
Cardamine pachystigma		3									
Cardamine pachystigma var. *pachystigma*		3									
Cardamine pensylvanica	Pennsylvania bittercress	1							X		
Carduus acanthoides	Plumeless thistle	3				X					
Carduus nutans	Musk Thistle	3				X					X
Carex abrupta	Abruptbeak sedge	1							X	X	
Carex amplifolia	Bigleaf sedge	1								X	
Carex angustata	Widefruit sedge	1							X	X	
Carex aquatilis	Water sedge	1							X	X	
Carex athrostachya	Slenderbeak sedge	1							X	X	
Carex aurea	Golden sedge	1							X	X	
Carex bolanderi	Bolander's sedge	1							X		

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Carex brainerdii	Brainerd's sedge	1							X		
*Carex breweri**		1							X		
Carex breweri var. *breweri*	Brewer's sedge	1							X		
Carex canescens	Silvery sedge	1							X		
Carex capitata	Capitate sedge	1							X		
Carex davyi	Davy's sedge	1		X	X				X		
Carex densa	Dense sedge	1								X	
*Carex deweyana**		1							X		
Carex deweyana ssp. *leptopoda*	Taperfruit shortscale sedge	1							X		
Carex diandra	Lesser panicled sedge	1							X		
Carex disperma	Softleaf sedge	3									
Carex douglasii	Douglas' sedge	1							X	X	
Carex echinata	Prickly sedge	1								X	
Carex echinata ssp. *echinata*	Prickley sedge	1							X		
Carex feta	Greensheath sedge	1							X		
Carex filifolia	Threadleaf sedge	1							X		
Carex filifolia var. *erostrata*	Shorthair sedge	1							X		
Carex fissuricola	Cleft sedge	1							X	X	
Carex fracta	Fragile sheath sedge	1							X	X	
Carex hassei	Saltsedge	3									
Carex haydeniana	Cloud sedge	1							X		
Carex helleri	Heller's sedge	1							X		
Carex heteroneura	Different nerve sedge	1							X	X	
Carex heteroneura var. *epapillosa*	Different nerve sedge	1							X		
Carex heteroneura var. *heteroneura*	Different nerve sedge	3									
Carex hoodii	Hood's sedge	1							X		
Carex illota	Sheep sedge	1							X		
Carex integra	Smoothbeak sedge	1							X	X	
Carex jonesii	Jones' sedge	1							X	X	

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Carex lanuginosa	Woolly sedge	1							X	X	
Carex lemmonii	Lemmon's sedge	1							X	X	
Carex lenticularis	Tufted sedge	1							X	X	
Carex lenticularis var. *impressa*	Lakeshore sedge	1							X		
Carex lenticularis var. *lipocarpa*	Kellogg sedge	1							X		
Carex leporinella	Sierra hare sedge	1							X		
Carex limosa	Mud sedge	1		X					X		
Carex luzulaifolia	Luzula-leaved sedge	1			X				X		
Carex luzulina	Woodrush sedge	1								X	
Carex luzulina var. *ablata*	Woodrush sedge	3									
Carex luzulina var. *luzulina*	Woodrush sedge	3									
Carex mariposana	Mariposa sedge	1						X	X		
Carex microptera	Smallwing sedge	1							X	X	
Carex multicaulis	Manystem sedge	1							X		
Carex multicostata	Manyrib sedge	1							X	X	
Carex nebrascensis	Nebraska sedge	1							X	X	
Carex nervina	Sierra sedge	1							X	X	
Carex nigricans	Black alpine sedge	1							X		
Carex phaeocephala	Dunhead sedge	1							X		
Carex preslii	Presl's sedge	1							X		
Carex raynoldsii	Raynolds' sedge	1							X		
Carex rossii	Ross' sedge	1							X	X	
Carex saliniformis	Carex	1								X	
*Carex scopulorum**		1							X	X	
Carex scopulorum var. *bracteosa*	Craterlike sedge	1							X	X	
Carex senta	Swamp carex	1								X	
Carex simulata	Analogue sedge	1							X		
Carex specifica		1							X		
Carex spectabilis	Showy sedge	1							X	X	

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Carex straminiformis	Shasta sedge	1							X		
Carex subfusca	Brown sedge	1							X		
Carex subnigricans	Nearlyblack sedge	1							X		
Carex tahoensis	Tahoe sedge	1			X				X		
Carex unilateralis		3									X
Carex utriculata	Beaked sedge	1							X	X	
Carex vernacula	Native sedge	1							X		
Carex vesicaria	Blister sedge	1							X	X	
Carex vesicaria var. *vesicaria*	Inflated sedge blister sedge	3									
*Carex viridula**		1								X	
Carex viridula var. *virdula*	Sedge	1								X	
Carex whitneyi	Whitney's sedge	1							X		
Cassiope mertensiana	Western moss heather	1							X		
Castilleja angustifolia	Northwestern paintbrush	3					M				
Castilleja applegatei	Wavyleaf paintbrush	1							X	X	
Castilleja applegatei ssp. *pallida*	Brewer's paintbrush	1			X				X		
Castilleja applegatei ssp. *pinetorum*	Wavyleaf paintbrush	3									
Castilleja campestris	Yellow owl's clover	3									
Castilleja campestris ssp. *campestris*	Indian paintbrush	3									
Castilleja lemmonii	Lemmon's paintbrush	1			X				X		
Castilleja linariifolia	Wyoming paintbrush	1					M		X		
Castilleja miniata	Scarlet paintbrush	1					M		X	X	
Castilleja miniata ssp. *miniata*	Green paintbrush scarlet paintbrush	3					M				
Castilleja minor	Lesser paintbrush	3					M				
Castilleja minor ssp. *minor*	Lesser paintbrush	3					M				
Castilleja nana	Dwarf alpine paintbrush	1			X				X		
Castilleja parviflora	Mountain paintbrush	1			X				X	X	
Castilleja pilosa	Parrothead paintbrush	1							X		
Castilleja pruinosa	Frosted Indian paintbrush	1							X		

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Castilleja tenuis	Hairy owl's clover	1							X		
Caulanthus major	Slender wild cabbage	3									
Caulanthus major var. *nevadensis*		3									
Ceanothus cordulatus	Whitethorn ceanothus	1							X	X	
Ceanothus prostratus	Squawcarpet	1							X	X	
Ceanothus velutinus	Tobacco brush	1					M		X	X	
Ceanothus velutinus var. *velutinus*	Tobacco brush	3					M				
Centaurea cyanus	Garden cornflower	1				X			X		
Centaurea diffusa	Diffuse knapweed	1				X				X	
Centaurea maculosa	Spotted knapweed	3				X					
Cephalanthera austiniae	Phantom orchid	1							X		
Cerastium arvense	Field chickweed	3					M				
*Cerastium beeringianum**		1								X	
Cerastium beeringianum var. *capillare*		1					M			X	
*Cerastium fontanum**		1							X	X	
Cerastium fontanum ssp. *vulgare*	Big chickweed	1							X	X	
Ceratophyllum demersum	Coon's tail	1							X		
Cercocarpus betuloides	Birchleaf mountain mahogany mountain mahogany	1					M			X	
Cercocarpus betuloides var. *betuloides*	Mountain mahogany	3					M				
Cercocarpus ledifolius	Curlleaf mountain mahogany	1					M		X		
Cercocarpus ledifolius var. *intermontanus*	Curlleaf mountain mahogany	3					M				
Chaenactis alpigena	Southern Sierra pincushion	1							X		
Chaenactis douglasii	Douglas' dustymaiden	1					M		X	X	
Chaenactis douglasii var. *alpina*	Alpine dustymaiden	3					M				
Chaenactis douglasii var. *douglasii*	Douglas' dustymaiden	1					M		X		
Chaenactis nevadensis	Nevada dustymaiden	1							X		
Chamaebatia foliolosa	Sierran mountain misery	1			X				X		
Chamaebatiaria millefolium	Fernbush	3					M				
Chamaesaracha nana	Dwarf chamaesaracha	1							X		

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Chamaesyce serpyllifolia	Thymeleaf sandmat	3									
Chamaesyce serpyllifolia ssp. *serpyllifolia*	Thymeleaf sandmat	3									
Cheilanthes gracillima	Lace lipfern	1							X	X	
Cheilanthes intertexta	Coastal lipfern	3									
Chenopodium album	Lamb's quarters/Pigweed	1							X		
Chenopodium atrovirens	Pinyon goosefoot	3									
Chenopodium berlandieri	Pitseed goosefoot	3									
Chenopodium chenopodioides		3				X					
Chenopodium desiccatum	Aridland goosefoot	1							X		
Chenopodium foliosum		3				X					
Chenopodium hians	Hians goosefoot	3									
*Chenopodium incanum**		3									
Chenopodium incanum var. *occidentale*	Mealy goosefoot	3									
Chenopodium incognitum	Pinyon goosefoot	1							X		
Chenopodium pratericola	Desert goosefoot	1							X		
Chimaphila menziesii	Little prince's pine	1							X	X	
Chimaphila umbellata	Pipsissewa	1					M		X	X	
Chorizanthe watsonii	Fivetooth spineflower	3									
Chrysolepis chrysophylla	Golden chinquapin	1								X	
Chrysolepis chrysophylla var. *chrysophylla*	Golden chinquapin	3									
Chrysolepis sempervirens	Sierra chinquapin	1							X	X	
Chrysothamnus humilis	Truckee rabbitbrush	3									
Chrysothamnus nauseosus	Rubber rabbitbrush	1					M		X	X	
Chrysothamnus nauseosus ssp. *albicaulis*	Rubber rabbitbrush rabbitbrush	1					M		X		
Chrysothamnus nauseosus ssp. *consimilis*	Rubber rabbitbrush	3					M				
Chrysothamnus nauseosus ssp. *hololeucus*	Rubber rabbitbrush	3					M				
Chrysothamnus parryi	Parry's rabbitbrush	1					M		X		
Chrysothamnus parryi ssp. *monocephalus*	Single-headed Parry's rabbitbrush	1					M		X		

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Chrysothamnus parryi ssp. *nevadensis*	Nevada Parry's rabbitbrush	1					M		X		
Chrysothamnus viscidiflorus	Green rabbitbrush	1					M		X	X	
Chrysothamnus viscidiflorus ssp. *lanceolatus*	Green rabbitbrush	3					M				
Chrysothamnus viscidiflorus ssp. *puberulus*	Yellow rabbitbrush	3					M				
Chrysothamnus viscidiflorus ssp. *viscidiflorus*	Green rabbitbrush	3					M				
Cicuta douglasii	Western water hemlock	1					WH, M		X	X	
*Cicuta maculata**		3									
Cicuta maculata var. *angustifolia*	Spotted water hemlock	3					M				
Cinna latifolia	Drooping woodreed	1							X	X	
*Circaea alpina**		1							X	X	
Circaea alpina ssp. *pacifica*	Pacific enchanter's nightshade	1							X	X	
Cirsium andersonii	Rose thistle	1							X	X	
Cirsium canovirens	Gray-green thistle	3									
Cirsium douglasii	Douglas' thistle	1							X		
Cirsium douglasii var. *breweri*	Swamp Thistle	1							X		
Cirsium occidentale	Cobwebby thistle	3									
Cirsium occidentale var. *venustum*	Coulter's thistle Venus thistle	3									
Cirsium scariosum	Dwarf Thistle elk thistle	1								X	
Cirsium vulgare	Bullthistle	1				X	M		X	X	
Clarkia lassenensis	Mt. Lassen fairyfan	3									
Clarkia rhomboidea	Diamond fairyfan	1							X		
Clarkia virgata	Sierra clarkia	3		X	X						
Claytonia exigua	Pale springbeauty	3									
Claytonia lanceolata	Western spring beauty	1							X		
Claytonia megarhiza	Fell-fields claytonia	3									
Claytonia nevadensis	Sierra springbeauty	1			X				X		
Claytonia parviflora	Narrowleaf miner's lettuce	1								X	
Claytonia parviflora ssp. *parviflora*	Narrowleaf miner's lettuce	3									
Claytonia perfoliata	Miner's lettuce	1								X	

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Claytonia perfoliata ssp. *perfoliata*	Claytonia	3									
Claytonia rubra	Redstem springbeauty	1							X		
Claytonia rubra ssp. *depressa*	Redstem springbeauty	1					WH		X		
Claytonia rubra ssp. *rubra*	Red-stemmed miner's lettuce	3									
Claytonia sibirica	Candy flower	3									
Clematis ligusticifolia	Yerba de chiva	3					M				
Collinsia heterophylla	Chinese houses	1								X	
Collinsia parryi	Collinsia	1								X	
Collinsia parviflora	Smallflower blue eyed Mary	1					M		X	X	
Collinsia sparsiflora		1								X	
Collinsia sparsiflora var. *collina*	Spinster's blue eyed Mary	1								X	
Collinsia torreyi	Torrey's blue eyed Mary	1							X	X	
Collinsia torreyi var. *latifolia*	Torrey's blue eyed Mary	3									
Collinsia torreyi var. *torreyi*	Torrey's blue eyed Mary	1							X		
Collinsia torreyi var. *wrightii*	Wright's blue eyed Mary	1							X		
Collomia grandiflora	Orange mountaintrumpet	1							X	X	
Collomia linearis	Narrowleaf mountaintrumpet	1							X	X	
Collomia tinctoria	Yellowdye mountaintrumpet	1							X		
*Comandra umbellata**		3									
Comandra umbellata ssp. *californica*	California bastard toadflax	3					M				
Conium maculatum	Poison hemlock	1				X	M			X	
Corallorrhiza maculata	Summer coralroot	1					M		X		
Corallorrhiza striata	Striped coral root	1								X	
Cordylanthus maritimus	Salt marsh bird's beak	3									
Cordylanthus maritimus ssp. *canescens*	Saltmarsh bird's beak	3									
Cordylanthus tenuis	Slender bird's beak	1							X		
Cornus sericea	Redosier dogwood	1					M		X	X	
Cornus sericea ssp. *occidentalis*	American dogwood	1					M		X		
Cornus sericea ssp. *sericea*	American dogwood	1					M		X		

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Coronopus didymus	Lesser swinecress	3				X					
*Corydalis caseana**		1							X		
Corydalis caseana ssp. *caseana*	Sierra corydalis	1		X					X		
*Corylus cornuta**		3									
Corylus cornuta var. *californica*	Hazelnut	3					M				
Crassula aquatica	Aquatic pygmy-weed pygmy weed	1							X		
Crepis acuminata	Longleaf hawksbeard	1					M		X		
Crepis bakeri	Baker's hawksbeard	1							X		
Crepis intermedia	Limestone hawksbeard	1							X		
Crepis modocensis	Siskiyou hawksbeard	1							X		
Crepis monticola	Mountain hawksbeard	3									
Crepis occidentalis	Largeflower hawksbeard	1							X		
Crepis pleurocarpa	Nakedstem hawksbeard	1							X		
Cryptantha affinis	Quill catseye	1							X	X	
Cryptantha ambigua	Basin catseye	1							X		
Cryptantha circumscissa	Cushion catseye	1							X		
Cryptantha echinella	Prickly catseye	1							X		
Cryptantha glomeriflora	Truckee catseye	3			X						
Cryptantha humilis	Roundspike catseye	1							X		
Cryptantha intermedia	Clearwater catseye	1								X	
Cryptantha muricata	Pointed catseye	1							X		
Cryptantha nubigena	Sierra catseye	1			X				X	X	
Cryptantha pterocarya	Wingnut catseye	3									
Cryptantha simulans	Pinewoods catseye	1							X	X	
Cryptantha torreyana	Torrey's catseye	1							X		
Cryptantha watsonii	Watson's catseye	3									
Cryptogramma acrostichoides	American rockbrake	1							X	X	
Cryptogramma cascadensis	Cascade Parsely Fern	3									
Cuscuta californica	Chaparral dodder	1					M		X		

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Cuscuta californica var. *breviflora*	California dodder	3					M				
Cuscuta californica var. *californica*	California dodder	3					M				
Cusickiella douglasii	Alkali draba	3									
Cycladenia humilis	Sacramento waxydogbane	3									
Cycladenia humilis var. *humilis*	Sacramento waxydogbane	3									
Cymopterus terebinthinus		1							X	X	
Cymopterus terebinthinus var. *californicus*	California wavewing	1							X		
Cymopterus terebinthinus var. *petraeus*	Rockloving desertparsley	3									
Cynoglossum occidentale	Western hound's tongue	1							X		
Cyperus squarrosus	Bearded flatsedge	1							X		
Cystopteris fragilis	Brittle bladderfern	1					M		X	X	
Cytisus scoparius	Scotch Broom	1				X			X	X	
Dactylis glomerata	Orchardgrass	1							X	X	
Danthonia californica	California oatgrass	1							X		
Danthonia californica var. *americana*	California oatgrass	1							X		
Danthonia californica var. *californica*		3									
Danthonia intermedia	Timber oatgrass	1									
Danthonia unispicata	Onespike danthonia	1							X		
Darmera peltata	Indian rhubarb	3					WH, M				
Delphinium andersonii	Anderson's larkspur	1								X	
Delphinium depauperatum	Slim larkspur	1							X	X	
Delphinium glaucum	Sierra larkspur	1							X	X	
Delphinium gracilentum	Pine forest larkspur	3			X						X
Delphinium nuttallianum	Meadow larkspur	1							X	X	
Delphinium patens	Spreading larkspur	1								X	
Delphinium polycladon	Mountain marsh larkspur	1			X				X	X	
Deschampsia cespitosa	Tufted hairgrass	1							X	X	
Deschampsia cespitosa ssp. *cespitosa*	Tufted hairgrass	3									
Deschampsia danthonioides	Annual hairgrass	1							X		

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Deschampsia elongata	Slender hairgrass	1							X	X	
Descurainia californica	Sierra tansy-mustard	1							X	X	
Descurainia incana	Mountain tansymustard	1								X	
Descurainia incisa		1							X		
Descurainia incisa ssp. *filipes*		3									
Descurainia incisa ssp. *incisa*	Mountain tansy-mustard	1							X		
Descurainia paradisa	Paradise tansymustard	3									
Descurainia pinnata	Western tansy-mustard	3					M				
Descurainia pinnata ssp. *intermedia*	Western tansymustard	3					M				
Descurainia sophia	Herb sophia	1								X	
*Dianthus armeria**		1								X	
Dianthus armeria ssp. *armeria*	Grass pink	1				X				X	
*Dianthus deltoide**		1								X	
Dianthus deltoides ssp. *deltoides*	Meadow pink	1				X				X	
Dicentra formosa	Pacific bleedingheart	3					M				
Dicentra uniflora	Longhorn steershead	1							X		
Dichelostemma capitatum	Verna pool blue dicks	3									
Dichelostemma capitatum ssp. *capitatum*	Bluedicks	3									
Dodecatheon alpinum	Alpine shootingstar	1							X	X	
Dodecatheon jeffreyi	Tall mountain shootingstar	1					M		X		
Dodecatheon pulchellum	Darkthroat shootingstar	1								X	
Downingia bacigalupii	Bach's calicoflower	3									
Downingia elegans	Elegant calicoflower	3									
Draba albertina	Slender draba	1							X		
Draba asterophora	Tahoe draba	1			X				X		
Draba asterophora var. *asterophora*	Lake Tahoe draba	1		X	X			X	X		
Draba asterophora var. *macrocarpa*	Cup Lake draba	1	X	X	X			X	X		
Draba breweri	Cushion draba	3			X						
Draba densifolia	Denseleaf draba	1							X		

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*Draba lemmonii**		1							X		
Draba lemmonii var. *lemmonii*	Lemmon's draba	1			X				X		
Draba oligosperma	Fewseeddraba	1							X		
*Draba paysonii**		1							X		
Draba paysonii var. *treleasei*	Trelease's whitlowgrass	1							X		
Draba reptans	Carolina draba	3				X	M				
Draperia systyla	Violet draperia	3									
Drosera rotundifolia	Roundleaf sundew	1					M		X		
Dryopteris arguta	Calif. Wood Fern	1								X	
Dudleya cymosa	Canyon liveforever	3									
Dudleya cymosa ssp. *cymosa*	Canyon liveforever	3									
Dugaldia hoopesii	Owlsclaws	1							X		
Dulichium arundinaceum	Three-way sedge	1							X		
Elatine rubella	Southwestern waterwort	1							X		
Eleocharis acicularis	Needle spikerush	1							X		
Eleocharis acicularis var. *acicularis*	Needle spikerush	3									
Eleocharis acicularis var. *bella*	Beautiful spikerush	1							X		
Eleocharis bolanderi	Bolander's spikerush	3									
Eleocharis macrostachya	Common spikerush	1							X		
Eleocharis montevidensis	Sand spikerush	3					M				
Eleocharis obtusa	Blunt spikesedge	1								X	
Eleocharis obtusa var. *engelmannii*		3									
Eleocharis pauciflora	Fewflower spikerush	3									
Elodea canadensis	Common waterweed	1							X		
Elodea nuttallii	Western waterweed	3									
Elymus elymoides	Squirreltail	1							X	X	
Elymus elymoides ssp. *californicus*	Squirreltail	3									
Elymus elymoides ssp. *elymoides*	Squirreltail	1							X		
*Elymus elymoides x trachycaulus**		1							X		

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Elymus glaucus	Blue wildrye	1					M		X	X	
Elymus glaucus ssp. *glaucus*	Blue wildrye	3					M				
*Elymus lanceolatus**		1								X	
Elymus lanceolatus ssp. *lanceolatus*	Thickspick wheatgrass	1								X	
Elymus multisetus	Big squirreltail	1							X	X	
Elymus sierrae	Sierra ryegrass	1			X				X		
Elymus trachycaulus	Slender wheatgrass	1							X	X	
Elymus trachycaulus ssp. *subsecundus*	Slender Wheatgrass	3									
Elymus trachycaulus ssp. *trachycaulus*	Slender wheatgrass	1							X		
Elymus Xhansenii ssp.	Hybrid of E. elimoides and E. glaucus	1								X	
*Elytrigia intermedia**		1							X		
Elytrigia intermedia ssp. *intermedia*	Intermediate wheatgrass	1				X			X		
*Epilobium angustifolium**		1							X	X	
Epilobium angustifolium ssp. *circumvagum*	Fireweed	1					M		X	X	
Epilobium brachycarpum	Autumn willowweed	1							X	X	
Epilobium canum	California fuchsia, zauschneria	1					M		X	X	
Epilobium canum ssp. *latifolium*	California Fuchsia	1					M		X		
Epilobium ciliatum	Hairy willowherb	1							X	X	
Epilobium ciliatum ssp. *ciliatum*	Willow-herb	1							X		
Epilobium ciliatum ssp. *glandulosum*	Glandular willowweed	1							X		
Epilobium densiflorum	Denseflower spike primrose dense boisduvalia	1							X	X	
Epilobium glaberrimum	Smooth willowweed	1							X	X	
Epilobium glaberrimum ssp. *fastigiatum*	Smooth willowweed	3									
Epilobium glaberrimum ssp. *glaberrimum*	Smooth willowweed	3									
Epilobium halleanum	Glandular willowherb	1							X		
*Epilobium hornemannii**		1							X	X	
Epilobium hornemannii ssp. *hornemannii*	Hornemann's willowherb	1							X	X	
Epilobium howellii	Subalpine fireweed	3		X	X			X			

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Epilobium lactiflorum	Milkflower willowweed	1							X		
Epilobium obcordatum	Heart willowweed	1							X		
Epilobium oreganum	Oregon fireweed	1	X					X	X		
Epilobium oregonense	Slimstem willowweed	1							X		
Epilobium torreyi	Narrow-leaved Boisduvalia	1							X		
Epipactis gigantea	Giant helleborine	1					M		X		
Equisetum arvense	Field horsetail	1					M		X	X	
*Equisetum hyemale**		1							X	X	
Equisetum hyemale ssp. *affine*	Ferris' horsetail common scouring rush	1					M		X	X	
Equisetum laevigatum	Smooth scouring rush	1								X	
Equisetum palustre	Marsh horsetail	1								X	
Eriastrum sparsiflorum	Great Basin woolstar	3									
Eriastrum wilcoxii	Wilcox's woolstar	3									
Ericameria bloomeri	Rabbitbush heathgoldenrod	1							X	X	
Ericameria cuneata	Cliff heathgoldenrod	3									
Ericameria discoidea	Whitestem heathgoldenrod	1							X		
Ericameria suffruticosa	Singlehead heathgoldenrod	1							X		
Erigeron algidus	Stalked fleabane	1							X		
Erigeron aphanactis	Rayless shaggy fleabane	1							X		
Erigeron barbellulatus	Shining fleabane	1			X				X		
Erigeron bloomeri	Scabland fleabane	3									
Erigeron bloomeri var. *bloomeri*	Scabland fleabane	3									
Erigeron breweri	Brewer's fleabane	1							X	X	
Erigeron breweri var. *porphyreticus*	Brewer's fleabane	1							X		
Erigeron compositus	Cutleaf daisy	1					M		X		
Erigeron coulteri	Large mountain fleabane	1							X	X	
Erigeron divergens	Spreading fleabane	1					M		X		
*Erigeron eatonii**		1							X		
Erigeron eatonii var. *nevadincola*		1							X		

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Erigeron eatonii var. *plantagineus*	Eaton's fleabane	1							X		
*Erigeron filifolius**		3									
Erigeron filifolius var. *filifolius*	Threadleaf fleabane	3					M				
Erigeron foliosus	Leafy fleabane	1					M		X		
Erigeron inornatus	Rayless fleabane	1							X		
Erigeron inornatus var. *inornatus*	Rayless fleabane	3									
Erigeron linearis	Desert yellow fleabane	1							X		
Erigeron miser	Starved fleabane	1		X	X			X	X		
Erigeron peregrinus	Wandering fleabane	1							X		
Erigeron peregrinus var. *callianthemus*	Subalpine fleabane	1							X		
Erigeron petrophilus	Cliff fleabane	3									
Erigeron petrophilus var. *sierrensis*	Sierra fleabane	3		X	X						
*Erigeron pumilus**		1							X		
Erigeron pumilus var. *intermedius*	Shaggy fleabane	1							X		
Erigeron pygmaeus	Pygmy fleabane	1							X		
Erigeron reductus	Rayless daisy	3									
Erigeron reductus var. *reductus*	Little rayless fleabane California rayless daisy	3									
Eriogonum baileyi	Bailey's buckwheat	1					M		X		
Eriogonum baileyi var. *baileyi*	Bailey's buckwheat	3					M				
Eriogonum baileyi var. *praebens*	Bailey's buckwheat	3					M				
Eriogonum cernuum	Nodding buckwheat	3					M				
Eriogonum cernuum var. *viminale*	Nodding buckwheat	3					M				
Eriogonum cespitosum	Matted buckwheat	3									
*Eriogonum douglasii**		3									
Eriogonum douglasii var. *douglasii*	Douglas' buckwheat	3									
Eriogonum elatum		1							X		
Eriogonum elatum var. *villosum*	Tall woolly buckwheat	1					M		X		
Eriogonum incanum	Frosted buckwheat	1			X				X	X	
Eriogonum latens	Inyo buckwheat	3									

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*Eriogonum lobbii**		1							X		
Eriogonum lobbii var. *lobbii*	Lobb's buckwheat	1							X		
Eriogonum luteolum	Goldencarpet buckwheat	3									
Eriogonum luteolum var. *luteolum*	Wickerstem buckwheat	3									
Eriogonum maculatum	Spotted buckwheat	3									
Eriogonum marifolium	Marumleaf buckwheat	1							X		
Eriogonum microthecum	Slender buckwheat	3									
Eriogonum microthecum var. *ambiguum*	Slender buckwheat	3									
Eriogonum microthecum var. *laxiflorum*	Slender buckwheat	3									
Eriogonum nudum	Naked buckwheat	1							X	X	
Eriogonum nudum var. *deductum*	Naked buckwheat	1							X		
Eriogonum nudum var. *nudum*	Naked buckwheat	3									
Eriogonum nudum var. *oblongifolium*	Naked buckwheat	3									
Eriogonum nutans	Dugway buckwheat	3									
Eriogonum ochrocephalum	Whitewoolly buckwheat	3									
Eriogonum ochrocephalum var. *ochrocephalum*	Whitewoolly buckwheat	3									
Eriogonum ovalifolium	Cushion buckwheat	1					M		X		
Eriogonum ovalifolium var. *eximium*	Brown-margined buckwheat	1		X			M		X		
Eriogonum ovalifolium var. *nivale*	Cushion buckwheat	1					M		X		
Eriogonum ovalifolium var. *ovalifolium*	Cushion buckwheat	3					M				
Eriogonum ovalifolium var. *purpureum*	Cushion buckwheat	3					M				
Eriogonum ovalifolium var. *vineum*		1							X		
Eriogonum rosense	Whitewoolly buckwheat	3									
Eriogonum spergulinum	Spurry buckwheat	1							X	X	
Eriogonum spergulinum var. *reddingianum*	Spurry buckwheat	1							X		
Eriogonum spergulinum var. *spergulinum*	Spurry buckwheat	3									
Eriogonum sphaerocephalum	Rock buckwheat	3									
Eriogonum sphaerocephalum var. *halimioides*	Rock buckwheat	3									
Eriogonum sphaerocephalum var. *sphaerocephalum*	Rock buckwheat	3									

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Eriogonum strictum	Blue Mountain buckwheat	3									
Eriogonum strictum var. *anserinum*		3									
Eriogonum umbellatum	Sulphur buckwheat	1					M		X	X	
Eriogonum umbellatum var. *furcosum*	Desert sulfur buckwheat	1					M		X		
Eriogonum umbellatum var. *nevadense*	Nevada buckwheat	3					M				
Eriogonum umbellatum var. *polyanthum*	Many-flowered buckwheat	1					M		X		
Eriogonum umbellatum var. *torreyanum*	Torrey buckwheat	3	X	X	X		M	X			
Eriogonum ursinum	Bear Valley buckwheat	1			X				X		
Eriogonum vimineum	Wickerstem buckwheat	3									
Eriogonum wrightii	Wright's buckwheat	1					M		X	X	
Eriogonum wrightii var. *subscaposum*	Wright's buckwheat	3					M				
Eriophorum criniger	Criniger's cotton grass	1							X		
Eriophorum gracile	Slender cottongrass	1							X		
Eriophyllum confertiflorum	Yellow yarrow	3									
Eriophyllum confertiflorum var. *confertiflorum*	Goldenyarrow	3									
Eriophyllum lanatum	Woolly sunflower	1					M		X	X	
Eriophyllum lanatum var. *croceum*	Common woollysunflower	1					M		X		
Eriophyllum lanatum var. *integrifolium*	Oregon sunshine woolly sunflower	1					M		X		
Erysimum capitatum	Western wallflower	1					M		X	X	
Erysimum capitatum ssp. *perenne*	Mountain wallflower sanddune wallflower	1					M		X	X	
Erysimum cheiranthoides	Wormseed mustard	1				X	M			X	
Erythronium purpurascens	Purple fawnlily	3			X						
*Festuca brachyphylla**		1							X		
Festuca brachyphylla ssp. *breviculmis*	Short-leaved fescue	1							X		
Festuca occidentalis	Western fescue	3									X
Festuca rubra	Red fescue	1							X		
Festuca subulata	Bearded fescue	1								X	
Festuca trachyphylla	Hard fescue	3				X					

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Festuca viridula	Greenleaf fescue	1							X		
Floerkea proserpinacoides	False mermaidweed	1							X		
Foeniculum vulgare	Fennel	1								X	
Fragaria vesca	California strawberry	3					M				
Fragaria virginiana	Mountain strawberry	1					M		X	X	
Fremontodendron californicum	California flannelbush	3					M				
Fremontodendron californicum ssp. *californicum*		3					M				
Fritillaria agrestis	Stinkbells	3		X							
Fritillaria atropurpurea	Spotted missionbells	1							X	X	
Galium aparine	Common bedstraw	1					M			X	
Galium bifolium	Twinleaf bedstraw	1								X	
Galium bolanderi	Bolander's bedstraw	1							X		
Galium grayanum	Gray's bedstraw	1							X		
Galium grayanum var. *grayanum*	Gray's bedstraw	3									
Galium hypotrichium	Alpine bedstraw	1							X		
*Galium mexicanum**		3									
Galium mexicanum var. *asperulum*	Mexican bedstraw	3									
Galium sparsiflorum	Sequoia bedstraw	3									
Galium trifidum	Threepetal bedstraw	1					M		X	X	
Galium trifidum var. *pacificum*	Threepetal bedstraw	1					M		X	X	
Galium trifidum var. *pusillum*	Threepetal bedstraw	1					M		X		
Galium triflorum	Fragrant bedstraw	1					M		X		
Gayophytum decipiens	Deceptive groundsmoke	1							X		
Gayophytum diffusum	Spreading groundsmoke	1							X	X	
Gayophytum diffusum ssp. *parviflorum*	Spreading groundsmoke	3									
Gayophytum heterozygum	Zigzag groundsmoke	1							X		
Gayophytum humile	Dwarf groundsmoke	1							X		
Gayophytum racemosum	Blackfoot groundsmoke	1							X		
Gayophytum ramosissimum	Pinyon groundsmoke	1							X		

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Gentiana calycosa	Rainier pleated gentian	1							X	X	
Gentiana newberryi	Alpine gentian	1							X		
*Gentianella amarella**		1							X		
Gentianella amarella ssp. *acuta*	Autumn dwarfgentian	1							X		
Gentianopsis simplex	Oneflower fringedgentian	1							X	X	
Geranium richardsonii	Richardson's geranium	1					M		X	X	
Geum macrophyllum	Largeleaf avens	1					M		X	X	
Geum triflorum	Old man's whiskers	1					M		X		
Gilia brecciarum	Nevada gilia	3									
Gilia brecciarum ssp. *brecciarum*	Nevada gilia	3									
Gilia capillaris	Miniature gilia	1							X	X	
Gilia capitata	Bluehead gilia	3									
Gilia capitata ssp. *mediomontana*	Blue field gilia	3									
Gilia leptalea	Bridges' gilia	1							X		
Gilia leptalea ssp. *bicolor*	Purple-throat gilia	1			X				X		
Gilia leptalea ssp. *leptalea*	Bridges' gilia	3									
Gilia lottiae	Lott's gilia	3									
Gilia modocensis	Modoc gilia	3									
Gilia salticola	Salt gilia	1							X		
Gilia sinistra	Alva Day's gilia	3									
Gilia sinuata	Rosy gilia	1					M		X		
Glyceria borealis	Northern mannagrass	1							X		
Glyceria elata	Tall mannagrass	1							X	X	
Glyceria striata	Fowl mannagrass	1							X	X	
Gnaphalium canescens	Wright's cudweed	1					M		X	X	
Gnaphalium canescens ssp. *microcephalum*	White everlasting smallhead cudweed	1					M		X		
Gnaphalium canescens ssp. *thermale*	Small-headed cudweed	3					M				
Gnaphalium palustre	Western marsh cudweed	1							X	X	
Gratiola neglecta	Clammy hedgehyssop	1							X		

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*Gypsophila elegans**		1							X		
Gypsophila elegans var. *elegans*		1				X			X		
Hackelia californica	California stickseed	3									
Hackelia floribunda	Manyflower stickseed	1					M			X	
Hackelia micrantha	Jessica sticktight	1							X	X	
Hackelia nervosa		1							X		
Hackelia velutina	Velvet stickseed	1			X				X	X	
Hastingsia alba	White hastingsia	3									
Hazardia whitneyi	Whitney's goldenbush	3									
Hazardia whitneyi var. *whitneyi*	Whitney's goldenbush	3									
Helenium autumnale	Common sneezeweed	3					M				
Helenium autumnale var. *montanum*	Mountain sneezeweed	3					M				
Helenium bigelovii	Bigelow's sneezeweed	1							X	X	
Helianthella californica	California helianthella	1							X	X	
Helianthella californica var. *nevadensis*	Sierra helianthella	1							X		
Helianthus annuus	Common sunflower	3					M				
Helianthus nuttallii	Nuttall's sunflower	3					M				
Helianthus nuttallii ssp. *nuttallii*	Nuttall's sunflower	3					M				
Heliotropium curassavicum	Salt heliotrope	1					M		X		
Heracleum lanatum	Common cowparsnip cow parsnip	1					M, WH		X	X	
Hesperochiron californicus	California hesperochiron	1							X		
Hesperochiron pumilus	Dwarf hesperochiron	1							X		
Hesperostipa comata	Needle & thread	1							X		
Hesperostipa comata ssp. *comata*		3									
Hesperostipa comata ssp. *intermedia*		3									
Heterotheca sessilifora		1							X		
Heterotheca sessilifora ssp. *bollanderi*		1							X		
Heterotheca villosa	Hairy goldenaster	1							X		
Heterotheca villosa var. *hispida*	Bristly hairy goldaster	3									

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Heuchera micrantha	Crevice alumroot	1					M		X		
Heuchera rubescens	Pink alumroot	1					M		X		
Heuchera rubescens var. *alpicola*	Pink alumroot	1					M		X		
Heuchera rubescens var. *glandulosa*	Pink alumroot	1					M		X		
Hieracium albiflorum	White hawkweed	1							X	X	
Hieracium gracile	Slender hawkweed	1							X	X	
Hieracium horridum	Prickly hawkweed	1							X		
Hieracium scouleri	Woollyweed	3									
Hippuris vulgaris	Common marestail	1							X		
Holodiscus discolor	Oceanspray	1					M		X	X	
Holodiscus microphyllus	Oceanspray	1							X	X	
Holodiscus microphyllus var. *glabrescens*	Rock-Spiraea	3									
Holodiscus microphyllus var. *microphyllus*		3									
Hordeum brachyantherum	Meadow barley	1							X	X	
Hordeum brachyantherum ssp. *californicum*	Meadow barley California barley	3									
Horkelia fusca	Tawny horkelia	1							X	X	
Horkelia fusca ssp. *parviflora*	Smallflower horkelia	1							X		
Horkelia tridentata	Threetooth honeydew	3									
Horkelia tridentata ssp. *flavescens*	Threetooth honeydew	3									
Horkelia tridentata ssp. *tridentata*	Threetooth honeydew	3									
Hulsea algida	Pain hulsea	1							X		
Hulsea heterochroma	Redray alpinegold	1							X		
Humulus lupulus	Common hop	1							X		
Hutchinsia procumbens	Prostrate hutchinsia	3									
Hydrophyllum capitatum		1							X	X	
Hydrophyllum capitatum var. *alpinum*	Woolen-breeches	1							X	X	
Hydrophyllum occidentale	Western waterleaf	1								X	
Hymenoxys cooperi	Cooper's hymenoxys	3									
Hypericum anagalloides	Tinker's penny	1							X	X	

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*Hypericum formosum**		1							X		
Hypericum formosum var. *scouleri*	Scouler's St. Johnswort	1							X		
Hypericum perforatum	Klamathweed	1				X	M			X	
Ipomopsis aggregata	Scarlet gilia	1					M		X	X	
Ipomopsis aggregata ssp. *bridgesii*	Bridge's gilia	3			X		M				
Ipomopsis aggregata ssp. *formosissima*	Wherrey's Scarlet Gilia	3					M				
Ipomopsis congesta	Ballhead gilia	1							X	X	
Ipomopsis congesta ssp. *congesta*	Ballhead gilia	3									
Ipomopsis congesta ssp. *montana*	Mountain ballhead gilia	1							X		
Ipomopsis congesta ssp. *palmifrons*	Ballhead gilia	3									
Ipomopsis polycladon	Manybranched gilia	3									
Ipomopsis tenuituba	Slendertube skyrocket	3									
Iris hartwegii	Rainbow iris	3									
Iris hartwegii ssp. *hartwegii*	Hartweg's iris	3									
Iris missouriensis	Western blue flag	1					M		X		
Isoetes bolanderi	Bolander's quillwort	1							X		
Isoetes howellii	Howell's quillwort	1							X		
Isoetes nuttallii	Nuttall's quillwort	3									
Isoetes occidentalis	Western quillwort	1							X		
Ivesia aperta	Sierra Valley mousetail	3									
Ivesia lycopodioides	Clubmoss mousetail	1							X		
Ivesia lycopodioides ssp. *lycopodioides*	Clubmoss mousetail	3			X						
Ivesia santolinoides	Sierra mousetail	1							X		
Ivesia sericoleuca	Plumas mousetail	3	X	X	X			X			
*Ivesia shockleyi**		1							X		
Ivesia shockleyi var. *shockleyi*	Shockley's mousetail	1			X				X		
Ivesia webberi	Webber's ivesia	3	X	X				X			
Jepsonia heterandra	Foothill buttonsaxifrage	3		X							
Juncus balticus	Baltic rush	1							X	X	

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Juncus bufonius	Toad rush	1					M		X		
Juncus capillaris	Hairystem dwarf rush	3									
Juncus chlorocephalus	Greenhead rush	1							X	X	
Juncus confusus	Colorado rush	1							X		
Juncus covillei	Coville's rush	3									
Juncus drummondii	Drummond's rush	1							X	X	
Juncus dubius	Dubius rush	3									
Juncus effusus	Common rush	1					M		X	X	
Juncus ensifolius	Swordleaf rush	1							X	X	
Juncus hemiendytus	Blood rush	1							X		
Juncus hemiendytus var. *abjectus*	Center Basin rush	1		X					X		
Juncus kelloggii	Kellogg's dwarf rush	3									
Juncus longistylis	Longstyle rush	1							X		
Juncus macrandrus	Longanther rush	1							X		
Juncus mertensianus	Mertens' rush	1							X	X	
Juncus mexicanus	Mexican rush	1							X		
Juncus nevadensis	Nevada rush	1							X	X	
Juncus occidentalis	Western rush	1							X		
Juncus orthophyllus	Straightleaf rush	1							X	X	
Juncus oxymeris	Pointed rush	1							X		
Juncus parryi	Parry's rush	1							X		
Juncus saximontanus	Rocky Mountain rush	1								X	
Juncus tenuis	Poverty rush	3					M				
Juncus triformis	Yosemite dwarf rush	3									
Juncus xiphioides	Irisleaf rush	1							X		
Juniperus californica	California juniper	1					M			X	
Juniperus communis	Common juniper	1					M		X		
Juniperus occidentalis	Western juniper	1					M		X	X	
Juniperus occidentalis var. *australis*	Southwestern juniper	3					M				

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Juniperus occidentalis var. *occidentalis*	Western juniper	3					M				
Kalmia polifolia	Mountain laurel	1					M		X		
Kalmia polifolia ssp. *microphylla*	Littleleaf mountain laurel	1					M		X		
Kalmia polifolia ssp. *polifolia*	Mountain laurel	3					M				
Keckiella breviflora	Bush beardtongue	1							X		
Keckiella breviflora var. *breviflora*	Bush beardtongue	3									
Keckiella breviflora var. *glabrisepala*	Bush beardtongue	3									
Keckiella lemmonii	Lemmon's penstemon	1							X		
Kelloggia galioides	Milk kelloggia	1							X	X	
Lactuca serriola	Wild lettuce	1							X	X	
*Lactuca tatarica**		3									
Lactuca tatarica ssp. *pulchella*	Blue lettuce	3									
Lappula redowskii	Redowski's stickseed	3					M				
Lappula redowskii var. *cupulata*	Stickseed	3					M				
Lappula redowskii var. *redowskii*		3					M				
Lathyrus lanszwertii	Thickleaf peavine	1							X	X	
Lathyrus lanszwertii var. *aridus*	Nevada peavine	1							X		
Lathyrus lanszwertii var. *lanszwertii*	Lanszwert's peavine	3									
*Lathyrus nevadensis**		1								X	
Lathyrus nevadensis var. *nevadensis*	Nevada peavine	1								X	
Lathyrus sulphureus	Snub peavine	3									
Layia glandulosa	Whitedaisy tidytips	3									
Ledum glandulosum	Western Labrador tea	1							X	X	
Lemna gibba	Swollen duckweed	1							X		
Lemna trisulca	Star duckweed	1							X		
Lepidium campestre	Field pepperweed	1				X			X	X	
Lepidium densiflorum	Common pepperweed	1					M		X	X	
Lepidium latifolium	Tall whitetop	1				X					X
Lepidium montanum	Mountain pepperweed	3					M				

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Lepidium montanum var. *canescens*	Mountain pepperweed	3					M				
Lepidium montanum var. *montanum*	Mountain pepperweed	3					M				
Lepidium virginicum	Virginia pepperweed	1					M			X	
Lepidium virginicum var. *medium*	Medium pepperweed	3					M				
Lepidium virginicum var. *pubescens*	Hairy pepperweed	1								X	
Leptodactylon californicum	Prickly-Phlox	1								X	
Leptodactylon pungens	Granite pricklygilia	1					M		X	X	
*Lesquerella occidentalis**		1							X		
Lesquerella occidentalis ssp. *occidentalis*	Western bladderpod	1							X		
Leucanthemum vulgare	Oxe-eye daisy	1								X	
Leucothoe davisiae	Sierra laurel	3									
Lewisia kelloggii	Kellogg's lewisia	3			X						
Lewisia longipetala	Long-petaled lewisia	1	X	X	X			X	X		
Lewisia nevadensis	Nevada bitterroot	1							X		
Lewisia pygmaea	Pigmy bitterroot	1					M		X		
Lewisia triphylla	Threeleaf lewisia	1							X		
Leymus cinereus	Basin wildrye	3									
Leymus triticoides	Beardless wildrye	1							X	X	
Ligusticum grayi	Gray's licoriceroot	1					WH		X	X	
Lilium kelleyanum	Kelley's lily	3									
Lilium pardalinum	Leopard lily	3									
Lilium pardalinum ssp. *shastense*	Shasta lily	3									
Lilium parvum	Sierra tiger lily	1			X		WH		X	X	
Lilium washingtonianum	Washington lily	1							X		
Lilium washingtonianum ssp. *washingtonianum*	Washington lily	3									
Limosella aquatica	Water mudwort	1					M		X		
Linanthus ciliatus	Whiskerbrush	1					M		X	X	
Linanthus harknessii	Harkness' flaxflower	1							X		
Linanthus nuttallii	Nuttall's deserttrumpets	1							X		

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Linanthus pachyphyllus	Sierra deserttrumpets	1			X					X	
Linanthus septentrionalis	Northern linanthus	1							X		
*Linaria genistifolia**		3									
Linaria genistifolia ssp. *dalmatica*	Dalmatian toadflax	3				X					
Linum bienne	Flax	1								X	
Linum lewisii	Prairie flax	1					M		X		
Listera convallarioides	Broadlipped twayblade	1							X	X	
Lithocarpus densiflorus	Tanoak	3					M				
Lithocarpus densiflorus var. *echinoides*	Serpentine bush tanoak	3					M				
Lithophragma glabrum	Bulbous woodlandstar	1							X	X	
Lithophragma parviflorum	Smallflower woodlandstar	3									
Lithophragma parviflorum var. *parviflorum*	Smallflower woodlandstar	3									
Lolium perenne	English ryegrass	1							X		
Lomatium dissectum	Fernleaf buscuitroot	1					M, WH		X		
Lomatium dissectum var. *multifidum*	Carrotleaf biscuitroot	3					M				
Lomatium macrocarpum	Bigseed biscuitroot	3					M				
Lomatium nevadense	Nevada biscuitroot	1							X		
Lomatium nevadense var. *nevadense*	Nevada biscuitroot	3									
Lomatium nevadense var. *parishii*	Parish's biscuitroot	3									
Lomatium nudicaule	Barestem biscuitroot	3					M				
Lomatium triternatum	Nineleaf biscuitroot	3									
Lonicera cauriana	Bluefly honeysuckle	1							X		
Lonicera conjugialis	Purpleflower honeysuckle	1							X	X	
Lonicera involucrata	Twinberry honeysuckle	1					M		X	X	
Lonicera involucrata var. *involucrata*	Twinberry honeysuckle	3					M				
Lotus crassifolius	Big deervetch	3									
Lotus crassifolius var. *crassifolius*	Broad-leaved lotus	3									
Lotus micranthus	Desert deervetch	1								X	
Lotus nevadensis	Nevada trefoil	1								X	

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Lotus oblongifolius	Streambank trefoil	1							X	X	
Lotus oblongifolius var. *oblongifolius*	Streambanktrefoil	1							X		
*Lotus purshianus**		1							X	X	
Lotus purshianus var. *purshianus*	Spanish clover	1							X	X	
Lupinus adsurgens	Drew's silky lupine	3									
Lupinus albicaulis	Sicklekeel lupine	3									
Lupinus andersonii	Anderson's lupine	1							X	X	
Lupinus angustiflorus	Narrow-flowered lupine	1							X		
Lupinus apertus	Summit lupine	3									
Lupinus arbustus	Spur lupine	1							X	X	
Lupinus argenteus	Silvery lupine	1							X	X	
Lupinus argenteus var. *meionanthus*	Lake Tahoe lupine	1							X		
Lupinus bicolor	Bicolor lupine	1							X		
Lupinus breweri	Brewer's lupine	1							X	X	
Lupinus breweri var. *breweri*	Brewer's lupine	3									
Lupinus breweri var. *bryoides*	Brewer's Lupine	1								X	
Lupinus breweri var. *grandiflorus*	Matted lupine	3									
Lupinus formosus	Western lupine	3									
Lupinus formosus var. *formosus*	Summer lupine	3									
Lupinus fulcratus	Greenstipule lupine	1			X				X		
Lupinus grayii	Gray's lupine	1			X				X	X	
Lupinus latifolius	Broadleaf lupine	1					WH			X	
Lupinus latifolius var. *barbatus*		3									
Lupinus latifolius var. *columbianus*		3									
Lupinus latifolius var. *viridifolius*		3									
Lupinus lepidus	Pacific lupine	1							X	X	
Lupinus lepidus var. *confertus*		3									
Lupinus lepidus var. *lobbii*	Lobb's lupine	1							X		
Lupinus lepidus var. *sellulus*	Dwarf lupine	1							X		

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Lupinus microcarpus	Lupine	3									
Lupinus obtusilobus	Bluntlobe lupine	1							X		
Lupinus polyphyllus	Bigleaf lupine	1					M		X	X	
Lupinus polyphyllus var. *burkei*	Bigleaf lupine	1					WH, M		X		
Luzula comosa	Hairy woodrush heath woodrush	1							X		
Luzula divaricata	Forked woodrush	1							X	X	
Luzula orestera	Heath woodrush	1			X				X		
Luzula parviflora	Smallflowered woodrush	3									
Luzula spicata	Spiked woodrush	1							X		
Luzula subcongesta	Donner woodrush	1							X	X	
Lychnis coronaria	Rose campion	1								X	
Lythrum portula	Broadleaf loosestrife	3				X					
Machaeranthera canescens	Hoary-aster	1							X	X	
Machaeranthera canescens var. *canescens*		1							X		
Machaeranthera canescens var. *shastensis*	Shasta prickly aster	3									
Madia bolanderi	Bolander's madia	1							X	X	
Madia elegans	Common madia	1							X		
Madia elegans ssp. *elegans*	Common madia	3									
Madia exigua	Threadstem tarweed	1							X		
Madia glomerata	Mountain tarweed	1					M		X	X	
Madia gracilis	Slender tarweed	1							X	X	
Madia minima	Little tarweed	1							X	X	
Madia yosemitana	Yosemite tarweed	1			X				X		
Malacothrix floccifera	Woolly desertdandelion	1							X		
Malva neglecta	Common mallow	1				X	M		X		
Marsilea oligospora	Pacific waterclover	3									
*Marsilea vestita**		1							X		
Marsilea vestita ssp. *vestita*	Hairy pepperwort	1							X		
Medicago lupulina	Black medick	1							X	X	

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Melica aristata	Bearded melicgrass	1							X	X	
Melica bulbosa	Oniongrass	1							X	X	
Melica fugax	Little oniongrass	1							X	X	
Melica harfordii	Harford's oniongrass	1							X		
Melica stricta	Rock melicgrass	1							X		
Melica subulata	Alaska oniongrass	3									
Melilotus alba	White sweet clover	1								X	
Melilotus officinalis	Yellow sweetclover	1							X		
Mentha arvensis	Wild mint	1							X	X	
*Mentha spicata**		1								X	
Mentha spicata var. *spicata*	Spearmint	1								X	
Mentzelia albicaulis	White-stemmed blazing star	3					M				
Mentzelia congesta	United blazingstar	1							X		
Mentzelia dispersa	Bushy blazingstar	1					WH		X		
Mentzelia laevicaulis	Smoothstem blazingstar	1					M		X		
Mentzelia montana	Variegated bract blazingstar	3									
Mentzelia veatchiana	Whitestem blazingstar	3					M				
Menyanthes trifoliata	Common buckbean	1					M		X		
Mertensia ciliata	Streamside bluebells	1					M		X	X	
Mertensia oblongifolia	Sagebrush bluebells	3									
Mertensia oblongifolia var. *amoena*	Sagebrush bluebells	3									
Mertensia oblongifolia var. *nevadensis*	Sierra bluebells	3									
Mertensia oblongifolia var. *oblongifolia*		3									
Microseris laciniata	Cutleaf silverpuffs	3									
Microseris laciniata ssp. *laciniata*	Cutleaf silverpuffs	3									
Microseris laciniata ssp. *leptosepala*	Cutleaf silverpuffs	3									
Microseris nutans	Nodding microceris	1							X	X	
Mimulus breviflorus	Shortflower monkeyflower	3									X
Mimulus breweri	Brewer's monkeyflower	1							X	X	

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Mimulus cardinalis	Crimson monkeyflower	1					M		X		
Mimulus floribundus	Manyflowered monkeyflower	1							X	X	
Mimulus guttatus	Seep monkeyflower	1					M		X	X	
Mimulus jepsonii	Jepson's monkeyflower	3									
Mimulus kelloggii	Kellogg's monkeyflower	1								X	
Mimulus layneae	Layne's monkeyflower	3									
Mimulus leptaleus	Slender monkeyflower	1			X				X		
Mimulus lewisii	Purple monkeyflower	1							X	X	
Mimulus mephiticus	Foul odor monkeyflower	1							X		
Mimulus moschatus	Musk monkeyflower	1							X	X	
Mimulus nanus	Dwarf purple monkeyflower	1							X		
Mimulus pilosus	False monkeyflower	3									
Mimulus primuloides	Primrose monkeyflower	1							X	X	
Mimulus primuloides ssp. *primuloides*		1							X		
Mimulus suksdorfii	Suksdorf's monkeyflower	3									
Mimulus tilingii	Tiling's monkeyflower	1							X	X	
Mimulus torreyi	Torrey's monkeyflower	1			X				X	X	
Minuartia nuttallii	Nuttall's sandwort	1							X		
Minuartia nuttallii ssp. *fragilis*	Brittle sandwort	3									
Minuartia nuttallii ssp. *gracilis*	Nuttall's Sandwort	1							X		
Minuartia pusilla	Annual sandwort	3									
Mitella breweri	Brewer's miterwort	1							X	X	
Mitella pentandra	Fivestamen miterwort	1							X		
Monardella glauca	Gray monardella	1							X		
Monardella lanceolata	Mustang mountainbalm	1					M		X		
Monardella odoratissima	Pacific monardella	1					M		X	X	
Monardella odoratissima ssp. *pallida*	Alpine mountainbalm	3									
Monardella sheltonii	Mint	1								X	
Monolepis nuttalliana	Nuttall's poverty weed	1					M		X		

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Monolepis spathulata	Beaver monolepis	3									
Montia chamissoi	Water minerslettuce	1							X	X	
Montia linearis	Narrowleaf minerslettuce	1							X	X	
Montia parvifolia	Littleleaf montia	1							X		
Muhlenbergia andina	Foxtail muhly	1							X		
Muhlenbergia filiformis	Pullup muhly	1							X	X	
Muhlenbergia jonesii	Modoc muhly	1			X					X	
Muhlenbergia montana	Mountain muhly	1							X		
Muhlenbergia richardsonis	Mat muhly	1							X		
Muilla transmontana	Great Basin muilla	1							X		
Myosotis latifolia	Forget-Me-Not	1								X	
Myosurus apetalus	Mouse-tail little mousetail	1							X		
Myosurus minimus	Little mousetail	3					M				
Myriophyllum sibiricum	Siberian milfoil	1									X
Myriophyllum spicatum	Eurasian watermilfoil	1				X			X	X	
Myriophyllum verticillatum		1							X		
Nama aretioides	Purple mat	3									
Nama aretioides var. *multiflorum*		3									
Nama densum	Dense purple mat	1							X		
Nama densum var. *densum*	Leafy fiddleleaf	3									
Nama lobbii	Lobb's fiddleleaf	1							X		
Nama rothrockii	Rothrock's fiddleleaf	1							X		
Narthecium californicum	California bog asphodel	1							X		
Navarretia breweri	Brewer's navarretia	1							X		
Navarretia divaricata	Divaricate navarretia	1							X	X	
Navarretia divaricata ssp. *divaricata*	Mountain navarretia	3									
Navarretia divaricata ssp. *vividior*	Divaricate navarretia	3									
Navarretia intertexta	Interwoven navarretia	1							X	X	
Navarretia intertexta ssp. *propinqua*	Near navarretia	1							X		

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Navarretia leucocephala	White vernal pool navarretia	1							X		
Navarretia leucocephala ssp. *minima*	Little white navarretia	1							X		
Nemophila menziesii	Menzies' baby blue eyes	3									
Nemophila parviflora	Small-flowered nemophila	3									
Nemophila parviflora var. *austinae*	Small-flowered nemophila	3									
Nemophila pedunculata	Meadow nemophila	1							X		
Nemophila spatulata	Sierra baby blue eyes	1							X	X	
Nicotiana attenuata	Coyote tobacco	1					WH, M		X		
Nothocalais alpestris	Alpine lake prairiedandelion	1							X		
*Nuphar luteum**		1							X	X	
Nuphar luteum ssp. *polysepalum*	Yellow pond-lily	1							X	X	
Nymphaea odorata	American white waterlily	1				X	M		X		
Oenanthe sarmentosa	Water parsely	1					M			X	
Oenothera caespitosa	Fragrant evening primrose	3					M				
Oenothera caespitosa ssp. *marginata*	Large white desert primrose	3					M				
Oenothera elata	Hooker's eveningprimrose	1							X		
Oenothera elata ssp. *hirsutissima*	Hooker's evening primrose	1							X		
Oenothera elata ssp. *hookeri*	Showy evening primrose	3									
*Oenothera flava**		3									
Oenothera flava ssp. *flava*	Yellow eveningprimrose	3					M				
*Onopordum acanthium**		3									
Onopordum acanthium ssp. *acanthium*	Scotch Thistle	3				X	M				
Ophioglossum pusillum	Northern adder's tongue	3									
Opuntia erinacea	Grizzlybear pricklypear	3									
Opuntia erinacea var. *utahensis*	Grizzlybear pricklypear	3									
Orobanche californica	California broomrape	1							X		
Orobanche corymbosa	Flattop broomrape	1							X		
Orobanche fasciculata	Clustered broomrape	1					M		X	X	
Orobanche parishii	Parish's broomrape	3									

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Orobanche uniflora	Oneflowered broomrape	1							X	X	
Orogenia fusiformis	California Indian potato	1							X		
Orthilia secunda	One-sided wintergreen	1							X	X	
Orthocarpus cuspidatus	Siskiyou owl's-clover	1							X		
Orthocarpus cuspidatus ssp. *cryptanthus*	Short-flowered owl's-clover	1							X		
Orthocarpus luteus	Yellow owl's clover	1							X		
Osmorhiza chilensis	Sweetcicely	1					M		X	X	
Osmorhiza occidentalis	Western sweet cicely	1					WH		X	X	
Oxypolis occidentalis	Western cowbane	1							X		
Oxyria digyna	Alpine mountainsorrel	1							X		
*Oxytheca dendroidea**		3									
Oxytheca dendroidea ssp. *dendroidea*	Tall oxytheca	3									
Oxytheca perfoliata	Roundleaf puncturebract	3									
Paeonia brownii	Mountain peony	1					M, WH		X	X	
Panicum acuminatum	Pacific panicgrass	3									
Panicum miliaceum	Broom Corn Millet	1								X	
Parnassia californica	Grass-of-Parnassus	1							X		
Parnassia fimbriata	Rocky Mountain parnassia	1					M		X		
Pectocarya setosa	Moth combseed	3									
Pedicularis attollens	Attol lousewort	1							X	X	
Pedicularis groenlandica	Elephanthead lousewort	1					WH, M		X	X	
Pedicularis racemosa	Leafy lousewort	3					M				
Pedicularis semibarbata	Bearded lousewort	1							X	X	
Pellaea brachyptera	Sierra cliffbrake	3									
Pellaea breweri	Brewer's cliffbrake	1							X		
Pellaea bridgesii	Bridges' cliffbrake	1							X	X	
Pellaea mucronata	Bird's-foot fern	3					M				
Pellaea mucronata var. *californica*	California cliffbrake	3					M				
Pellaea mucronata var. *mucronata*	Bird's-foot fern	3					M				

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Penstemon azureus	Azure penstemon	3									
Penstemon azureus var. *azureus*	Shortstalk penstemon	3									
*Penstemon davidsonii**		1							X		
Penstemon davidsonii var. *davidsonii*	Davidson's penstemon	1							X		
Penstemon deustus	Scabland penstemon	1					M		X	X	
Penstemon deustus var. *pedicellatus*	Hot-rock beardtongue	1					M		X		
Penstemon deustus var. *suffrutescens*	Hot-rock beardtongue	3					M				
Penstemon fruticiformis	Death Valley beardtongue	1								X	
Penstemon gracilentus	Slender penstemon	1							X	X	
Penstemon heterodoxus	Sierra beardtongue	1							X		
Penstemon heterodoxus var. *heterodoxus*	Sierra beardtongue	3									
Penstemon laetus	Mountain blue penstemon	3					M				
Penstemon laetus var. *laetus*	Western gray beardtongue	3					M				
Penstemon newberryi	Mountainpride penstemon	1							X	X	
Penstemon newberryi var. *newberryi*	Newberry's penstemon	3									
Penstemon personatus	Close-throated beardtongue	1		X	X			X		X	
Penstemon procerus	Littleflower penstemon	1							X		
Penstemon procerus var. *formosus*	Pincushion beardtongue	1							X		
Penstemon roezlii	Regel's penstemon	1							X	X	
Penstemon rydbergii	Rydberg's penstemon	1							X	X	
Penstemon rydbergii var. *oreocharis*	Meadow Beardtongue	1							X		
Penstemon speciosus	Royal penstemon	1							X	X	
Pentagramma triangularis	Gold fern	3					M				
Pentagramma triangularis ssp. *triangularis*	Goldback fern	3					M				
Peraphyllum ramosissimum	Wild crab apple	3									
Perideridia bacigalupii	Bacigalupi's perideridia	3		X	X						
Perideridia bolanderi	Bolander's yampah	1							X		
Perideridia bolanderi ssp. *bolanderi*	Bolander's yampah	3									
Perideridia lemmonii	Lemmon's yampah	1							X		

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Perideridia parishii	Parish's yampah	1							X	X	
Perideridia parishii ssp. *latifolia*	Parish's yampah	3									
*Phacelia bicolor**		3									
Phacelia bicolor var. *bicolor*	Twocolor phacelia	3									
Phacelia eisenii	Eisen's scorpionweed	1			X				X		
Phacelia glandulifera	Oak phacelia	3									
Phacelia hastata	Silverleaf phacelia	1					M		X	X	
Phacelia hastata ssp. *compacta*	Compact phacelia	1					M		X		
Phacelia hastata ssp. *hastata*	Mountain phacelia	3					M				
*Phacelia heterophylla**		1							X	X	
Phacelia heterophylla ssp. *virgata*	Varileaf phacelia	1							X	X	
Phacelia humilis	Low scorpionweed	1							X	X	
Phacelia humilis var. *humilis*	Low scorpionweed	3									
Phacelia hydrophylloides	Waterleaf phacelia	1							X	X	
Phacelia imbricata	Imbricate scorpionweed	3									
Phacelia imbricata ssp. *imbricata*	Imbricate scorpionweed	3									
Phacelia marcescens	Persistentflower scorpionweed	3			X						
Phacelia mutabilis	Changeable scorpionweed	1							X		
Phacelia procera	Mountain phacelia	3									
Phacelia quickii		1							X		
Phacelia racemosa	Racemose scorpionweed	1			X				X		
Phacelia ramosissima	Branching phacelia	1					M		X		
Phacelia ramosissima var. *eremophila*	Brancing phacelia	1					M		X		
Phacelia ramosissima var. *ramosissima*	Branching phacelia	3					M				
Phacelia ramosissima var. *subglabra*	Branching phacelia	3					M				
Phacelia tetramera	Fourpart scorpionweed	3									
Phalacroseris bolanderi	Bolander's mock dandelion	3			X						
Phleum alpinum	Mountain timothy	1							X	X	
Phleum pratense	Timothy	1							X	X	

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Phlox austromontana		1							X		
Phlox condensata	Condensed phlox	1							X		
Phlox diffusa	Spreading phlox	1							X	X	
*Phlox douglasii**		1							X		
Phlox douglasii ssp. *rigida*	Stiff phlox	1							X		
Phlox gracilis	Annual phlox	1							X	X	
*Phlox hoodii**		3									
Phlox hoodii ssp. *canescens*	Carpet phlox	3									
Phlox speciosa	Showy phlox	3									
Phlox stansburyi	Colddesert phlox	3					M				
Phoenicaulis cheiranthoides	Phoenicaulis	1					M		X		
Phoradendron densum	Dense mistletoe	1									
Phoradendron juniperinum	Mistletoe	3					M				
Phoradendron libocedri	Incense-cedar mistletoe	1							X		
Phoradendron pauciflorum	Fir mistletoe	1								X	
Phyllodoce breweri	Purple mountainheath	1							X	X	
Pinus albicaulis	Whitebark pine	1							X	X	
Pinus contorta	Lodgepole pine	1					M, CH		X	X	
Pinus contorta ssp. *murrayana*	Lodgepole pine	1					CH, M		X		
Pinus jeffreyi	Jeffrey pine	1					CH		X	X	
Pinus lambertiana	Sugar pine	1					M, CH, WH		X	X	
Pinus monophylla	Single-leaf pinyon pine	1					M		X		
Pinus monticola	Western white pine	1					M, CH		X	X	
Pinus ponderosa	Ponderosa pine	1					M, CH		X	X	
Pinus washoensis	Washoe Pine	3									
Piperia elegans		3									X
Piperia unalascensis	Alaska rein orchid	1							X		
Plagiobothrys cognatus	Sleeping popcornflower	1							X		
Plagiobothrys hispidulus	Sleeping popcornflower	1							X		

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Plagiobothrys hispidus	Cascade popcornflower	1							X		
Plagiobothrys kingii	King's popcornflower	3									
Plagiobothrys kingii var. *harknessii*	Great Basin popcornflower	3									
Plagiobothrys torreyi	Torrey's popcornflower	1							X		
Plagiobothrys torreyi var. *diffusus*	San Francisco popcornflower	3									
Plantago lanceolata	Narrowleaf plantain	1				X	M		X	X	
Platanthera leucostachys	Scentbottle, white bog orchid, white flowered bog	1							X	X	
Platanthera sparsiflora	Sparse-flowered bog-orchid	1							X	X	
Pleuricospora fimbriolata	Fringed pinesap	1							X	X	
Pleuropogon californicus	Semaphore Grass	1								X	
Poa bolanderi	Bolander's bluegrass	1							X	X	
Poa compressa	Canada bluegrass	1				X			X		
Poa cusickii	Skyline bluegrass	1							X	X	
Poa cusickii ssp. *cusickii*		3									
Poa cusickii ssp. *epilis*	Skyline bluegrass	1							X		
*Poa fendleriana**		1							X		
Poa fendleriana ssp. *longiligula*	Skyline bluegrass	1							X		
*Poa glauca**		1							X		
Poa glauca ssp. *rupicola*	Timberline bluegrass	1							X		
Poa nemoralis	Wood Bluegrass	1				X			X		
Poa palustris	Fowl bluegrass	1				X			X		
Poa pratensis		1							X		
Poa pratensis ssp. *pratensis*	Kentucky bluegrass	1				X			X		
Poa pringlei	Pringle's bluegrass	3									
Poa secunda	One-sided bluegrass	1							X	X	
Poa secunda ssp. *juncifolia*	Western bluegrass, one-sided bluegrass	3									
Poa secunda ssp. *secunda*	One-sided bluegrass	1							X		
Poa stebbinsii	Stebbins' bluegrass	3			X						

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Poa wheeleri	Wheeler's bluegrass	1								X	
Podistera nevadensis	Sierra podistera	1		X					X		
Polemonium californicum	Moving polemonium	1							X	X	
Polemonium occidentale	Western sky pilot	1							X	X	
Polemonium pulcherrimum	Sky pilot	1							X	X	
Polemonium pulcherrimum var. *pilosum*	White-flowered polemonium	3									
Polemonium pulcherrimum var. *pulcherrimum*	(none)	3									
Polygala cornuta	Sierra milkwort	3									
Polygala cornuta var. *cornuta*	Sierra milkwort	3									
Polygonum amphibium	Water smartweed	1					M		X	X	
Polygonum amphibium var. *emersum*	Kelp	1									
Polygonum amphibium var. *stipulaceum*	Water smartweed	1					M		X	X	
Polygonum arenastrum	Common knotweed	1				X			X	X	
Polygonum bistortoides	American bistort	1							X	X	
Polygonum davisiae	Davis' knotweed	1							X		
Polygonum douglasii	Douglas' knotweed	1							X		
Polygonum douglasii ssp. *douglasii*	Douglas' knotweed	3									
Polygonum douglasii ssp. *johnstonii*	Johnston's knotweed	1							X		
Polygonum douglasii ssp. *majus*	(none)	3									
Polygonum minimum	Broadleaf knotweed	1							X		
Polygonum persicaria	(none)	1							X		
Polygonum phytolaccifolium	Poke knotweed	1							X		
Polygonum polygaloides	Milkwort knotweed	1							X		
Polygonum polygaloides ssp. *kelloggii*	Kellogg's knotweed	1							X		
Polygonum shastense	Shasta knotweed	1							X	X	
Polypodium hesperium	Western polypody	3									
Polystichum imbricans	Cliff sword fern	3									
Polystichum imbricans ssp. *imbricans*	Cliff sword fern, imbricate sword fern, naked swor	3									
Polystichum kruckebergii	Kruckeberg's sword fern	1		X					X		

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Polystichum lonchitis	Holly fern	1							X		
Polystichum munitum	Western sword fern	3					M				
Polystichum scopulinum	Mountain hollyfern	3									
*Populus balsamifera**		1							X	X	
Populus balsamifera ssp. *trichocarpa*	Black cottonwood	1					M		X	X	
Populus tremuloides	Quaking aspen	1					M		X	X	
Porterella carnosula	Fleshy porterella	1							X		
*Potamogeton alpinus**		1							X		
Potamogeton alpinus ssp. *tenuifolius*	Alpine pondweed	1							X		
Potamogeton amplifolius	Broad-leaved pondweed	3									
*Potamogeton epihydrus**		1							X		
Potamogeton epihydrus ssp. *nuttallii*	Ribbonleaf pondweed	1		X					X		
Potamogeton foliosus	Leafy pondweed	3									
Potamogeton foliosus var. *foliosus*	Leafy pondweed	3									
Potamogeton gramineus	Variableleaf pondweed	1							X		
Potamogeton illinoensis	Shining pondweed	3									
Potamogeton natans	Floating-leaved pondweed	1					M		X		
Potamogeton nodosus	Long-leaved pondweed	1							X		
Potamogeton pectinatus	Fennel-leaved pondweed	1							X		
Potamogeton pusillus	Small pondweed	1							X		
Potamogeton pusillus var. *pusillus*	Small pondweed	3									
Potamogeton pusillus var. *tenuissimus*	Small pondweed	3									
Potamogeton richardsonii	Richardson's pondweed	3									
Potentilla anserina	Silverweed cinquefoil	3					M				
Potentilla anserina ssp. *anserina*		3					M				
Potentilla biennis	Biennial cinquefoil	1							X		
*Potentilla diversifolia**		1							X		
Potentilla diversifolia var. *diversifolia*	Varileaf cinquefoil	1							X		
Potentilla drummondii	Drummond's cinquefoil	1							X		

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Potentilla drummondii ssp. *breweri*	Brewer's potentilla	3									
Potentilla drummondii ssp. *bruceae*		3									
Potentilla drummondii ssp. *drummondii*		3									
Potentilla flabellifolia	High mountain cinquefoil	1							X		
Potentilla fruticosa	Shrubby cinquefoil	1					M		X		
Potentilla glandulosa	Gland cinquefoil	1					M		X	X	
Potentilla glandulosa ssp. *ashlandica*	Mountain cinquefoil	3					M				
Potentilla glandulosa ssp. *glandulosa*	Sticky Cinquefoil	1					M		X		
Potentilla glandulosa ssp. *hansenii*	Hansen's cinquefoil	3					M				
Potentilla glandulosa ssp. *nevadensis*	Nevada cinquefoil	1					M		X		
Potentilla glandulosa ssp. *pseudorupestris*	Sticky cinquefoil	1					M		X		
Potentilla glandulosa ssp. *reflexa*	Sticky cinquefoil	1					M		X		
Potentilla gracilis	Northwest cinquefoil	1							X	X	
Potentilla gracilis var. *fastigiata*	Slendercinquefoil	1							X		
Potentilla grayi	Gray's cinquefoil	3			X						
Potentilla palustris	Purple marshlocks	1					M		X		
Primula suffrutescens	Sierran primrose	1							X		
Prunella vulgaris		1							X	X	
Prunella vulgaris var. *lanceolata*	Lanceleaf selfheal	1							X	X	
Prunus emarginata	Bitter cherry	1					M		X	X	
*Prunus virginiana**		1							X	X	
Prunus virginiana var. *demissa*	Western chokecherry	1					M, WH		X	X	
Pseudostellaria jamesiana	Sticky Starwort	1							X	X	
Psilocarphus brevissimus	Woolly marbles	1							X		
Psilocarphus brevissimus var. *brevissimus*	Short woollyheads	3									
Psilocarphus tenellus	Slender woollyheads	3									
Psilocarphus tenellus var. *tenellus*	Woolly marbles	3									
*Pteridium aquilinum**		1							X	X	
Pteridium aquilinum var. *pubescens*	Bracken	1					WH, M		X	X	

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Pterospora andromedea	Woodland pinedrops	1					M		X	X	
Ptilagrostis kingii	King's ricegrass	1			X					X	
Purshia tridentata	Antelope bitterbrush	1					M		X	X	
Purshia tridentata var. *tridentata*	Antelope bitterbrush	3					M				
Pyrola asarifolia	Ginger-leaved wintergreen	1					M		X	X	
Pyrola asarifolia ssp. *asarifolia*	Liverleaf wintergreen	1					M		X		
Pyrola asarifolia ssp. *bracteata*	Pink wintergreen	3					M				
Pyrola minor	Snowline wintergreen	1							X	X	
Pyrola picta	Whiteveined wintergreen	1					M		X	X	
Pyrrocoma apargioides	Alpineflames	1							X		
Pyrrocoma hirta	Tacky goldenweed	3									
Pyrrocoma hirta var. *lanulosa*	Tacky goldenweed	3									
Pyrrocoma lanceolata	Lanceleaf goldenweed	3									
Pyrrocoma lanceolata var. *lanceolata*	Lanceleaf goldenweed	3									
Pyrrocoma lanceolata var. *subviscosa*	Lanceleaf goldenweed	3									
Pyrrocoma racemosa	Clustered goldenweed	3									
Pyrrocoma racemosa var. *paniculata*	Clustered goldenweed	3									
Pyrrocoma uniflora	Plantain goldenweed	3									
Pyrrocoma uniflora var. *uniflora*	One-flowered pyrrocoma	3									
Quercus chrysolepis	Canyon live oak	1					M		X		
Quercus vaccinifolia	Huckleberry oak	1							X	X	
Raillardella argentea	Silky raillardella	1							X		
Raillardella scaposa	Stem raillardella	1							X	X	
Ranunculus alismifolius	Alisma-leaved buttercup	1							X	X	
Ranunculus alismifolius var. *alismellus*	Alisma-leaved buttercup	1							X		
Ranunculus alismifolius var. *alismifolius*	Alisma-leaved buttercup	1							X		
Ranunculus andersonii	Anderson's buttercup	3									
Ranunculus aquatilus	Water buttercup	1							X	X	
Ranunculus aquatilus var. *capillaceus*	Water buttercup	1							X		

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*Ranunculus cymbalaria**		1							X		
Ranunculus cymbalaria var. *saximontanus*	Rocky Mountain buttercup	1					M		X		
Ranunculus eschscholtzii	Eschscholtz's buttercup	1							X		
Ranunculus eschscholtzii var. *oxynotus*	Eschscholtz's buttercup	1							X		
Ranunculus flammula	Water buttercup	1							X		
Ranunculus glaberrimus	Smooth buttercup	3					M				
Ranunculus glaberrimus var. *ellipticus*	Elliptical buttercup	3					M				
Ranunculus glaberrimus var. *glaberrimus*	Sagebrush buttercup	3					M				
Ranunculus occidentalis	Western buttercup	1					M		X	X	
Ranunculus orthorhynchus	Beaked buttercup	3									
Ranunculus orthorhynchus var. *orthorhynchus*	Straightbeak buttercup	3									
Ranunculus testiculatus		3				X					
Ranunculus uncinatus	Hooked-fruit buttercup	1					M		X		
Rhamnus ilicifolia	Hollyleaf redberry	3									
Rhamnus purshiana	Cascara sagrada	3					M				
Rhamnus rubra	Sierra coffeeberry	1			X				X		
Rhamnus tomentella		3									
Rhynchospora alba	White beaked-bush	3		X							
Ribes aureum	Golden currant	3					WH				
Ribes aureum var. *aureum*	Golden currant	3									
Ribes cereum	Wax currant	1							X	X	
Ribes divaricatum	Spreading gooseberry	1					M		X		
Ribes inerme	Whitestem gooseberry	1							X	X	
Ribes inerme var. *inerme*	Whitestem gooseberry	3									
Ribes lasianthum	Alpine gooseberry	1							X	X	
Ribes montigenum	Gooseberry currant	1							X	X	
Ribes nevadense	Sierra currant	1							X	X	
Ribes roezlii	Sierra gooseberry	1					WH		X	X	
Ribes roezlii var. *roezlii*	Roezl's gooseberry	3									

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Ribes velutinum	Desert gooseberry	3					WH				
Ribes viscosissimum	Sticky currant	1							X	X	
Rorippa curvipes	Bluntleaf yellowcress	1							X		
Rorippa curvipes var. *curvipes*	Bluntleaf yellowcress	3									
Rorippa curvipes var. *truncata*		3									
Rorippa curvisiliqua	Curvepod yellowcress	1							X	X	
Rorippa nasturtium-aquaticum	Water cress	1							X	X	
Rorippa palustris	Bog yellowcress	3									
Rorippa palustris var. *occidentalis*	Western bog yellowcress	3									
Rorippa subumbellata	Tahoe yellow cress	1	X	X	X			X	X		
Rosa bridgesii	Wood rose	3									
Rosa pinetorum	Pine rose	3									
*Rosa woodsii**		1							X	X	
Rosa woodsii var. *ultramontana*	Interior rose	1					M		X	X	
Rubus glaucifolius	Waxleaf raspberry	3									
Rubus leucodermis	Whitebark raspberry	3					M				
Rubus parviflorus	Thimbleberry	1					M		X	X	
Rudbeckia californica	California coneflower	3									
Rudbeckia californica var. *californica*	California coneflower	3									
Rumex acetosella	Common sheep sorrel	1				X	M		X	X	
Rumex crispus	Curly dock	1							X	X	
Rumex paucifolius	Fewleaved dock	1							X		
Rumex salicifolius	Willow dock	1					M		X	X	
Rumex salicifolius var. *denticulatus*	Willow dock	1					M		X		
Rumex salicifolius var. *lacustris*	Lake dock	3					M				
Rumex salicifolius var. *triangulivalvis*	Mexican dock willow dock	1					M		X		
Sagina saginoides	Arctic pearlwort	1							X		
Sagittaria cuneata	Tule potato	1					M		X		
Salix arctica	Arctic willow	3									

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Salix boothii	Booth's willow	1							X		
Salix eastwoodiae	Mountain willow	1							X		
Salix exigua	Sandbar willow	1					M		X	X	
Salix geyeriana	Geyer's willow	1							X	X	
Salix jepsonii	Jepson's willow	1							X	X	
Salix lasiolepis	Arroyo willow	1					M		X		
Salix lemmonii	Lemmon's willow	1							X	X	
Salix ligulifolia	Strapleaf willow	3									
Salix lucida	Shining willow	1					M			X	
Salix lucida ssp. *caudata*	Shining willow	3					M				
Salix lucida ssp. *lasiandra*	Shining willow	1					M		X	X	
Salix lutea	Yellow willow	3									
Salix melanopsis	Dusky willow	1							X		
Salix orestera	Sierra willow	1							X	X	
*Salix planifolia**		1								X	
Salix planifolia ssp. *planifolia*	Tea-leaved willow	1								X	
Salix prolixa	Mackenzie's willow	1								X	
Salix scouleriana	Scouler's willow	1					M		X	X	
Sambucus melanocarpa	Black elderberry	1					M			X	
Sambucus mexicana	Blue elder	1					M, WH		X	X	
Sambucus racemosa	Scarlet elderberry	1					M		X	X	
Sambucus racemosa var. *microbotrys*	Red elderberry	3					M				
Sanguisorba occidentalis	Western burnet	3									
Sanicula graveolens	Sierra sanicle	1							X		
Sanicula tuberosa	Turkey pea	1							X		
Sarcobatus vermiculatus	Greasewood	3					M				
Sarcodes sanguinea	Snowplant	1							X	X	
Saxifraga aprica	Sierra saxifrage	1							X		
Saxifraga bryophora	Bud saxifrage	1			X				X		

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Saxifraga californica	California saxifrage	3									
*Saxifraga nidifica**		1							X		
Saxifraga nidifica var. *nidifica*	Peak saxifrage	1							X		
Saxifraga odontoloma	Brook saxifrage	1							X	X	
Saxifraga oregana	Oregon saxifrage	1							X		
Saxifraga tolmiei	Tolmie's saxifrage	1							X		
*Scheuchzeria palustris**		3									
Scheuchzeria palustris ssp. *americana*	American Scheuchzeria	3		X				X			
Scirpus californicus	California bulrush	1							X		
Scirpus congdonii	Congdon's bulrush	1							X		
Scirpus maritimus	Prairie Rush	3									
Scirpus microcarpus	Panicled bulrush	1							X	X	
Scirpus nevadensis	Great Basin bulrush	3					M				
Scirpus pungens	Three-square common threesquare	1								X	
Scirpus subterminalis	Water bulrush	1		X					X		
Scrophularia desertorum	Desert figwort	1							X		
Scutellaria galericulata	Marsh skullcap	1		X			M		X		
Sedum lanceolatum	Spearleaf stonecrop	1							X		
Sedum obtusatum	Sierra stonecrop	1							X	X	
Sedum obtusatum ssp. *boreale*	Sierran stonecrop	3									
Sedum obtusatum ssp. *obtusatum*	Sierra stonecrop	3									
Sedum radiatum	Coast Range stonecrop	3									
*Sedum roseum**		1							X		
Sedum roseum ssp. *integrifolium*	Rosy stonecrop	1							X		
Sedum spathulifolium	Yellow stonecrop	3					M				
Sedum stenopetalum	Wormleaf stonecrop	1							X		
Selaginella watsonii	Watson's spike-moss	1							X		
Senecio aronicoides	Rayless groundsel	1							X		
Senecio canus	Woolly groundsel	1							X		

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Senecio cymbalarioides	Cleftleaf groundsel	3									
Senecio fremontii	Fremont's groundsel	1							X		
Senecio fremontii var. *occidentalis*	Fremont's ragwort	1							X		
Senecio hydrophilus	Water groundsel	1								X	
Senecio integerrimus	Forest groundsel	1							X	X	
Senecio integerrimus var. *exaltatus*	Columbia groundsel	1							X		
Senecio integerrimus var. *major*	Lambstongue groundsel	1							X		
Senecio pauciflorus	Alpine groundsel	3									
Senecio scorzonella	Sierra ragwort	1			X				X		
*Senecio serra**		1							X	X	
Senecio serra var. *serra*	Tall ragwort	1							X	X	
Senecio streptanthifolius	Cleftleaf groundsel	1							X		
Senecio triangularis	Arrowleaf groundsel	1					M		X	X	
Senecio vulgaris	Common groundsel	1								X	
Senecio werneriifolius	Hoary groundsel	1							X		
Shepherdia argentea	Buffalo berry	3					M				
Sibbaldia procumbens	Creeping sibbaldia	1							X		
Sidalcea glaucescens	Waxy checkermallow	1							X	X	
Sidalcea malvaeflora	Checker mallow	3									
Sidalcea malvaeflora ssp. *asprella*	Harsh checker-mallow	3									
Sidalcea oregana	Oregon checkermallow	1							X	X	
Sidalcea oregana ssp. *oregana*	Oregon checkermallow	3									
Sidalcea oregana ssp. *spicata*		1							X		
Silene bernardina	Palmer's catchfly	1							X		
Silene bridgesii	Bridges' catchfly	3			X						X
Silene douglasii	Douglas' catchfly	1							X	X	
Silene grayi	Gray's catchfly	3									
Silene invisa	Short-petaled campion	1		X					X		
Silene lemmonii	Lemmon's catchfly	1							X	X	

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Silene menziesii	Menzies' campion	3									
Silene occidentalis	Western catchfly	1			X				X		
Silene occidentalis ssp. *occidentalis*	Western catchfly	3			X						
Silene sargentii	Sargent's catchfly	1							X	X	
Silene verecunda	San Francisco campion	3									
Silene verecunda ssp. *andersonii*	Anderson's campion	3									
Sisymbrium altissimum	Tall tumblemustard	3				X	M				
Sisymbrium loeselii	Small tumbleweed mustard	3				X					
Sisyrinchium elmeri	Elmer's goldeneyed grass	1							X		
Sisyrinchium idahoense	Idaho blueeyed grass	1							X		
Smilacina racemosa	Large false solomon's seal	1					M		X	X	
Smilacina stellata	Little false solomon's seal	1					M, WH		X	X	
Solanum rostratum	Buffalo berry	1							X		
Solanum triflorum	Three-flowered nightshade	3				X	M				
Solanum xanti	Purple nightshade	1					M		X		
*Solidago altissima**		3									
Solidago altissima var. *altissima*	Late goldenrod	3				X	M				
Solidago californica	California goldenrod	1					M		X		
*Solidago canadensis**		1								X	
Solidago canadensis ssp. *elongata*	Canada goldenrod goldenrod	1					M			X	
Solidago gigantea	Smooth goldenrod	1		X			M			X	
Solidago multiradiata	Northern goldenrod	1							X	X	
Solidago sparsiflora		3					M				
Solidago spectabilis	Showy goldenrod	3									
Sorbus californica	California mountainash	1							X	X	
Sorbus scopulina	Mountain ash	3									
Sorbus scopulina var. *scopulina*	Mountain ash	3									
Sparganium angustifolium	Narrowleaf burreed	1							X		
Sparganium natans	Small bur-reed	1		X					X		

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Spergularia rubra	Red sandspurry	1				X			X	X	
Sphaeralcea ambigua	Apricot mallow	3					M				
Sphaeralcea munroana	Munro's globemallow	3									
Sphaeromeria potentilloides	Powerful tansy	3									
Sphaeromeria potentilloides var. *potentilloides*	Fivefinger chickensage	3									
Sphenosciadium capitellatum	Swamp whiteheads	1					WH, M		X	X	
Spiraea densiflora	Mountain spirea	1							X	X	
Spiranthes porrifolia	Creamy ladiestresses	1							X		
Spiranthes romanzoffiana	Hooded ladiestresses	1					M		X		
Stachys ajugoides	Ajuga hedge nettle	1							X	X	
Stachys ajugoides var. *ajugoides*	Hedge Nettle	1								X	
Stachys ajugoides var. *rigida*	Rigid hedge-nettle marsh hedgenettle	1							X		
*Stellaria borealis**		1								X	
Stellaria borealis ssp. *sitchana*	Northern starwort	1								X	
Stellaria calycantha	Northern starwort	3									
Stellaria crispa	Curled starwort	1							X		
Stellaria graminea	Chickweed	1								X	
*Stellaria longipes**		1							X	X	
Stellaria longipes var. *longipes*	Meadow starwort	1							X	X	
Stellaria media	Common chickweed	1				X	M		X	X	
Stellaria umbellata	Umbrella starwort	1							X		
Stenotus acaulis	Stemless mock goldenweed	1							X		
Stephanomeria exigua	Small wirelettuce	3					M				
Stephanomeria exigua ssp. *exigua*	Small wirelettuce	3					M				
Stephanomeria lactucina	Mountain lettuce	1							X		
Stephanomeria spinosa	Thorn skeletonweed	1					M		X		
Stephanomeria tenuifolia	Narrowleaf wirelettuce	1					M		X		
Stephanomeria virgata	Rod wirelettuce	3					M				
Stephanomeria virgata ssp. *pleurocarpa*	Wand wirelettuce	3					M				

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Streptanthus cordatus	Heartleaf twistflower	1					M		X		
Streptanthus cordatus var. *cordatus*	Heartleaf twistflower	3					M				
Streptanthus tortuosus	Shieldplant	1							X	X	
Streptanthus tortuosus var. *orbiculatus*	Shieldplant	1							X		
*Subularia aquatica**		1							X		
Subularia aquatica var. *americana*	American Awlwort	1							X		
Swertia albicaulis	Whitestem elkweed	3									
Swertia albicaulis var. *nitida*	Whitestem elkweed	3									
Swertia radiata	Monument plant	1					M		X		
Symphoricarpos mollis	Creeping snowberry	1					M		X	X	
Symphoricarpos rotundifolius	Roundleaf snowberry	1							X	X	
Symphoricarpos rotundifolius var. *parishii*	Parish's snowberry	3									X
Symphoricarpos rotundifolius var. *rotundifolius*	Huckleberry snowberry	3									
Tanacetum vulgare	Tansy	1							X	X	
Taraxacum officinale	Common dandelion	1				X	M		X	X	
Tetradymia canescens	Spineless horsebrush	1					M		X		
Tetradymia glabrata	Smooth horsebrush	3									
Tetradymia spinosa	Shortspine horsebrush	3									
Thalictrum fendleri	Fendler's meadowrue	1					WH, M		X	X	
Thalictrum fendleri var. *fendleri*	Fendler's meadowrue	3					M				
Thalictrum sparsiflorum	Fewflower meadowrue	1					M		X	X	
Thelypodium crispum	Crisped thelypody	3									
Thelypodium integrifolium	Entireleaved thelypody	3									
Thelypodium integrifolium ssp. *complanatum*	Entireleaved thelypody	3									
Thelypodium laciniatum	Cutleaf thelypody	3									
Thelypodium milleflorum	Manyflower thelypody	3									
Tiquilia nuttallii	Nuttall's coldenia	3									
*Tofieldia occidentalis**		1							X		
Tofieldia occidentalis ssp. *occidentalis*	Western tofieldia	1							X		

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Tonestus eximius	Lake Tahoe serpentweed	1		X	X				X		
Torreyochloa erecta	Upright mannagrass	1							X		
*Torreyochloa pallida**		1							X	X	
Torreyochloa pallida var. *pauciflora*	Sierra Nevada alkali grass weak mannagrass	1							X	X	
Townsendia scapigera	Tufted townsend daisy	1			X				X		
Tragopogon dubius	Yellow salsify	1								X	
*Trautvetteria caroliniensis**		1								X	
Trautvetteria caroliniensis var. *occidentalis*	False bugbane	1								X	
Tricardia watsonii	Three hearts	3									
Trichostema oblongum	Oblong bluecurls	1							X		
Trifolium andersonii	Anderson's clover	3									
Trifolium andersonii var. *andersonii*	Anderson's clover	3									
Trifolium beckwithii	Beckwith's clover	3									
Trifolium breweri	Brewer's clover	1							X		
Trifolium cyathiferum	Cup clover	1							X	X	
Trifolium dubium	Little Hop Clover / Shamrock	1								X	
Trifolium hybridum	Alsike clover	1				X	M		X		
*Trifolium kingii**		1							X		
Trifolium kingii var. *productum*	King's clover	1							X		
Trifolium lemmonii	Lemmon's clover	3		X							
Trifolium longipes	Longstalk clover	1							X	X	
Trifolium longipes var. *shastense*	Shasta clover	3									
Trifolium microcephalum		1							X		
Trifolium monanthum	Mountain carpet clover	1							X	X	
Trifolium monanthum var. *monanthum*	Mountain carpet clover	1							X		
Trifolium pratense	Red clover	1							X	X	
Trifolium repens	White clover	1							X	X	
Trifolium variegatum		1							X		

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Trifolium wormskioldii	Cows clover	1							X		
Triglochin maritima	Seaside arrow-grass	3									
Trillium albidum	Giant white wakerobin	3									
Trisetum canescens	Nodding oatgrass	1							X		
Trisetum cernuum	Nodding oatgrass	1							X		
Trisetum spicatum	Spike trisetum	1							X	X	
Trisetum wolfii	Wolf's trisetum	1							X	X	
Triteleia hyacinthina	White brodiaea	1					WH		X		
Triteleia ixioides	Prettyface	1					WH		X	X	
Triteleia ixioides ssp. *anilina*	Prettyface	3									
Triteleia ixioides ssp. *scabra*	Prettyface	1							X		
Triteleia lugens		3									X
Triteleia montana		1							X		
Tsuga heterophylla	Western Hemlock	1								X	
Tsuga mertensiana	Mountain hemlock	1					M		X	X	
Typha latifolia	Broadleaf cattail	3					M, WH				
*Urtica dioica**		1							X	X	
Urtica dioica ssp. *holosericea*	Hoary nettle	1					M		X	X	
Utricularia minor	Lesser bladderwort	1							X		
Utricularia vulgaris	Common bladderwort	1							X		
Vaccinium caespitosum	Dwarf bilberry	1							X		
Vaccinium deliciosum	Cascade bilberry	3									
*Vaccinium uliginosum**		1							X	X	
Vaccinium uliginosum ssp. *occidentale*	Western blueberry	1							X	X	
Valeriana californica	California valerian	1							X	X	
*Veratrum californicum**		1								X	
Veratrum californicum var. *californicum*	California corn lily	1					WH, M			X	
Verbascum thapsus	Common mullein	1				X	M		X	X	
Verbena lasiostachys	Western vervain	3					M				

			Ecological Criteria				Cultural Criteria		Source		
Scientific name	Common name	Reliability	T,E,SC	Rare	SN endemic	Exotic	Harvest	Agency emphasis	Smith	Manley Schlesinger	USDA
Verbena lasiostachys var. *lasiostachys*	Western vervain	3					M				
Veronica americana	American speedwell	1					M		X	X	
Veronica arvensis	Corn speedwell	1							X		
Veronica cusickii	Cusick's speedwell	1		X					X		
*Veronica peregrina**		1							X		
Veronica peregrina ssp. *xalapensis*	Hairy purslane speedwell	1					M		X		
Veronica scutellata	Marsh speedwell	1							X		
*Veronica serpyllifolia**		1							X		
Veronica serpyllifolia ssp. *humifusa*	Brightblue speedwell	1					M		X		
Veronica wormskjoldii	American alpine speedwell	1							X		
*Vicia americana**		1								X	
Vicia americana var. *americana*	American vetch	1					M			X	
Viola adunca	Hookedspur violet	1					M		X	X	
Viola bakeri	Baker's violet	1							X		
Viola beckwithii	Great Basin violet	1							X		
Viola douglasii	Douglas' violet	1								X	
Viola glabella	Pioneer violet	1							X	X	
Viola lobata	Moosehorn violet	3									
Viola lobata ssp. *lobata*	Moosehorn violet	3									
Viola macloskeyi	Small white violet	1							X	X	
Viola pinetorum	Pine violet	1							X		
Viola pinetorum ssp. *grisea*	Grey-leaved violet	1		X				X	X		
Viola pinetorum ssp. *pinetorum*	Pine violet	1							X		
Viola praemorsa	Astoria violet	1								X	
Viola praemorsa ssp. *linguifolia*	Upland yellow violet	3									
Viola purpurea	Goosefoot violet	1							X	X	
Viola purpurea ssp. *integrifolia*	Smooth-leaved violet	1							X		
Viola purpurea ssp. *purpurea*	Goosefoot violet	3									
Viola purpurea ssp. *venosa*	Goosefoot yellow violet	3									

			Ecological Criteria				Cultural Criteria		Source		
Scientific name	**Common name**	**Reliability**	**T,E,SC**	**Rare**	**SN endemic**	**Exotic**	**Harvest**	**Agency emphasis**	**Smith**	**Manley Schlesinger**	**USDA**
Viola sheltonii	Shelton's violet	1							X		
*Viola sororia**		1							X		
Viola sororia ssp. *affinis*	Northern bog violet	1							X		
Viola tomentosa	Woolly violet	1		X	X				X		
Vulpia myuros	Rattail fescue	3				X					
Vulpia octoflora	Sixweeks fescue	1								X	
Whitneya dealbata	Mock leopardbane	1			X				X		
Woodsia scopulina	Cliff fern	1							X	X	
Wyethia mollis	Woolly wyethia	1					WH, M		X	X	
Zannichellia palustris	Horned pondweed	3									
Zigadenus paniculatus	Foothill deathcamas	3					M				
*Zigadenus venenosus**		1								X	
Zigadenus venenosus var. *venenosus*	Death camas	1					WH, M			X	

Appendix F

Nonvascular Plants of the Lake Tahoe Basin

APPENDIX F

NONVASCULAR PLANTS OF THE LAKE TAHOE BASIN

Erik M. Holst and Matthew D. Schlesinger

Table F-1—Documented and potential nonvascular plants in the Lake Tahoe basin. Reliability codes: 1 = high—documented as occurring in the basin; 2 = low—potentially occurring in the basin based on known occurrence in the Sierra Nevada. Sierra Nevada endemic and rare classifications are from Shevock (1996); additional information was obtained from Desjardin (1999) and SFSU (1998a, 1998b). Source codes: MANL = Manley (unpubl. data); SHEV = Shevock (1996); UCB = UCB (1999a).

Scientific name	Reliability	Endemic	Rare	MANL	SHEV	UCB
Amblystgium sp.	1			X		
Amphidium californicum	2					X
Amphidium lapponicum	1			X		X
Anacolia menziesii	2					X
Andreaea nivalis	2		X		X	
Antitrichia californica	2					X
Aulacomnium androgynum	1			X		X
Aulacomnium palustre	2					X
Barbula sp.	1			X		
Bartramia ithyphylla	2					X
Brachythecium asperrimum	2					X
Brachythecium frigidum	1			X		X
Brachythecium sp.	1			X		
Bruchia bolanderi	2		X		X	
Bryum argenteum	2					X
Bryum caespiticium	2					X
Bryum canariense	2					X
Bryum capillare	2					X

Scientific name	Reliability	Endemic	Rare	MANL	SHEV	UCB
Bryum dichotomum	2					X
Bryum miniatum	2					X
Bryum pallens	2					X
Bryum pseudotriquetrum	1			X		X
Bryum sp.	1			X		
Campylium sp.	1			X		
Campylium stellatum	2		X		X	
Ceratodon purpureus	2					X
Claopodium whippleanum	2					X
Dendroalsia abietina	2					X
Didymodon sp.	1		X	X		
Distichium inclinatum	2				X	
Drepanocladus sp.	1			X		
Eurhynchium praelongum	2					X
Eurhynchium pulchellum	1			X		
Fissidens bryoides	2					X
Fontinalis antipyretica	1			X		
Fontinalis sp.	1			X		
Funaria hygrometrica	2					X
Grimmia alpestris	1			X		
Grimmia hamulosa	2	X	X		X	
Grimmia mixleyi	2		X		X	
Grimmia unicolor	1			X		
Homalothecium aeneum	2					X
Homalothecium nevadense	2					X
Homalothecium nuttallii	2					X
Homalothecium pinnatifidum	2					X
Hydrogrimmia mollis	2		X		X	
Hygrohypnum ochraceum	2					X
Hygrohypnum sp.	1			X		
Hypnum subimponens	2					X
Isothecium cristatum	2					X

Scientific name	Reliability	Endemic	Rare	MANL	SHEV	UCB
Isothecium myosuroides	2					X
Kindbergia praelonga	2					X
Leptobryum pyriforme	2					X
Lescura palens	1			X		
Lescuraea pallida	2		X		X	
Leucolepis acanthoneuron	2					X
Marchantia polymorpha	1			X		
Meiotrichum lyallii	1			X		X
Metaneckera menziesii	2					X
Mnium arizonicum	2		X		X	
Myurella julacea	2		X		X	
Orthodicranum strictum	2					X
Orthotrichum affine	2					X
Orthotrichum alpestre	2					X
Orthotrichum euryphyllum	2		X		X	
Orthotrichum laevigatum	2					X
Orthotrichum lyellii	2					X
Orthotrichum pylaisii	2					X
Orthotrichum rupestre	2					X
Orthotrichum speciosum	2					X
Orthotrichum spjutii	2	X	X		X	
Orthotrichum tenellum	2					X
Philonotis americana	1			X		
Philonotis fontana	2					X
Philonotis tomentella	2					X
Philonotis yezoana	1			X		
Plagiomnium insigne	2					X
Plagiomnium medium	2					X
Plagiomnium rostratum	1			X		
Plagiomnium sp.	1			X		
Plagiothecium denticulatum	2					X
Pohlia camptotrachela	2					X

Scientific name	Reliability	Endemic	Rare	MANL	SHEV	UCB
Pohlia cruda	2					X
Pohlia nutans	1			X		X
Pohlia sp.	1			X		
Pohlia wahlenbergii	2					X
Polytrichastrum alpinum	2					X
Polytrichum commune	2					X
Polytrichum juniperinum	2					X
Polytrichum piliferum	2					X
Polytrichum sexangulare	2		X		X	
Pseudobraunia californica	2					X
Pseudotaxiphyllum elegans	2					X
Pterigynandrum filiforme	2					X
Pterogonium gracile	2					X
Ptychomitrium gardneri	2					X
Racomitrium aciculare	2					X
Racomitrium heterostichum	2					X
Racomitrium hispanicum	2		X		X	
Racomitrium varium	2					X
Roellia roellii	2					X
Sanionia uncinata	2					X
Scapania sp.	1			X		
Schistidium agassizii	2					X
Schistidium apocarpum	2					X
Schistidium rivulare	2					X
Schistidium sp.	1			X		
Scleropodium cespitans	2					X
Scleropodium colpophyllum	2					X
Scleropodium obtusifolium	1			X		X
Scleropodium sp.	1			X		
Scleropodium touretii	2					X
Scouleria aquatica	1			X		X
Sphagnum mendocinum	2					X

Scientific name	Reliability	Endemic	Rare	MANL	SHEV	UCB
Tayloria serrata	2		X		X	
Tortula californica	2		X		X	
Tortula laevipila	2					X
Tortula muralis	2					X
Tortula papillosissima	2					X
Tortula princeps	2					X
Tortula ruralis	2					X
Tortula subulata	2					X
Warnstorfia exannulata	1			X		X
Weissia controversa	2					X

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APPENDIX G

VERTEBRATE SPECIES OF THE LAKE TAHOE BASIN

APPENDIX G

VERTEBRATE SPECIES OF THE LAKE TAHOE BASIN

Matthew D. Schlesinger and J. Shane Romsos

We compiled a list of all vertebrate species that have ever been recorded in the Lake Tahoe basin (Table G-1). We determined that the basin has been at least visited by a total of 262 birds, 66 mammals, 8 reptiles, 6 amphibians, and 27 fish, not including domesticated species. In general, information on vertebrates was relatively comprehensive, and the species lists we compiled are fairly accurate and complete. We discuss the data sources consulted, and the criteria used to determine the status of each species below. Table G-1 provides scientific names for all species discussed in the text.

Birds

The Lake Tahoe basin bird species pamphlet (Eastern Sierra Interpretive Association ca. 1993) provided the most complete listing of birds observed in recent times. The pamphlet was based primarily on consultation with local ornithologists and on birds treated in Orr and Moffitt (1971). We added the Brant based on Orr and Moffitt (1971). We added 3 species, the Black-Chinned Hummingbird, California Quail, and Wild Turkey, based on observations in lotic and lentic riparian studies in the basin (Manley and Schlesinger in prep.). We added the Green Heron based on an incidental observation in Keane and Morrison (1994). We added the Yellow-Billed Magpie based on survey work by the USDA Forest Service (unpubl. data). We did not include the following 4 species listed in Tahoe Regional Planning Agency and USDA Forest Service (1971a) as the existence of these species in the basin has not been otherwise documented: Common Barn Owl, Great Gray Owl, Short-Eared Owl, and Yellow-Breasted Chat.

Mammals

We obtained information on the mammals occurring in the basin from a variety of sources. The primary sources were Orr (1949) and Hall (1995), from which we included all species documented as occurring in the basin. We added 5 species from Manley and Schlesinger (in prep) and/or Keane and Morrison (1994): beaver, desert woodrat, least chipmunk, western gray squirrel, and western jumping mouse. We added 5 bats based on surveys by Pierson (1998) and Tatum (1998a, 1998b): Brazilian free-tailed bat, California myotis, fringed myotis, pallid bat, and western pipistrelle. We added the wolverine based on sightings in Grinnell et al. (1937). We added the canyon mouse based on historical records (Museum of Vertebrate Zoology, University of California at Berkeley). We did not include the following 8 species listed in Tahoe Regional Planning Agency and USDA Forest Service (1971a) as the existence of these species in the basin has not been otherwise documented: Great Basin pocket mouse, hoary bat, Inyo shrew, long-legged myotis, northern pocket gopher, small-footed myotis, spotted bat, Townsend's big-eared bat, and western harvest mouse.

Amphibians

Species detected in Manley and Schlesinger (in prep) were included. We added the northern leopard frog based on records from the University of California at Berkeley's Museum of Vertebrate Zoology discussed in Jennings and Hayes (1994).

Reptiles

No surveys directed explicitly at reptiles have been performed in the Lake Tahoe basin.

Table G-1—Vertebrate species of the Lake Tahoe basin. Sources: Orr = Orr and Moffitt (1971) for birds, Orr (1949) for mammals; PA = 'Pastel' series (TRPA and USDA 1971a, 1971b); BL = Lake Tahoe Basin bird species pamphlet (Eastern Sierra Interpretive Association ca. 1993); Hall = Hall (1995); K&M = Keane and Morrison (1994); M&S = Manley and Schlesinger (in preparation); OTH = other sources; Rel = reliability of data.

Common Name	Scientific Name	Current[1]	Candidate Focal Species[2]	Orr	Pa	BL/Hall	K&M[3]	M&S[3]	Oth[4]	Rel[5]
Birds										
Cooper's Hawk	*Accipiter cooperii*	Yes	Yes	Y	Y	Y	I	Y	MVZ	1
Northern Goshawk	*Accipiter gentilis*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Sharp-shinned Hawk	*Accipiter striatus*	Yes	Yes	Y	Y	Y	I	Y		1
Spotted Sandpiper	*Actitis macularia*	Yes	Yes	Y	Y	Y		Y	MVZ	1
Western/Clark's Grebe	*Aechmophorus occidentalis/clarkii*	Yes	Yes	Y	Y	Y		Y		1
Northern Saw-whet Owl	*Aegolius acadicus*	Yes	No(R)	Y	Y	Y				1
White-throated Swift	*Aeronautes saxatalis*	Yes	No(R)		Y	Y				3
Red-winged Blackbird	*Agelaius phoeniceus*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Tricolored Blackbird	*Agelaius tricolor*	Yes	No(M)		Y		I			1
Wood Duck	*Aix sponsa*	Yes	Yes	Y	Y	Y				1
Chukar	*Alectoris chukar*	No(A)	-			Y				3
Sage Sparrow	*Amphispiza belli*	No(A)	-			Y				3
Black-throated Sparrow	*Amphispiza bilineata*	No(A)	-	Y	Y	Y				1
Northern Pintail	*Anas acuta*	Yes	Yes	Y	Y	Y			MVZ	1
American Wigeon	*Anas americana*	Yes	Yes	Y	Y	Y				1
Northern Shoveler	*Anas clypeata*	Yes	Yes	Y	Y	Y			MVZ	1
Green-winged Teal	*Anas crecca*	Yes	Yes	Y	Y	Y	I	Y		1
Cinnamon Teal	*Anas cyanoptera*	Yes	Yes	Y	Y	Y				1
Blue-winged Teal	*Anas discors*	No(A)	-			Y				3
Eurasian Wigeon	*Anas penelope*	No(A)	-			Y				3
Mallard	*Anas platyrhynchos*	Yes	Yes	Y	Y	Y		Y	MVZ	1
Gadwall	*Anas strepera*	Yes	Yes	Y	Y	Y				1
Greater White-fronted Goose	*Anser albifrons*	Yes	No(R)	Y		Y				1
American Pipit	*Anthus rubescens*	Yes	Yes		Y	Y				3
Western Scrub Jay	*Aphelocoma californica*	Yes	Yes	Y	Y	Y				1
Golden Eagle	*Aquila chrysaetos*	Yes	Yes	Y	Y	Y	I	Y		1
Black-chinned Hummingbird	*Archilochus alexandri*	Yes	No(M)					Y		1
Great Egret	*Ardea alba*	Yes	No(R)	Y	Y	Y		Y		1
Great Blue Heron	*Ardea herodias*	Yes	Yes	Y	Y	Y	I	I		1

Common Name	Scientific Name	Current[1]	Candidate Focal Species[2]	Orr	Pa	BL/Hall	K&M[3]	M&S[3]	Oth[4]	Rel[5]
Ruddy Turnstone	*Arenaria interpres*	No(A)	-			Y				3
Long-eared Owl	*Asio otus*	Yes	No(R)	Y	Y	Y				1
Lesser Scaup	*Aythya affinis*	Yes	Yes	Y	Y	Y				1
Redhead	*Aythya americana*	Yes	No(R)	Y	Y	Y				1
Ring-necked Duck	*Aythya collaris*	Yes	Yes	Y	Y	Y	I	Y		1
Greater Scaup	*Aythya marila*	Yes	Yes		Y	Y				3
Canvasback	*Aythya valisineria*	Yes	Yes	Y	Y	Y				1
Bohemian Waxwing	*Bombycilla cedrorum*	No(A)	-			Y				3
Cedar Waxwing	*Bombycilla cedrorum*	Yes	Yes	Y	Y	Y	I			1
American Bittern	*Botaurus lentiginosus*	Yes	No(R)	Y	Y	Y			MVZ	1
Brant	*Branta bernicla*	No(A)	-	Y						1
Canada Goose	*Branta canadensis*	Yes	Yes	Y	Y	Y		Y	MVZ	1
Great Horned Owl	*Bubo virginianus*	Yes	Yes	Y	Y	Y	I	Y	MVZ	1
Bufflehead	*Bucephala albeola*	Yes	Yes	Y	Y	Y		Y		1
Common Goldeneye	*Bucephala clangula*	Yes	Yes	Y	Y	Y	I			1
Barrow's Goldeneye	*Bucephala islandica*	Yes	Yes	Y	Y	Y				1
Red-tailed Hawk	*Buteo jamaicensis*	Yes	Yes	Y	Y	Y	Y	Y		1
Rough-legged Hawk	*Buteo lagopus*	Yes	No(R)	Y		Y	I			1
Red-shouldered Hawk	*Buteo lineatus*	No(A)	-			Y				3
Ferruginous Hawk	*Buteo regalis*	No(A)	-	Y		Y	I			1
Swainson's Hawk	*Buteo swainsoni*	No(A)	-	Y	Y	Y				1
Green Heron	*Butorides virescens*	Yes	No(M)		?		I			1
Lapland Longspur	*Calcarius lapponicus*	No(A)	-			Y				3
Chestnut-collared Longspur	*Calcarius ornatus*	No(A)	-	Y		Y				1
Sanderling	*Calidris alba*	No(A)	-			Y			MVZ	1
Baird's Sandpiper	*Calidris bairdii*	No(A)	-			Y				3
Red Knot	*Calidris canutus*	No(A)	-			Y				3
Pectoral Sandpiper	*Calidris melanotos*	No(A)	-			Y				3
Least Sandpiper	*Calidris minutilla*	Yes	No(R)	Y	Y	Y				1
California Quail*	*Callipepla californica*	Yes	Yes	Y				Y		1
Anna's Hummingbird	*Calypte anna*	Yes	Yes			Y				3
Pine Siskin	*Carduelis pinus*	Yes	Yes	Y	Y	Y	Y	Y		1
Lesser Goldfinch	*Carduelis psaltria*	Yes	Yes	Y	Y	Y	I	Y		1
American Goldfinch	*Carduelis tristis*	Yes	No(R)	Y	Y	Y				1

Common Name	Scientific Name	Current[1]	Candidate Focal Species[2]	Orr	Pa	BL/Hall	K&M[3]	M&S[3]	Oth[4]	Rel[5]
Cassin's Finch	*Carpodacus cassinii*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
House Finch	*Carpodacus mexicanus*	Yes	Yes	Y		Y			MVZ	1
Purple Finch	*Carpodacus purpureus*	Yes	Yes	Y	Y	Y	I			1
Turkey Vulture	*Cathartes aura*	Yes	Yes	Y	Y	Y	I	Y		1
Hermit Thrush	*Catharus guttatus*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Swainson's Thrush	*Catharus ustulatus*	Yes	Yes	Y	Y	Y	I	Y		1
Canyon Wren	*Catherpes mexicanus*	No(E)	Yes	Y		Y				1
Willet	*Catoptrophorus semipalmatus*	Yes	No(R)	Y	Y	Y				1
Brown Creeper	*Certhia americana*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Belted Kingfisher	*Ceryle alcyon*	Yes	Yes	Y	Y	Y		Y	MVZ	1
Vaux's Swift	*Chaetura vauxi*	Yes	No(R)	Y	Y	Y				1
Snowy Plover	*Charadrius alexandrinus*	No(A)	-			Y			MVZ	1
Semipalmated Plover	*Charadrius semipalmatus*	Yes	No(M)		Y	Y				3
Killdeer	*Charadrius vociferus*	Yes	Yes	Y	Y	Y	I	Y	MVZ	1
Snow Goose	*Chen caerulescens*	Yes	No(R)	Y	Y	Y				1
Ross's Goose	*Chen rossii*	No(A)	-	Y		Y				1
Black Tern	*Chlidonias niger*	Yes	No(R)	Y	Y	Y			MVZ	1
Lark Sparrow	*Chondestes grammacus*	Yes	No(R)	Y	Y	Y				1
Common Nighthawk	*Chordeiles minor*	Yes	Yes	Y	Y	Y	I	Y	MVZ	1
American Dipper	*Cinclus mexicanus*	Yes	Yes	Y	Y	Y	I	Y		1
Northern Harrier	*Circus cyaneus*	Yes	Yes	Y	Y	Y		Y		1
Marsh Wren	*Cistothorus palustris*	Yes	Yes	Y	Y	Y		Y		1
Oldsquaw	*Clangula hyemalis*	No(A)	-			Y				3
Evening Grosbeak	*Coccothraustes vespertinus*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Northern Flicker	*Colaptes auratus*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Band-tailed Pigeon	*Columba fasciata*	Yes	Yes	Y	Y	Y	Y	Y		1
Rock Dove*	*Columba livia*	Yes	Yes			Y	I	Y		1
Olive-sided Flycatcher	*Contopus cooperi*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Western Wood-pewee	*Contopus sordidulus*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
American Crow	*Corvus brachyrhynchos*	Yes	Yes	Y		Y		Y		1
Common Raven	*Corvus corax*	Yes	Yes		Y	Y	Y	Y		1
Steller's Jay	*Cyanocitta stelleri*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Tundra Swan	*Cygnus columbianus*	Yes	Yes	Y		Y				1
Black Swift	*Cypseloides niger*	Yes	No(R)			Y		Y		1

Common Name	Scientific Name	Current[1]	Candidate Focal Species[2]	Orr	Pa	BL/Hall	K&M[3]	M&S[3]	Oth[4]	Rel[5]
Blue Grouse	*Dendragapus obscurus*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Yellow-rumped Warbler	*Dendroica coronata*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Black-throated Gray Warbler	*Dendroica nigrescens*	Yes	No(R)		Y	Y	I	Y		1
Hermit Warbler	*Dendroica occidentalis*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Yellow Warbler	*Dendroica petechia*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Blackpoll Warbler	*Dendroica striata*	No(A)	-			Y				3
Townsend's Warbler	*Dendroica townsendi*	Yes	No(R)	Y	Y	Y	I			1
Pileated Woodpecker	*Dryocopus pileatus*	Yes	Yes	Y	Y	Y	Y	Y		1
Snowy Egret	*Egretta thula*	Yes	No(R)		Y	Y				3
Pacific-slope Flycatcher	*Empidonax difficilis*	Yes	Yes		Y	Y	I	Y		1
Hammond's Flycatcher	*Empidonax hammondii*	Yes	Yes	Y	Y	Y		Y		1
Dusky Flycatcher	*Empidonax oberholseri*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Willow Flycatcher	*Empidonax traillii*	Yes	Yes	Y	Y	Y		Y	MVZ	1
Gray Flycatcher	*Empidonax wrightii*	No(A)	-			Y				3
Horned Lark	*Eremophila alpestris*	Yes	Yes	Y	Y	Y				1
Western Sandpiper	*Ereunetes mauri*	Yes	No(R)	Y	Y	Y				1
Dunlin	*Erolia alpina*	Yes	No(R)	Y		Y				1
Brewer's Blackbird	*Euphagus cyanocephalus*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Merlin	*Falco columbarius*	Yes	No(R)		Y	Y	I			1
Prairie Falcon	*Falco mexicanus*	Yes	No(R)	Y	Y	Y				1
Peregrine Falcon	*Falco peregrinus*	No(E)	Yes	Y	Y	Y				1
American Kestrel	*Falco sparverius*	Yes	Yes	Y	Y	Y	I	I	MVZ	1
American Coot	*Fulica americana*	Yes	Yes	Y	Y	Y		Y	MVZ	1
Common Snipe	*Gallinago gallinago*	Yes	Yes	Y	Y	Y		Y	MVZ	1
Yellow-billed Loon	*Gavia adamsii*	Yes	No(R)			Y				3
Arctic Loon	*Gavia arctica*	Yes	No(R)		Y	Y				3
Common Loon	*Gavia immer*	Yes	Yes	Y	Y	Y	I		MVZ	1
Common Yellowthroat	*Geothlypis trichas*	Yes	No(R)	Y	Y	Y			MVZ	1
Northern Pygmy-owl	*Glaucidium gnoma*	Yes	Yes	Y	Y	Y	I	Y		1
Sandhill Crane	*Grus canadensis*	Yes	No(R)	Y	Y	Y				1
Pinyon Jay	*Gymnorhinus cyanocephalus*	Yes	No(R)	Y	Y	Y				1
Bald Eagle	*Haliaeetus leucocephalus*	Yes	Yes	Y	Y	Y	I	I		1
Black-necked Stilt	*Himantopus mexicanus*	Yes	No(R)	Y		Y				1
Barn Swallow	*Hirundo rustica*	Yes	Yes	Y	Y	Y	I	Y	MVZ	1

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Bullock's Oriole	*Icterus bullockii*	Yes	No(R)	Y	Y	Y				1
Least Bittern	*Ixobrychus exilis*	Yes	No(R)	Y		Y				1
Varied Thrush	*Ixoreus naevius*	Yes	Yes	Y	Y	Y	Y			1
Dark-eyed Junco	*Junco hyemalis*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Northern Shrike	*Lanius excubitor*	Yes	No(R)	Y	Y	Y				1
Loggerhead Shrike	*Lanius ludovicianus*	Yes	No(R)		Y	Y	I			1
Herring Gull	*Larus argentatus*	Yes	No(R)	Y		Y				1
California Gull	*Larus californicus*	Yes	Yes	Y	Y	Y		Y		1
Ring-billed Gull	*Larus delawarensis*	Yes	Yes	Y	Y	Y		Y		1
Glaucous-winged Gull	*Larus glaucescens*	No(A)	-	Y		Y				1
Glaucous Gull	*Larus hyperboreus*	No(A)	-			Y				3
Bonaparte's Gull	*Larus philadelphia*	Yes	No(R)	Y		Y				1
Thayer's Gull	*Larus thayeri*	Yes	No(R)			Y				3
Gray-crowned Rosy Finch	*Leucosticte tephrocotis*	Yes	Yes	Y	Y	Y			MVZ	1
Short-billed Dowitcher	*Limnodromus griseus*	No(A)	-	Y		Y				1
Long-billed Dowitcher	*Limnodromus scolopaceus*	Yes	No(R)		Y	Y				3
Marbed Godwit	*Limosa fedoa*	Yes	No(R)		Y	Y				3
Hooded Merganser	*Lophodytes cucullatus*	Yes	Yes	Y	Y	Y				1
Red Crossbill	*Loxia curvirostra*	Yes	Yes	Y	Y	Y	Y	Y		1
Lewis's Woodpecker	*Melanerpes lewis*	No(E)	Yes	Y	Y	Y				1
White-winged Scoter	*Melanitta deglandi*	No(A)	-	Y		Y				1
Surf Scoter	*Melanitta perspicillata*	No(A)	-			Y				3
Wild Turkey*	*Meleagris gallopavo*	Yes	Yes					I		1
Swamp Sparrow	*Melospiza georgiana*	No(A)	-			Y				3
Lincoln's Sparrow	*Melospiza lincolnii*	Yes	Yes	Y	Y	Y	I	Y	MVZ	1
Song Sparrow	*Melospiza melodia*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Common Merganser	*Mergus merganser*	Yes	Yes	Y	Y	Y	I	Y	MVZ	1
Red-breasted Merganser	*Mergus serrator*	Yes	No(R)	Y		Y				1
Northern Mockingbird	*Mimus polyglottos*	Yes	No(R)			Y				3
Brown-headed Cowbird	*Molothrus ater*	Yes	Yes	Y	Y	Y	Y	Y		1
Townsend's Solitaire	*Myadestes townsendi*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Ash-throated Flycatcher	*Myiarchus cinerascens*	Yes	No(R)		Y	Y				3
Clark's Nutcracker	*Nucifraga columbiana*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Long-billed Curlew	*Numenius americanus*	Yes	No(R)	Y	Y	Y				1

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Whimbrel	*Numenius phaeopus*	No(A)	-			Y				3
Black-crowned Night Heron	*Nycticorax nycticorax*	Yes	Yes	Y	Y	Y		Y		1
MacGillivray's Warbler	*Oporornis tolmiei*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Mountain Quail	*Oreortyx pictus*	Yes	Yes	Y	Y	Y	Y	Y		1
Flammulated Owl	*Otus flammeolus*	Yes	No(R)	Y		Y	I		MVZ	1
Western Screech-owl	*Otus kennicottii*	Yes	Yes		Y	Y				3
Ruddy Duck	*Oxyura jamaicensis*	Yes	Yes	Y	Y	Y				1
Osprey	*Pandion haliaetus*	Yes	Yes	Y	Y	Y	I	Y		1
House Sparrow*	*Passer domesticus*	Yes	Yes	Y	Y	Y		Y		1
Savannah Sparrow	*Passerculus sandwichensis*	No(E)	Yes	Y	Y	Y			MVZ	1
Fox Sparrow	*Passerella iliaca*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Lazuli Bunting	*Passerina amoena*	Yes	Yes	Y	Y	Y		Y		1
American White Pelican	*Pelecanus erythrorhynchos*	Yes	Yes	Y	Y	Y				1
Cliff Swallow	*Petrochelidon pyrrhonota*	Yes	Yes	Y	Y	Y	Y	Y		1
Double-crested Cormorant	*Phalacrocorax auritus*	Yes	No(R)	Y	Y	Y				1
Common Poorwill	*Phalaenoptilus nuttallii*	Yes	No(R)	Y	Y	Y			MVZ	1
Red-necked Phalarope	*Phalaropus lobatus*	Yes	No(R)	Y	Y	Y				1
Wilson's Phalarope	*Phalaropus tricolor*	Yes	No(R)	Y	Y	Y		Y	MVZ	1
Black-headed Grosbeak	*Pheucticus melanocephalus*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Yellow-billed Magpie	*Pica nuttalli*	Yes	No(M)						USDA	2
Black-billed Magpie	*Pica pica*	Yes	Yes	Y	Y	Y		Y		1
White-headed Woodpecker	*Picoides albolarvatus*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Black-backed Woodpecker	*Picoides arcticus*	Yes	Yes	Y	Y	Y	Y	Y		1
Downy Woodpecker	*Picoides pubescens*	Yes	Yes		Y	Y	Y	Y		1
Three-toed Woodpecker	*Picoides tridactylus*	No(A)	-			Y				3
Hairy Woodpecker	*Picoides villosus*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Pine Grosbeak	*Pinicola enucleator*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Green-tailed Towhee	*Pipilo chlorurus*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
California Towhee	*Pipilo crissalis*	Yes	No(R)			Y				3
Spotted Towhee	*Pipilo maculatus*	Yes	Yes	Y	Y	Y	Y	Y		1
Western Tanager	*Piranga ludoviciana*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
White-faced Ibis	*Plegadis chihi*	No(A)	-	Y		Y				1
Black-bellied Plover	*Pluvialis squatarola*	No(A)	-			Y				3
Horned Grebe	*Podiceps auritus*	Yes	No(M)	Y	Y	Y				1

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Red-necked Grebe	*Podiceps grisegena*	Yes	No(R)	Y	Y	Y				1
Eared Grebe	*Podiceps nigricollis*	Yes	Yes	Y	Y	Y		I		1
Pied-billed Grebe	*Podilymbus podiceps*	Yes	Yes	Y	Y	Y	I		MVZ	1
Black-capped Chickadee	*Poecile atricapillus*	Yes	No(R)			Y				3
Mountain Chickadee	*Poecile gambeli*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Chestnut-backed Chickadee	*Poecile rufescens*	No(A)	-			Y				3
Blue-gray Gnatcatcher	*Polioptila caerulea*	Yes	No(R)	Y	Y	Y	I			1
Vesper Sparrow	*Pooecetes gramineus*	Yes	No(R)	Y	Y	Y				1
Sora	*Porzana carolina*	Yes	Yes	Y		Y		Y	MVZ	1
Purple Martin	*Progne subis*	Yes	No(R)		Y	Y				3
Bushtit	*Psaltriparus minimus*	Yes	Yes	Y	Y	Y		Y		1
Virginia Rail	*Rallus limicola*	Yes	No(R)	Y	Y	Y			MVZ	1
American Avocet	*Recurvirostra americana*	Yes	No(R)	Y	Y	Y				1
Ruby-crowned Kinglet	*Regulus calendula*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Golden-crowned Kinglet	*Regulus satrapa*	Yes	Yes	Y	Y	Y	Y	Y		1
Bank Swallow	*Riparia riparia*	Yes	Yes		Y	Y		Y		1
Rock Wren	*Salpinctes obsoletus*	Yes	Yes	Y	Y	Y		Y	MVZ	1
Black Phoebe	*Sayornis nigricans*	No(A)	-		Y	Y	I			1
Say's Phoebe	*Sayornis saya*	No(A)	-		Y	Y				3
Broad-tailed Hummingbird	*Selasphorus platycercus*	Yes	No(M)			Y				3
Rufous Hummingbird	*Selasphorus rufus*	Yes	Yes	Y	Y	Y	I	Y	MVZ	1
American Redstart	*Setophaga ruticilla*	No(A)	-			Y				3
Mountain Bluebird	*Sialia currucoides*	Yes	Yes	Y	Y	Y	I	Y	MVZ	1
Western Bluebird	*Sialia mexicana*	Yes	Yes	Y	Y	Y	Y	I	MVZ	1
Red-breasted Nuthatch	*Sitta canadensis*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
White-breasted Nuthatch	*Sitta carolinensis*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Pygmy Nuthatch	*Sitta pygmaea*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Red-breasted Sapsucker	*Sphyrapicus ruber*	Yes	Yes	Y	Y	Y	Y	Y		1
Williamson's Sapsucker	*Sphyrapicus thyroideus*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Brewer's Sparrow	*Spizella breweri*	Yes	No(R)	Y	Y	Y				1
Chipping Sparrow	*Spizella passerina*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	Yes	No(R)	Y	Y	Y		Y		1
Calliope Hummingbird	*Stellula calliope*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Parasitic Jaeger	*Stercorarius parasiticus*	No(A)	-	Y	Y	Y				1

Common Name	Scientific Name	Current[1]	Candidate Focal Species[2]	Orr	Pa	BL/Hall	K&M[3]	M&S[3]	Oth[4]	Rel[5]
Caspian Tern	*Sterna caspia*	Yes	No(R)	Y		Y		Y		1
Forster's Tern	*Sterna forsteri*	Yes	Yes	Y	Y	Y		Y	MVZ	1
Common Tern	*Sterna hirundo*	Yes	No(R)	Y		Y				1
Spotted Owl	*Strix occidentalis*	Yes	Yes		Y	Y	I			1
Western Meadowlark	*Sturnella neglecta*	Yes	Yes	Y	Y	Y	I	Y	MVZ	1
European Starling*	*Sturnus vulgaris*	Yes	Yes		Y	Y		Y		1
Least Grebe	*Tachybaptus dominicus*	Yes	No(R)			Y				3
Tree Swallow	*Tachycineta bicolor*	Yes	Yes	Y	Y	Y	I	Y	MVZ	1
Violet-green Swallow	*Tachycineta thalassina*	Yes	Yes	Y	Y	Y	I	Y		1
Bewick's Wren	*Thryomanes bewickii*	Yes	No(R)		Y	Y		Y		1
Lesser Yellowlegs	*Tringa flavipes*	No(A)	-			Y				3
Greater Yellowlegs	*Tringa melanoleuca*	Yes	No(R)	Y	Y	Y				1
House Wren	*Troglodytes aedon*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Winter Wren	*Troglodytes troglodytes*	Yes	Yes	Y	Y	Y		Y		1
American Robin	*Turdus migratorius*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Eastern Kingbird	*Tyrannus tyrannus*	No(A)	-			Y				3
Western Kingbird	*Tyrannus verticalis*	Yes	No(R)	Y		Y				1
Orange-crowned Warbler	*Vermivora celata*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Nashville Warbler	*Vermivora ruficapilla*	Yes	Yes	Y	Y	Y	Y	Y		1
Cassin's Vireo	*Vireo cassinii*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Warbling Vireo	*Vireo gilvus*	Yes	Yes	Y	Y	Y	Y	Y		1
Wilson's Warbler	*Wilsonia pusilla*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	Yes	Yes	Y	Y	Y		Y	MVZ	1
Sabine's Gull	*Xema sabini*	No(A)	-	Y		Y				1
Mourning Dove	*Zenaida macroura*	Yes	Yes	Y	Y	Y	Y	Y	MVZ	1
White-throated Sparrow	*Zonotrichia albicollis*	Yes	No(R)			Y				3
Golden-crowned Sparrow	*Zonotrichia atricapilla*	Yes	No(R)	Y	Y	Y	I		MVZ	1
White-crowned Sparrow	*Zonotrichia leucophrys*	Yes	Yes	Y	Y	Y	I	Y	MVZ	1
Harris's Sparrow	*Zonotrichia querula*	No(A)	-		Y	Y				3
Mammals										
Pallid bat	*Antrozous pallidus*	Yes	Yes		Y				H?,CR	1
Mountain beaver	*Aplodontia rufa*	Yes	Yes	Y	Y			Y	MVZ	1
Coyote	*Canis latrans*	Yes	Yes	Y	Y		I	Y		1
Beaver*	*Castor canadensis*	Yes	Yes		Y		I	Y		1

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Big brown bat	*Eptesicus fuscus*	Yes	Yes	Y	Y				H,CR?,M VZ	1
Porcupine	*Erethizon dorsatum*	Yes	Yes	Y	Y		I	Y	MVZ	1
Mountain lion	*Felis concolor*	Yes	Yes	Y	Y		I			1
Bobcat	*Felis rufus*	Yes	Yes	Y	Y		I	Y		1
Northern flying squirrel	*Glaucomys sabrinus*	Yes	Yes	Y	Y		Y	Y	MVZ	1
Wolverine	*Gulo gulo*	No(E)	Yes		Y					1
Silver-haired bat	*Lasionycteris noctivagans*	Yes	Yes	Y	Y				H	1
Sierra Nevada snowshoe hare	*Lepus americanus tahoensis*	Yes	Yes	Y	Y		I		MVZ	1
Black-tailed hare	*Lepus californicus*	Yes	Yes	Y	Y					1
White-tailed hare	*Lepus townsendii*	No(E)	Yes	Y	Y					1
River otter	*Lutra canadensis*	Yes	Yes	Y	Y					1
Yellow-bellied marmot	*Marmota flaviventris*	Yes	Yes	Y	Y			Y	MVZ	1
Marten	*Martes americana*	Yes	Yes	Y	Y		I		MVZ	1
Fisher	*Martes pennanti*	Yes	Yes	Y	Y		I			1
Striped skunk	*Mephitis mephitis*	Yes	Yes	Y	Y			Y		1
Long-tailed vole	*Microtus longicaudus*	Yes	Yes	Y	Y		Y	Y	MVZ	1
Montane vole	*Microtus montanus*	Yes	Yes	Y	Y		Y	Y		1
Ermine	*Mustela erminea*	Yes	Yes	Y	Y		Y	Y	MVZ	1
Long-tailed weasel	*Mustela frenata*	Yes	Yes	Y	Y		Y	Y	MVZ	1
Mink	*Mustela vison*	Yes	Yes	Y	Y					1
California myotis	*Myotis californicus*	Yes	Yes						H,CR,M VZ	1
Long-eared myotis	*Myotis evotis*	Yes	Yes	Y	Y				H,CR,M VZ	1
Little brown myotis	*Myotis lucifugus*	Yes	Yes	Y	Y				H,MVZ	1
Fringed myotis	*Myotis thysanodes*	Yes	Yes		Y				H,CR,M VZ	1
Yuma myotis	*Myotis yumanensis*	Yes	Yes	Y	Y				H,CR,M VZ	1
Bushy-tailed woodrat	*Neotoma cinerea*	Yes	Yes	Y	Y			Y		1
Desert woodrat	*Neotoma lepida*	Yes	Yes					Y		1
Pika	*Ochotona princeps*	Yes	Yes	Y	Y				MVZ	1
Mule deer	*Odocoileus hemionus*	Yes	Yes	Y	Y		I	Y	MVZ	1
Muskrat	*Ondatra zibethicus*	Yes	Yes	Y	Y					1

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Mountain sheep	*Ovis canadensis californiana*	No(E)	Yes						NEV	3
Brush mouse	*Peromyscus boylii*	Yes	Yes	Y	Y			Y		1
Canyon mouse	*Peromyscus crinitus*	No(E)	Yes			Y			MVZ	1
Deer mouse	*Peromyscus maniculatus*	Yes	Yes	Y	Y		Y	Y	MVZ	1
Pinyon mouse	*Peromyscus truei*	Yes	Yes	Y	Y			Y		1
Heather vole	*Phenacomys intermedius*	No(E)	Yes	Y	Y					1
Western pipstrelle	*Pipistrellus hesperus*	Yes	Yes						CR	1
Raccoon	*Procyon lotor*	Yes	Yes	Y	Y		I	Y		1
Broad-footed mole	*Scapanus latimanus*	Yes	Yes	Y	Y			Y		1
Western gray squirrel	*Sciurus griseus*	Yes	Yes		Y		I	Y		1
Dusky shrew	*Sorex monticolus*	Yes	Yes	Y	Y			Y		1
Water shrew	*Sorex palustris*	Yes	Yes	Y	Y			Y	MVZ	1
Trowbridge's shrew	*Sorex trowbridgii*	Yes	Yes	Y	Y			Y	MVZ	1
Vagrant shrew	*Sorex vagrans*	Yes	Yes	Y				Y	MVZ	1
California ground squirrel	*Spermophilus beecheyi*	Yes	Yes	Y	Y		Y	Y	MVZ	1
Belding's ground squirrel	*Spermophilus beldingi*	Yes	Yes	Y	Y		I	Y	MVZ	1
Golden-mantled ground squirrel	*Spermophilus lateralis*	Yes	Yes	Y	Y		Y	Y	MVZ	1
Western spotted skunk	*Spilogale gracilis*	Yes	Yes	Y	Y					1
Nuttall's cottontail	*Sylvilagus nuttallii*	Yes	Yes	Y	Y			Y	MVZ	1
Brazilian free-tailed bat	*Tadarida brasiliensis*	Yes	Yes		Y				H,CR?	1
Yellow-pine chipmunk	*Tamias amoenus*	Yes	Yes	Y	Y		Y	Y	MVZ	1
Least chipmunk	*Tamias minimus*	Yes	Yes		Y			Y		1
Long-eared chipmunk	*Tamias quadrimaculatus*	Yes	Yes	Y	Y		Y	Y		1
Allen's chipmunk	*Tamias senex*	Yes	Yes	Y	Y		Y	Y	MVZ	1
Lodgepole chipmunk	*Tamias speciosus*	Yes	Yes	Y	Y		Y	Y	MVZ	1
Douglas' squirrel	*Tamiasciurus douglasii*	Yes	Yes	Y	Y		Y	Y	MVZ	1
Badger	*Taxidea taxus*	Yes	Yes	Y						1
Mountain pocket gopher	*Thomomys monticola*	Yes	Yes	Y	Y			Y	MVZ	1
Black bear	*Ursus americanus*	Yes	Yes	Y	Y		I	Y		1
Grizzly bear	*Ursus arctos*	No(E)	Yes						SNEP	3
Sierra Nevada red fox	*Vulpes vulpes necator*	No(E)	Yes	Y	Y					1
Western jumping mouse	*Zapus princeps*	Yes	Yes		Y		Y	Y	MVZ	1
Amphibians										
Long-toed salamander	*Ambystoma macrodactylum*	Yes	Yes					Y	MVZ	1

Common Name	Scientific Name	Current[1]	Candidate Focal Species[2]	Orr	Pa	BL/Hall	K&M[3]	M&S[3]	Oth[4]	Rel[5]
Western toad	*Bufo boreas*	Yes	Yes				I	Y	MVZ	1
Pacific treefrog	*Hyla regilla*	Yes	Yes				Y	Y	MVZ	1
Bullfrog*	*Rana catesbeiana*	Yes	Yes					Y		1
Mountain yellow-legged frog	*Rana muscosa*	Yes	Yes					Y	MVZ	1
Northern leopard frog[#]	*Rana pipiens*	No(E)	Yes						MVZ	1
Reptiles										
Rubber boa	*Charina bottae*	Yes	Yes				I		MVZ	1
Northern alligator lizard	*Elgaria coerulea*	Yes	Yes				Y		MVZ	1
Southern alligator lizard	*Elgaria multicarinata*	Yes	Yes					Y	MVZ	1
Sagebrush lizard	*Sceloporus graciosus*	Yes	Yes				I		MVZ	1
Western fence lizard	*Sceloporus occidentalis*	Yes	Yes				Y	Y	MVZ	1
Western aquatic garter snake	*Thamnophis couchii*	Yes	Yes				Y	Y	MVZ	1
Western terrestrial garter snake	*Thamnophis elegans*	Yes	Yes					Y	MVZ	1
Common garter snake	*Thamnophis sirtalis*	Yes	Yes					Y		1
Fish										
Goldfish*	*Carassius auratus*	Yes	Yes						LE	3
Tahoe sucker	*Catostomus tahoensis*	Yes	Yes		Y			Y	MI,MO	1
Lake whitefish*	*Coregonus clupeaformis*	No(E)	-						CO	3
Piute sculpin	*Cottus beldingi*	Yes	Yes		Y				MI,MO	1
Carp*	*Cyprinus carpio*	Yes	Yes					Y	AL	3
Mosquito fish*	*Gambusia affinis*	Yes	Yes		Y			Y		1
Tui chub	*Gila bicolor*	Yes	Yes		Y			Y		1
Brown bullhead*	*Ictalurus nebulosis*	Yes	Yes		Y			Y		1
Bluegill*	*Lepomis macrochirus*	Yes	Yes						BE	3
Largemouth bass*	*Macropterus salmoides*	Yes	Yes						AL	3
Smallmouth bass*	*Micropterus dolomieui*	Yes	Yes						AL	3
Golden shiner*	*Notemigonus crysoleucas*	Yes	Yes		Y					1
Golden trout*	*Oncorhynchus aquabonita*	Yes	Yes		Y					1
Lahontan cutthroat trout	*Oncorhynchus clarkii henshawi*	Yes	Yes		Y			Y		1
Rainbow trout*	*Oncorhynchus mykiss*	Yes	Yes		Y			Y		1
Kokanee salmon*	*Oncorhynchus nerka kennerlyi*	Yes	Yes		Y					1
Chinook salmon*	*Oncorhynchus tshawytscha*	No(E)	-						CO	3
White crappie*	*Pomoxis annularis*	Yes	Yes						AL	3
Black crappie*	*Pomoxis nigromaculatus*	Yes	Yes						AL	3

Common Name	Scientific Name	Current[1]	Candidate Focal Species[2]	Orr	Pa	BL/Hall	K&M[3]	M&S[3]	Oth[4]	Rel[5]
Mountain whitefish	*Prosopium williamsoni*	Yes	Yes		Y					1
Speckled dace	*Rhinichthys osculus*	Yes	Yes		Y					1
Lahontan redside shiner	*Richardsonius egregius*	Yes	Yes		Y					1
Atlantic salmon*	*Salmo salar*	No(E)	-						CO	3
German brown trout*	*Salmo trutta*	Yes	Yes		Y			Y		1
Brook trout*	*Salvelinus fontinalis*	Yes	Yes		Y			Y		1
Mackinaw (lake) trout*	*Salvelinus namaycush*	Yes	Yes		Y					1
Arctic grayling*	*Thymallus arcticus*	No(E)	-						CO	3

Notes:
[1] Yes = determined to occur in the basin currently; No(A) = accidental according to Lake Tahoe basin bird species pamphlet (Eastern Sierra Interpretive Association ca. 1993); No(E) = presumed to be extirpated from the basin based on a lack of sightings in the last 30 years.
[2] Yes = included in focal species analyses; No(R) = excluded from analyses due to rarity (Eastern Sierra Interpretive Association ca. 1993); No(M) = excluded due to miscellaneous reasons, such as lack of available data or infrequency of sightings.
[3] Y = observed during surveys; I = observed incidentally.
[4] Other sources—AL = Allen (1999), BE = Bezzone (1999), CO = Cordone (1986), CR = Tatum (1998a, 1998b), H = Pierson (1998), LE = Lehr (1999), MI = Miller (1951), MO = Moyle (1976), MVZ = Museum of Vertebrate Zoology, University of California at Berkeley, NEV = Nevers 1976, USDA = USDA (unpublished data).
[5] Reliability: 1 = documented records from scientific studies, inventories, or museum records; 2 = documented records from agency surveys; 3 = undocumented records without specific dates or locations (includes personal communications).
* = Exotic species
[#] = Possible exotic species

Detections from Manley and Schlesinger (in prep.) and Keane and Morrison (1994) provided confirmations of the occurrence of reptile species in the basin. Other species might be present but remain undocumented.

Fish

We obtained information on the fish species occurring in the basin from the following sources: Miller (1951), Moyle (1976), Beauchamp et al. (1994), Tahoe Regional Planning Agency (1971a), Cordone et al. (1971), Cordone (1986, letter to Tahoe Regional Planning Agency), Shade (personal communication), Bezzone (personal communication), Lehr (personal commu-nication), and Manley and Schlesinger (in prep). The 'native' silver trout (*Salmo regalis*) referred to by Miller (1951) was assumed to be a subspecies of introduced rainbow trout (Moyle 1976).

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Appendix H

Invertebrates of the Lake Tahoe Basin

APPENDIX H

INVERTEBRATES OF THE LAKE TAHOE BASIN

Erik M. Holst and Matthew D. Schlesinger

Table H-1—Documented and potential invertebrates of the Lake Tahoe basin. Species endemic to Lake Tahoe are noted with an "X". Reliability codes: 1 = high-documented occurrence; 2 = moderate-potentially occurring based on at least two sources or identified in areas adjacent to the basin; 3 = low-potentially occurring based on a single source. Sources consulted: Frantz and Cordone (1966, 1996), Kimsey (pers. comm.), Manley and Schlesinger (in prep), NAMC (1999), and Storer and Usinger (1963). Other sources: H = Hampton (1988); S = SFSU (1999a); USFW = USFWS (1999)

Phylum	Class	Order	Family	Scientific name	Common name	Basin endemic	Reliability	Kimsey	Storer & Usinger	Frantz-Cordone	Manley & Schlesinger	NAMC	Other sources
Annelida	Clitellata	Haplotaxida	Haplotaxidae	Haplotaxis			1			X			
		Haplotaxida	Naididae	Arcteonais lomondi			1			X			
		Haplotaxida	Naididae	Uncinais uncinata			1			X			
		Haplotaxida	Tubificidae	Ilyodrilus frantzi typica			1			X			
		Haplotaxida	Tubificidae	Limnodrilus hoffmeisteri			1			X			
		Haplotaxida	Tubificidae	Rhyacodrilus brevidentus		X	1			X			
		Haplotaxida	Tubificidae	Rhyacodrilus sodalis			1			X			
		Haplotaxida	Tubificidae	Spirosperma beetoni		X	1			X			
		Haplotaxida	Tubificidae	Varichaetadrilus minutus		X	1			X			
		Lumbriculida	Lumbriculidae	Kincaidiana freidris			1			X			
		Lumbriculida	Lumbriculidae	Rhynchelmis rostrata			1			X			
	Hirudinea	Pharyngobdellida	Erpobdellidae	Erpobdella punctata			1			X			
		Pharyngobdellida	Erpobdellidae	Helobdella stagnalis			1			X			
		Rhynchobdellida	Pisciolidae	Illimobdella moorei			1			X			
	Oligochaeta	Plesiopora	Tubificidae	Isochaeta nevadana			1			X			
		Plesiopora	Tubificidae	Pelosclex beetoni			1			X			
		Plesiopora	Tubificidae	Psammoryctides minutus			1			X			
Arthropoda	Arachnida	Arachnida	Agelenidae		Funnel web weavers		1				X		
		Arachnida	Amaurobiidae		Spider		1				X		

Phylum	Class	Order	Family	Scientific name	Common name	Basin endemic	Reliability	Kimsey	Storer & Usinger	Frantz-Cordone	Manley & Schlesinger	NAMC	Other sources
		Arachnida	Antrodiaetidae		Folding door trap-door spiders		1				X		
		Arachnida	Araneidae	Argiope	Orb Weaver		3		X				
		Arachnida	Clubionidae		Two clawed hunting spiders		1				X		
		Arachnida	Dictynidae		Spiders		1				X		
		Arachnida	Gnaphosidae		Ground spider		1				X		
		Arachnida	Hahniidae		Spider		1				X		
		Arachnida	Linyphiidae	Pitohyphantes costatus	Sheet-Web Spiders		1				X		
		Arachnida	Lycosidae	Lycosa	Wolf Spider		3		X				
		Arachnida	Lycosidae		Wolf spider		1				X		
		Arachnida	Micryphantidae		Dwarf spiders		1				X		
		Arachnida	Philodromidae		Spider		1				X		
		Arachnida	Pholcidae		Long legged or Cellar spider		1				X		
		Arachnida	Salticidae	Salticus	Jumping Spider		3		X				
		Arachnida	Salticidae		Jumping spiders		1				X		
		Arachnida	Segestriidae		Spider		1				X		
		Arachnida	Tetragnathidae		Long jawed orb weavers		1				X		
		Arachnida	Theridiidae		Comb-footed Spiders		1				X		
		Arachnida	Thomisidae		Crab spiders		1				X		
		Opiliones	Phalangiidae	Phalangium	Harvestman		3		X				
		Opiliones	Phalangiidae		Daddy long legs		1				X		
	Arachnoidea	Acarina	Hydrachoellae	Lobertia	Water Mite		3		X				
		Acarina	Tetranychidae	Oligonychus spp.			3		X				
		Acarina	Tetranychidae	Tetranychus	Red Spider Mite		3		X				
		Acarina	Torrenticolidae				3					X	
		Acarina	Trombidiidae		Mites		1				X		
		Hydrachnellae	Hydrovolziidae	Hydrovolzia			1			X			
		Hydrachnellae	Hygrobatidae	Hygrobates			1			X			
		Hydrachnellae	Lebertiidae	Lebertia			1			X			
		Hydrachnellae	Limnesiidae	Limnesia			1			X			
		Hydrachnellae	Pionidae	Piona			1			X			
	Chilopoda				Centipedes		1				X		

Phylum	Class	Order	Family	Scientific name	Common name	Basin endemic	Reliability	Kimsey	Storer & Usinger	Frantz-Cordone	Manley & Schlesinger	NAMC	Other sources
	Crustacea	Amphipoda	Gammaridae	Gammarus lacustris			3					X	
		Amphipoda	Gammaridae	Stygobromus hubbsi			1			X			
		Amphipoda	Gammaridae	Stygobromus lacicolus		X	1			X			
		Amphipoda	Gammaridae	Stygobromus tahoensis		X	1			X			
		Amphipoda	Hyalellidae	Hyalella inermis	Scud		1			X			
		Amphipoda	Hyalellidae	Hyallella azteca			1			X			
		Anostraca	Branchinectidae	Branchinecta shantzi	Fairy Shrimp		3		X				
		Cladocera	Bosminidae	Bosmina longirostris			1			X			
		Cladocera	Bosminidae	Drepanothrix dentata			1			X			
		Cladocera	Daphnidae	Dalphnia pulcaria			1						
		Cladocera	Daphnidae	Daphnia pulex			1			X			
		Cladocera	Daphnidae	Daphnia rosea			1			X			
		Cladocera	Daphnidae	Simocephalus serrulatus			1			X			
		Cladocera	Macrothricidae	Acroperus harpae			1			X			
		Cladocera	Macrothricidae	Alona affinis			1			X			
		Cladocera	Macrothricidae	Alona quadrangularis			1			X			
		Cladocera	Macrothricidae	Camptocercus rectirostris			1			X			
		Cladocera	Macrothricidae	Chydorus latus			1			X			
		Cladocera	Macrothricidae	Chydorus sphaericus			1			X			
		Cladocera	Macrothricidae	Eurycercus lamellatus			1			X			
		Cladocera	Macrothricidae	Hyocryptus acutifrons			1			X			
		Cladocera	Macrothricidae	Ilyocryptus acutifrons			1			X			
		Cladocera	Macrothricidae	Pleuroxus denticulatus			1			X			
		Cladocera	Sididae	Latona setifera			1			X			
		Copepoda					3					X	
		Decapoda	Astacidae	Pacifastacus leniusculus	Crayfish		1			X			
		Diplopoda			Millipedes		1				X		
		Eucopepoda	Cylclopidae	Acanthocyclops vernalis			1			X			
		Eucopepoda	Cylclopidae	Cyclops	Copepod		3		X				
		Eucopepoda	Cylclopidae	Macrocyclops albidus			1			X			
		Eucopepoda	Cytheridae	Uncinocythere			1			X			
		Eucopepoda	Diaptomidae	Diaptomus tyrrelli			1			X			
		Eucopepoda	Diaptomidae	Leptodiaptomus tyrrelli			1			X			

Phylum	Class	Order	Family	Scientific name	Common name	Basin endemic	Reliability	Kimsey	Storer & Usinger	Frantz-Cordone	Manley & Schlesinger	NAMC	Other sources
		Eucopepoda	Lernaeopodidae	Samincola edwardsii			1			X			
		Eucopepoda	Temoridae	Epischura nevadensis			1			X			
		Isopoda	Armadillidiae	Porcellio	Sowbug		3		X				
		Mysidacea	Mysidae	Mysis relicta	Opossum shrimp		1			X			
		Ostracoda					3					X	
		Podocopa	Cypridae	Candona tahoensis		X	1			X			
		Podocopa	Cypridae	Eucypris	Muscle Shrimp		3		X				
	Insecta	Blattaria	Blattellidae		cockroaches		2	X					
		Blattaria	Blattidae		cockroaches		2	X					
		Coleoptera	Alleculidae		Comb-clawed beetles		1				X		
		Coleoptera	Amphizoidae	Amphizoa insolens			3		X				
		Coleoptera	Anobiidae		Death watch beetles		1				X		
		Coleoptera	Anthicidae		Antlike flower beetle		1				X		
		Coleoptera	Anthribidae		Fungus weevil		1				X		
		Coleoptera	Artematopidae		Beetle		1				X		
		Coleoptera	Bostrichidae				2	X					
		Coleoptera	Bruchidae				2	X					
		Coleoptera	Buprestidae	Chalcophora	Metallic Wood Borer		3		X				
		Coleoptera	Buprestidae	Melanophila	Metallic Wood Borer		3		X				
		Coleoptera	Buprestidae	Pauprestis aurlenta	Metallic Wood Borer		3		X				
		Coleoptera	Buprestidae		Metallic wood-boring beetles		1				X		
		Coleoptera	Byrrhidae				3					X	
		Coleoptera	Cantharidae		Soldier beetles		1				X		
		Coleoptera	Carabidae	Cychrus	Carabid beetles		3		X				
		Coleoptera	Carabidae		Ground beetle		1				X		
		Coleoptera	Cephaloidae		False longhorn beetles		1				X		
		Coleoptera	Cerambycidae	Ergates	Long-horned Beetle		3		X				
		Coleoptera	Cerambycidae		Long-horned beetles		1				X		
		Coleoptera	Chrysomelidae		Leaf beetles		1				X		
		Coleoptera	Cicindelidae		Tiger Beetles		1				X		
		Coleoptera	Ciidae		Minute Tree Fungus Beetles		3					X	
		Coleoptera	Cleridae		Checkered beetles		1				X		

Phylum	Class	Order	Family	Scientific name	Common name	Basin endemic	Reliability	Kimsey	Storer & Usinger	Frantz-Cordone	Manley & Schlesinger	NAMC	Other sources
		Coleoptera	Coccinellidae		Ladybird beetles		1				X		
		Coleoptera	Colydiidae		Cylindrical bark beetles		1						
		Coleoptera	Corylophidae		Minute fungus beetles		1				X		
		Coleoptera	Cucujidae		Flat Bark Beetles		3		X				
		Coleoptera	Cupedidae	Priacma	Reticulated beetles		3		X				
		Coleoptera	Curculionidae	Brachyrhinus	Weevil		3		X				
		Coleoptera	Curculionidae	Cylindrocopturus	Pine Reproduction Weevil		3		X				
		Coleoptera	Curculionidae	Rhodobaenus tredecimpunctatus	Weevil		3		X				
		Coleoptera	Curculionidae		Weevils		1				X		
		Coleoptera	Dascillidae		Soft-bodied plant beetles		2	X					
		Coleoptera	Dermestidae		Dermestid Beetles		1				X		
		Coleoptera	Dryopidae	Helichus			3					X	
		Coleoptera	Dytiscidae	Agabinus			3					X	
		Coleoptera	Dytiscidae	Agabus disintegratus	Predaceous Diving Beetles		3		X				
		Coleoptera	Dytiscidae	Agabus obliterus	Predaceous Diving Beetles		3		X				
		Coleoptera	Dytiscidae	Bidessus affinis	Predaceous Diving Beetles		3		X				
		Coleoptera	Dytiscidae	Colymbetes rugipennis	Predaceous Diving Beetles		3		X				
		Coleoptera	Dytiscidae	Deronectes			3					X	
		Coleoptera	Dytiscidae	Hydaticus			3					X	
		Coleoptera	Dytiscidae	Hydroporus funestus	Predaceous Diving Beetles		3		X				
		Coleoptera	Dytiscidae	Hydroporus striatellus	Predaceous Diving Beetles		3		X				
		Coleoptera	Dytiscidae	Hydrovatus			3					X	
		Coleoptera	Dytiscidae	Hygrotus nigrescens	Predaceous Diving Beetles		3		X				
		Coleoptera	Dytiscidae	Laccophilus decipiens	Predaceous Diving Beetles		3		X				
		Coleoptera	Dytiscidae	Oreodytes			3					X	
		Coleoptera	Dytiscidae	Rhantus			3					X	
		Coleoptera	Dytiscidae	Uvarus			3					X	

Phylum	Class	Order	Family	Scientific name	Common name	Basin endemic	Reliability	Kimsey	Storer & Usinger	Frantz-Cordone	Manley & Schlesinger	NAMC	Other sources
		Coleoptera	Dytiscidae		Predaceous diving beetles		1				X		
		Coleoptera	Elateridae		Click beetles		1				X	X	
		Coleoptera	Elmidae	Ampumixis			3					X	
		Coleoptera	Elmidae	Atractelmis			3					X	
		Coleoptera	Elmidae	Cleptelmis ornata			3					X	
		Coleoptera	Elmidae	Dubiraphia			3					X	
		Coleoptera	Elmidae	Heterlimnius corpulentus	Riffle Beetle		3		X				
		Coleoptera	Elmidae	Lara			3					X	
		Coleoptera	Elmidae	Narpus concolor			3					X	
		Coleoptera	Elmidae	Optioservus			3					X	
		Coleoptera	Elmidae	Ordobrevia			3					X	
		Coleoptera	Elmidae	Oulimnius			3					X	
		Coleoptera	Elmidae	Rhizelmis nigra			3					X	
		Coleoptera	Elmidae	Zaitzevia			3					X	
		Coleoptera	Endomychidae		Handsome fungus beetles		1				X		
		Coleoptera	Erotylidae		Pleasing fungus beetles		2	X					
		Coleoptera	Eucnemidae		False click beetles		2	X					
		Coleoptera	Gyrinidae	Gyrinus picipes	Whirligig beetles		3		X				
		Coleoptera	Helophoridae	Helophorus			3					X	
		Coleoptera	Heteroceridae		Variegated mud loving beetles		1				X		
		Coleoptera	Histeridae		Hister beetles		1				X		
		Coleoptera	Hydraenidae	Hydraena			3					X	
		Coleoptera	Hydraenidae	Ochthebius			3					X	
		Coleoptera	Hydrochidae	Hydrochus			3					X	
		Coleoptera	Hydrophilidae	Ametor			3					X	
		Coleoptera	Hydrophilidae	Berosus maculosus	Water Scavenger		3		X				
		Coleoptera	Hydrophilidae	Crenitis alticda	Water Scavenger		3		X				
		Coleoptera	Hydrophilidae	Enochrus			3					X	
		Coleoptera	Hydrophilidae	Hydrobius			3					X	
		Coleoptera	Hydrophilidae	Lacobius ellipticus	Water Scavenger		3		X				
		Coleoptera	Hydrophilidae	Paracymus			3					X	

Phylum	Class	Order	Family	Scientific name	Common name	Basin endemic	Reliability	Kimsey	Storer & Usinger	Frantz-Cordone	Manley & Schlesinger	NAMC	Other sources
		Coleoptera	Hydrophilidae	Tropisternus ellipticus	Water Scavenger		3		X				
		Coleoptera	Lampyridae		Fireflies		3		X				
		Coleoptera	Leiodidae		Round fungus beetle		1				X		
		Coleoptera	Lucanidae		Stag beetles		1				X		
		Coleoptera	Lycidae		Net winged beetles		1				X		
		Coleoptera	Melandryidae		False darkling beetle		1				X		
		Coleoptera	Meloidae		Blister beetles		1				X		
		Coleoptera	Melyridae		Soft winged flower beetles		1				X		
		Coleoptera	Mordellidae		Tumbling flower beetles		1				X		
		Coleoptera	Nitidulidae		Sap beetles		1				X		
		Coleoptera	Nosodendridae		Wounded tree beetles		1				X		
		Coleoptera	Oedemeridae		False blister beetles		1				X		
		Coleoptera	Phalacridae		Shining flower beetles		1				X		
		Coleoptera	Phengodidae		Pink glow worms		2	X					
		Coleoptera	Psephenidae	Acneus			3					X	
		Coleoptera	Psephenidae	Eubrianax edwardsi			3					X	
		Coleoptera	Psephenidae	Eubrianix			3					X	
		Coleoptera	Psephenidae	Psephenus			3					X	
		Coleoptera	Ptilidae		Feather winged beetle		1				X		
		Coleoptera	Ptilodactylidae	Anchycteis			3					X	
		Coleoptera	Ptilodactylidae	Stenocolus			3					X	
		Coleoptera	Rhipiphoridae		Wedge-shaped beetles		2	X					
		Coleoptera	Rhynchitidae		Beetle		1				X		
		Coleoptera	Rhysodidae		Wrinkled bark beetles		3					X	
		Coleoptera	Salpingidae		Narrow waisted bark beetles		2	X					
		Coleoptera	Scarabaeidae		Scarab beetles		1				X		
		Coleoptera	Scolytidae	Conophthorus	Bark beetles		3		X				
		Coleoptera	Scolytidae	Dendroctonus	Bark beetles		3		X				
		Coleoptera	Scolytidae		Bark or engraver beetles		1				X		
		Coleoptera	Silphidae		Carrion beetles		1				X		
		Coleoptera	Staphylinidae	Micralymma			3					X	

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		Coleoptera	Staphylinidae		Rove beetles		1				X		
		Coleoptera	Tenebrionidae		Darkling beetles (Stink)		1				X		
		Coleoptera	Trogossitidae		Bark gnawing beetles		1				X		
		Collembola	Hypogastruridae		Collembolas		1				X		
		Collembola	Hypogastrurinae	Xenylla humicola			3		X				
		Collembola	Isotomidae		Collembola		1				X		
		Collembola	Onchiuridae		Onchiurids (Collembola)		1				X		
		Collembola	Poduridae	Achorutes armatus			3		X				
		Collembola	Sminthuridae	Sminthurides aquaticus			3		X				
		Collembola	Sminthuridae	Sminthurides malmgreni			3		X				
		Collembola	Sminthuridae		Globular springtails		1				X		
		Dermaptera	Forficulidae		Common earwigs		1				X		
		Dermaptera	Labiidae		Little earwigs		1				X		
		Diptera	Acroceridae		Small headed flies		1				X		
		Diptera	Anthomyiidae		Anthomyiid flies		1				X		
		Diptera	Anthomyzidae		Anthomyzid flies		1				X		
		Diptera	Asilidae		Robber flies		1				X		
		Diptera	Atherceridae	Atherix			3					X	
		Diptera	Bibionidae		March flies		1				X		
		Diptera	Blephariceridae	Agathon			3					X	
		Diptera	Blephariceridae	Bibiocephala			3					X	
		Diptera	Blephariceridae	Blephmaricera			3					X	
		Diptera	Bombyliidae		Bee Flies		3		X		X		
		Diptera	Calliphoridae		Blowflies		1				X		
		Diptera	Cecidomyiidae		Gall gnats		1				X		
		Diptera	Ceratopogonidae	Atrichopogon			3					X	
		Diptera	Ceratopogonidae	Bezzia			3					X	
		Diptera	Ceratopogonidae	Dasyhelea			3					X	
		Diptera	Ceratopogonidae	Forcipomyia			3					X	
		Diptera	Ceratopogonidae	Palpomyia			1			X			
		Diptera	Ceratopogonidae	Probezzia			3					X	
		Diptera	Chaoboridae	Eucorethr	Phantom midge		3		X				

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		Diptera	Chironomidae	Ablabesmyia monilis			1			X			
		Diptera	Chironomidae	Apsectrotanypus			1			X			
		Diptera	Chironomidae	Boreoheptagyia			3					X	
		Diptera	Chironomidae	Chironominae			3					X	
		Diptera	Chironomidae	Cladotanytarsus No. 1			1			X			
		Diptera	Chironomidae	Cladotanytarsus No. 2			1			X			
		Diptera	Chironomidae	Conchapelopia			1			X			
		Diptera	Chironomidae	Cryptochironomus digilatus	Gnats/midges		3		X				
		Diptera	Chironomidae	Cryptochironomus near fuivus			1			X			
		Diptera	Chironomidae	Diamesinae			3					X	
		Diptera	Chironomidae	Dicrotendipes near modestus			1			X			
		Diptera	Chironomidae	Endochironomus near nigricans			1			X			
		Diptera	Chironomidae	Harnischia			1			X			
		Diptera	Chironomidae	Harnischia near nais			1			X			
		Diptera	Chironomidae	Heterotrissocladius oliveri			1			X			
		Diptera	Chironomidae	Metriocnemus lundbeck	Gnats/midges		3		X				
		Diptera	Chironomidae	Monodiamesa bathyphila			1			X			
		Diptera	Chironomidae	Orthocladius obumbratus			1			X			
		Diptera	Chironomidae	Paracladopelma			1			X			
		Diptera	Chironomidae	Paracladopelma near nais			1			X			
		Diptera	Chironomidae	Paratendipes albimanus	Gnats/midges		3		X				
		Diptera	Chironomidae	Paratrichocladius			1			X			
		Diptera	Chironomidae	Pentaneura			1			X			
		Diptera	Chironomidae	Pentaneura carnea	Gnats/midges		3		X				
		Diptera	Chironomidae	Phaenopsectra near profusa			1			X			
		Diptera	Chironomidae	Polypedilum isocercus	Gnats/midges		3		X				
		Diptera	Chironomidae	Polypedilum laetums	Gnats/midges		3		X				
		Diptera	Chironomidae	Polypedilum near scalaenum			1			X			

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		Diptera	Chironomidae	Potypedilum parascalaenum ?			1			X			
		Diptera	Chironomidae	Procladius bellus?			1			X			
		Diptera	Chironomidae	Procladius culiciformis	Gnats/midges		3		X				
		Diptera	Chironomidae	Prodiamesa bathyphila			1			X			
		Diptera	Chironomidae	Pseudochironomus pseudoviridus			1			X			
		Diptera	Chironomidae	Pseudodiamesa pertinax			1			X			
		Diptera	Chironomidae	Psilotanypus bellus?			1			X			
		Diptera	Chironomidae	Rheotanytarsus			1			X			
		Diptera	Chironomidae	Stenochironomus taeniapennis	Gnats/midges		3		X				
		Diptera	Chironomidae	Stictochironomus			1			X			
		Diptera	Chironomidae	Syndiamesa pertinax			1			X			
		Diptera	Chironomidae	Tanypodinae			3					X	
		Diptera	Chironomidae	Tanytarsus near guerlus			1			X			
		Diptera	Chironomidae	Tendipes near modestus			1			X			
		Diptera	Chironomidae		Midges		1				X		
		Diptera	Chloropidae		Fruit flies		1				X		
		Diptera	Culicidae	Aedes communis	Snow Mosquitoes		3		X				
		Diptera	Culicidae	Aedes fitchii	True Mosquitoes		3		X				
		Diptera	Culicidae	Culex territans	True Mosquitoes		3		X				
		Diptera	Culicidae	Culex tarsalis	True Mosquitoes		3		X				
		Diptera	Culicidae	Culiseta impatiens	True Mosquitoes		3		X				
		Diptera	Culicidae	Culiseta inornata	True Mosquitoes		3		X				
		Diptera	Deuterophlebiidae	Deuterophlebia			3					X	
		Diptera	Diastatidae		Diastatid flies		1				X		
		Diptera	Dixidae	Dixa			2		X			X	
		Diptera	Dixidae	Dixella			3					X	
		Diptera	Dixidae	Meringodixa			3					X	
		Diptera	Dixidae		Dixid midges		1				X		
		Diptera	Dolichopodidae		Long-legged flies		1				X		
		Diptera	Drosophilidae		Pomace flies		1				X		

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		Diptera	Empididae	Chelifera			3					X	
		Diptera	Empididae	Clinocera			3					X	
		Diptera	Empididae	Hemerodromia			3					X	
		Diptera	Empididae	Oreogeton			3					X	
		Diptera	Empididae		Dance flies		1				X		
		Diptera	Ephydridae		Shore flies		1				X		
		Diptera	Heleomyzidae		Heleomyzid flies		1				X		
		Diptera	Hippoboscidae		Louse flies		1		X		X		
		Diptera	Lauxaniidae		Lauxaniid flies		1				X		
		Diptera	Lonchopteridae		Spear winged flies		1				X		
		Diptera	Micropezidae		Stilt-legged flies		2	X					
		Diptera	Muscidae	Limnophora			3					X	
		Diptera	Muscidae		House flies		1		X		X		
		Diptera	Mycetophilidae		Fungus gnats		1				X		
		Diptera	Oestridae		Bot Flies		3		X				
		Diptera	Otitidae		Picture winged flies		2	X					
		Diptera	Pelecorhynchidae	Glutops			3					X	
		Diptera	Phoridae		Humpbacked flies		1				X		
		Diptera	Piophilidae		Skipper flies		2	X					
		Diptera	Pipunculidae		Big-headed flies		2	X					
		Diptera	Platypezidae		flat-footed flies		2	X					
		Diptera	Psychodidae	Maruina			3					X	
		Diptera	Psychodidae	Pericoma			1				X		
		Diptera	Psychodidae		Moth Flies		3		X				
		Diptera	Ptychopteridae	Ptychoptera			3					X	
		Diptera	Ptychopteridae				1				X		
		Diptera	Rhagionidae		Snipe flies		1				X		
		Diptera	Sarcophagidae		Flesh flies		1				X		
		Diptera	Scatophagidae		Dung flies		1				X		
		Diptera	Scatopsidae		Black scavenger flies		2	X					
		Diptera	Sciaridae		Dark winged fungus gnats		1				X		
		Diptera	Sciomyzidae		Marsh flies		1				X		

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		Diptera	Sepsidae		Black scavenger flies		1				X		
		Diptera	Simuliidae	Cnephia mutata	Blackflies		3		X				
		Diptera	Simuliidae	Prosimulium			3					X	
		Diptera	Simuliidae	Simulium			2		X			X	
		Diptera	Simuliidae	Twinnia			3					X	
		Diptera	Simuliidae				1				X		
		Diptera	Sphaeroceridae		Small dung flies		1				X		
		Diptera	Stratiomyidae	Caloparyphus			3					X	
		Diptera	Stratiomyidae	Euparyphus flaviventris	Soldier Flies		3		X				
		Diptera	Stratiomyidae	Euparyphus tahoensis	Soldier Flies		3		X				
		Diptera	Stratiomyidae	Myxosargus			3					X	
		Diptera	Stratiomyidae	Stratiomys discaloides	Soldier Flies		3		X				
		Diptera	Syrphidae	Lonchaea viridana	Drone or Flower Flies		3		X				
		Diptera	Syrphidae	Retinodiplosis	Drone or Flower Flies		3		X				
		Diptera	Syrphidae		Syrphid Flies		1				X		
		Diptera	Tabanidae	Chrysops	Horseflies, Deerflies		3		X				
		Diptera	Tabanidae	Tabanus			3					X	
		Diptera	Tabanidae		Horse & Deer Flies		1				X		
		Diptera	Tachinidae		Tachinid flies		1		X		X		
		Diptera	Tephritidae		Fruit flies		1		X		X		
		Diptera	Thaumaleidae				3					X	
		Diptera	Therevidae		Stiletto flies		1				X		
		Diptera	Tipulidae	Antocha monticola			3					X	
		Diptera	Tipulidae	Dicranota			3					X	
		Diptera	Tipulidae	Gonomyia			3					X	
		Diptera	Tipulidae	Hesperoconopa			3					X	
		Diptera	Tipulidae	Hexatoma			3					X	
		Diptera	Tipulidae	Limnophila freeborni	Crane fly		3		X				
		Diptera	Tipulidae	Molophilus			3					X	
		Diptera	Tipulidae	Ormosia pernodosa	Crane fly		3		X				
		Diptera	Tipulidae	Pedicia			3					X	
		Diptera	Tipulidae	Polymera burra	Crane fly		3		X				
		Diptera	Tipulidae	Rhabdomastix			3					X	

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		Diptera	Tipulidae		Crane flies		1				X		
		Diptera	Tipulidae	Tipula newcomeri	Crane fly		3		X				
		Diptera	Trichoceridae		Winter crane flies		2	X					
		Diptera	Xylomyidae				2	X					
		Diptera	Xylophagidae				2	X					
		Embioptera	Anisembiidae		Webspinners		1				X		
		Ephemeroptera	Ameletidae	Ameletus imbellis			3		X				
		Ephemeroptera	Baetidae	Acentrella			3					X	
		Ephemeroptera	Baetidae	Baetis			3					X	
		Ephemeroptera	Baetidae	Callibaetis			1			X			
		Ephemeroptera	Baetidae	Callibaetis pacificus			3		X				
		Ephemeroptera	Baetidae	Centroptilum			1			X			
		Ephemeroptera	Baetidae	Pseudocloeon			3					X	
		Ephemeroptera	Ephemerellidae	Attenella delantala			3					X	
		Ephemeroptera	Ephemerellidae	Attenella soquele			3					X	
		Ephemeroptera	Ephemerellidae	Caudatella heterocaudata			3					X	
		Ephemeroptera	Ephemerellidae	Caudatella hysterix			3					X	
		Ephemeroptera	Ephemerellidae	Drunella coloradensis			3					X	
		Ephemeroptera	Ephemerellidae	Drunella doddsi			3					X	
		Ephemeroptera	Ephemerellidae	Drunella flavilinea			3					X	
		Ephemeroptera	Ephemerellidae	Drunella spinifera			3					X	
		Ephemeroptera	Ephemerellidae	Ephemerella glacialis			3		X				
		Ephemeroptera	Ephemerellidae	Ephemerella inermis			3					X	
		Ephemeroptera	Ephemerellidae	Ephemerella infrequens			3					X	
		Ephemeroptera	Ephemerellidae	Serratella teresa			3					X	
		Ephemeroptera	Ephemerellidae	Timpanoga hecuba			3					X	
		Ephemeroptera	Ephemerellidae				3					X	
		Ephemeroptera	Heptageniidae	Cinygma			3					X	
		Ephemeroptera	Heptageniidae	Cinygmula tioga			3		X				
		Ephemeroptera	Heptageniidae	Epeorus dulciana			3		X				
		Ephemeroptera	Heptageniidae	Epeorus grandis			3		X				
		Ephemeroptera	Heptageniidae	Heptagenia			1			X			
		Ephemeroptera	Heptageniidae	Heptegenia ruboventris			3		X				

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		Ephemeroptera	Heptageniidae	Ironodes			3					X	
		Ephemeroptera	Heptageniidae	Leucrocuta			3					X	
		Ephemeroptera	Heptageniidae	Nixe			3					X	
		Ephemeroptera	Heptageniidae	Rhithrogena			2		X			X	
		Ephemeroptera	Isonychiidae	Isonychia			3					X	
		Ephemeroptera	Leptophlebiidae	Choroterpes			1			X			
		Ephemeroptera	Leptophlebiidae	Leptophlebia			3					X	
		Ephemeroptera	Leptophlebiidae	Paraleptophlebia associata			3		X				
		Ephemeroptera	Leptophlebiidae	Paraleptophlebia spp.			1			X			
		Ephemeroptera	Leptophlebiidae	Paraleptophlebia spp. of the packi, bicornuta, zayante, and helinae groups (may include a new species)			1			X			
		Ephemeroptera	Siphonuridae	Siphlonurus			1			X			
		Ephemeroptera	Tricorythidae	Tricorythodes fallax			1			X			
		Grylloblattodea	Grylloblattidae	Grylloblatta			3		X				
		Hemiptera	Aleyrodidae		White Flies		3		X				
		Hemiptera	Anthocoridae		Pirate Bugs		3		X				
		Hemiptera	Aphididae		Aphids		1		X		X		
		Hemiptera	Aradidae		Flat Bugs		3		X				
		Hemiptera	Belostomatidae	Lethocerus americanus			1			X			
		Hemiptera	Belostomatidae		Giant waterbugs		1				X		
		Hemiptera	Cercopidae		Spittlebugs and froghoppers		1				X		
		Hemiptera	Cicadellidae		Leafhoppers		1		X		X		
		Hemiptera	Cicadidae		Cicadas		1				X		
		Hemiptera	Cimicidae		Bat, Swallow, & Bed Bugs		3		X				
		Hemiptera	Coccidae		Scale Insects, Mealy Bugs		3		X				
		Hemiptera	Coreidae		Leaf footed bugs		1				X		
		Hemiptera	Corixidae	Callicorixa audeni	Water boatmen		3		X				
		Hemiptera	Corixidae	Cenocorixa spp.	Water boatmen		3		X				
		Hemiptera	Corixidae	Graptocorixa californica	Water boatmen		3		X				

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		Hemiptera	Corixidae	Sigara spp.	Water boatmen		3		X				
		Hemiptera	Corixidae				1				X		
		Hemiptera	Cydnidae		Burrower bugs		1				X		
		Hemiptera	Delphacidae		Delphacid planthoppers		1				X		
		Hemiptera	Fulgoridae		Planthoppers		3		X				
		Hemiptera	Gelastocoridae	Gelastocoris oculatus	Toad bug		3		X				
		Hemiptera	Gerridae	Aquarius			3					X	
		Hemiptera	Gerridae	Gerris remigis	Water Strider		3		X				
		Hemiptera	Gerridae	Microvelia	Broad-shldrd. Water Strider		3		X				
		Hemiptera	Gerridae	Rhagovelia	Broad-shldrd. Water Strider		3		X				
		Hemiptera	Gerridae	Trepobates			3					X	
		Hemiptera	Gerridae		Water Striders		1				X		
		Hemiptera	Largidae		Hemiptera		1				X		
		Hemiptera	Lygaeidae		Seed bugs		1				X		
		Hemiptera	Membracidae		Treehoppers		3		X				
		Hemiptera	Mesoveliidae	Mesovelia muslanti	Water treader		3		X				
		Hemiptera	Miridae		Leaf or plant bugs		1				X		
		Hemiptera	Nabidae		Damselbugs		1				X		
		Hemiptera	Naucoridae	Ambrysus			3					X	
		Hemiptera	Nepidae	Ranatra fusca	Water scorpian		3		X				
		Hemiptera	Notonectidae	Notonecta unifasciata	Backswimmers		3		X				
		Hemiptera	Pentatomidae		Stink bugs		1				X		
		Hemiptera	Psyllidae		Psyllids		1				X		
		Hemiptera	Pyrrhocoridae		Red bugs or stainers		1				X		
		Hemiptera	Reduviidae		Assasin bugs		1				X		
		Hemiptera	Rhopalidae		Scentless plant bugs		1				X		
		Hemiptera	Saldidae		Shore bugs		1				X		
		Hemiptera	Scutelleridae		Shield backed bugs		1				X		
		Hemiptera	Thyreocoridae		Black bugs		1				X		
		Hemiptera	Tingidae		Lace Bugs		3		X				
		Hemiptera	Veliidae				3					X	
		Hymenoptera	Andrenidae		Andrenid bees		1				X		

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		Hymenoptera	Anthophoridae		Cuckoo bees, Digger bees		1		X		X		
		Hymenoptera	Apidae		Bees		1				X		
		Hymenoptera	Argidae		Argid sawflies		3		X				
		Hymenoptera	Aulacidae		Aulacid wasps		3		X				
		Hymenoptera	Bethylidae				3		X				
		Hymenoptera	Braconidae		Braconids		1				X		
		Hymenoptera	Cephidae		Stem sawflies		1				X		
		Hymenoptera	Ceraphronidae		Ceraphronid wasps		2	X					
		Hymenoptera	Chalcididae		Chalcid Wasps		3		X				
		Hymenoptera	Chrysididae		Cuckoo wasps		1				X		
		Hymenoptera	Cimbicidae		Cimbicid sawflies		1				X		
		Hymenoptera	Colletidae		Yellow faced and plasterer bees		1				X		
		Hymenoptera	Diapriidae		Diapriids		1				X		
		Hymenoptera	Diprionidae				2	X					
		Hymenoptera	Dryinidae		Dryinid wasps		2	X					
		Hymenoptera	Encyrtidae		Encyrtid wasps		2	X					
		Hymenoptera	Eucharitidae		Eucharitid wasps		2	X					
		Hymenoptera	Eulophidae		Eulophid wasps		2	X					
		Hymenoptera	Eupelmidae		Eupelmids		1				X		
		Hymenoptera	Eurytomidae		Eurytomid wasps		2	X					
		Hymenoptera	Formicidae	Camponotus	Carpenter Ant		3		X				
		Hymenoptera	Formicidae	Formica fusca	Brown Ant		3		X				
		Hymenoptera	Formicidae	Formica rufa	Red Ant		3		X				
		Hymenoptera	Formicidae	Polyergus rufescens	Amozon Ant		3		X				
		Hymenoptera	Formicidae		Ants		1				X		
		Hymenoptera	Gasteruptiidae		Gasteruptiid wasp		2	X					
		Hymenoptera	Halictidae		Halictid bees		1				X		
		Hymenoptera	Ichneumonidae		Ichneumonids		1				X		
		Hymenoptera	Leucospidae		Leucospid wasps		2	X					
		Hymenoptera	Megachilidae		Leafcutting bees		1				X		
		Hymenoptera	Melittidae		Melittid bees		1				X		
		Hymenoptera	Mutillidae		Velvet ants		2	X					

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		Hymenoptera	Mymaridae		Mymarid wasps		2	X					
		Hymenoptera	Ormyridae		Ormyrid wasps		2	X					
		Hymenoptera	Orussidae		Orussid wasps		3		X				
		Hymenoptera	Perilampidae		perilampid wasps		2	X					
		Hymenoptera	Platygastridae		Platygastrid wasps		1				X		
		Hymenoptera	Pompilidae		Spider wasps		1				X		
		Hymenoptera	Proctotrupidae		Proctotrupid wasps		2	X					
		Hymenoptera	Pteromalidae		Pteromalidae		1				X		
		Hymenoptera	Sapygidae		Sapygid wasps		1						
		Hymenoptera	Scelionidae		Scelionid wasps		2	X					
		Hymenoptera	Siricidae		Wood Wasps		3		X				
		Hymenoptera	Sphecidae		Sphecid wasps		1				X		
		Hymenoptera	Stephanidae		Stephanid wasps		2	X					
		Hymenoptera	Tenthredinidae		Sawflies		1				X		
		Hymenoptera	Tiphiidae		Tiphiid wasps		1				X		
		Hymenoptera	Torymidae		Torymids		1				X		
		Hymenoptera	Trichogrammatidae		Trichogramma wasps		2	X					
		Hymenoptera	Trigonalyidae		Trigonalyid wasps		2	X					
		Hymenoptera	Vespidae	Polistes fuscatus	Paper wasps		3		X				
		Hymenoptera	Vespidae	Vespula germanica	European yellow jacket		3		X				
		Hymenoptera	Vespidae	Vespula pennsylvanica	Yellow Jackets		3		X				
		Hymenoptera	Vespidae		Vespid wasps		1				X		
		Hymenoptera	Xyelidae		Xyelid sawflies		1				X		
		Isoptera			termites		3		X				
		Lepidoptera	Acrolepiidae		Diamondback moths		1				X		
		Lepidoptera	Adelidae		Fairy Moths		3		X				
		Lepidoptera	Arctiidae		Tiger Moths		3		X				
		Lepidoptera	Danaidae		Milkweed butterflies		1				X		
		Lepidoptera	Gelechiidae	Evagora milleri	lodgepole needleminer		3		X				
		Lepidoptera	Geometridae		Inchworm		1				X		
		Lepidoptera	Gracilariidae		Blotch Leafminers		3		X				
		Lepidoptera	Hesperiidae	Amblyscirtes vialis	Common roadside-skipper		3						S

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		Lepidoptera	Hesperiidae	Carterocephalus paleamon	Arctic skipper		3						S
		Lepidoptera	Hesperiidae	Epargyreus clarus	Silver-spotted skipper		3						S
		Lepidoptera	Hesperiidae	Erynnis icelus	Dreamy duskywing		3						S
		Lepidoptera	Hesperiidae	Erynnis pacuvius	Pacuvius duskywing		3						S
		Lepidoptera	Hesperiidae	Erynnis persius	Persius duskywing		3						S
		Lepidoptera	Hesperiidae	Erynnis propertius	Propertius duskywing		2		X				S
		Lepidoptera	Hesperiidae	Erynnis tristis	Mournful duskywing		3						S
		Lepidoptera	Hesperiidae	Euphyes vestris	Dun skipper		3						S
		Lepidoptera	Hesperiidae	Hesperia colorado	Western branded skipper		3						S
		Lepidoptera	Hesperiidae	Hesperia juba	Yuba skipper		1				X		
		Lepidoptera	Hesperiidae	Hesperia lindseyi	Lindsey's skipper		3						S
		Lepidoptera	Hesperiidae	Hesperia miriamae	Skipper		3		X				
		Lepidoptera	Hesperiidae	Ochlodes ruralis	Rural skipper		3						S
		Lepidoptera	Hesperiidae	Ochlodes sylvanoides	Woodland skipper		3						S
		Lepidoptera	Hesperiidae	Poanes melane	Umber skipper		3						S
		Lepidoptera	Hesperiidae	Polites sabuleti	Sandhill skipper		2		X				S
		Lepidoptera	Hesperiidae	Polites sonora	Sonora skipper		3						S
		Lepidoptera	Hesperiidae	Pyrgus communis	Common checkered-skipper		2		X				S
		Lepidoptera	Hesperiidae	Pyrgus ruralis	Two-banded checkered-skipper		3						S
		Lepidoptera	Hesperiidae	Thorybes mexicana ssp. nevada	Nevada Cloudy-wing		1				X		
		Lepidoptera	Hesperiidae	Thorybes nevada	Nevada Dusky-wing		3		X				
		Lepidoptera	Hesperiidae	Thorybes pylades	Northern cloudywing		3						S
		Lepidoptera	Lasiocampidae		Tent Caterpillars		3		X				
		Lepidoptera	Lycaenidae	Agriades glandon	Gray Blue		3		X				
		Lepidoptera	Lycaenidae	Agriades podarce	Sierra Nevada blue		3						S
		Lepidoptera	Lycaenidae	Atlides halesus	Great purple hairstreak		3						S
		Lepidoptera	Lycaenidae	Callophrys affinis perplexa	Bramble hairstreak		3						S
		Lepidoptera	Lycaenidae	Callophrys augustinus	Brown elfin		3						S
		Lepidoptera	Lycaenidae	Callophrys eryphon	Western pine elfin		2		X				S

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		Lepidoptera	Lycaenidae	Callophrys gryneus siva	'Siva' juniper hairstreak		3						S
		Lepidoptera	Lycaenidae	Callophrys johnsoni	Johnson's hairstreak		3						S
		Lepidoptera	Lycaenidae	Callophrys mossii	Moss' elfin		3						S
		Lepidoptera	Lycaenidae	Callophrys nelsoni	Nelson's hairstreak		3						S
		Lepidoptera	Lycaenidae	Callophrys sheridani lemberti	'Alpine' Sheridan's hairstreak		3						S
		Lepidoptera	Lycaenidae	Callophrys spinetorum	Thicket hairstreak		3						S
		Lepidoptera	Lycaenidae	Celastrina argiolus	Echo Blue		3		X				
		Lepidoptera	Lycaenidae	Celastrina ladon	Spring azure		3						S
		Lepidoptera	Lycaenidae	Celastrina ladon ssp. echo	Spring Azure, Echo Blue		1				X		
		Lepidoptera	Lycaenidae	Euphilotes battoides	Western square-dotted blue		3						S
		Lepidoptera	Lycaenidae	Euphilotes enoptes	Pacific dotted-blue		3						S
		Lepidoptera	Lycaenidae	Everes amyntula	Western tailed-blue		3						S
		Lepidoptera	Lycaenidae	Glaucopsyche lygdamus	Silvery blue		2		X				S
		Lepidoptera	Lycaenidae	Glaucopsyche piasus	Arrowhead blue		3						S
		Lepidoptera	Lycaenidae	Habrodais grunus	Golden hairstreak		3						S
		Lepidoptera	Lycaenidae	Icaricia acmon	Acmon blue		3						S
		Lepidoptera	Lycaenidae	Icaricia acmon s acmon	Acmon Blue		1				X		
		Lepidoptera	Lycaenidae	Icaricia icarioides	Boisduval's blue		3						S
		Lepidoptera	Lycaenidae	Icaricia lupini	Lupine blue		3						S
		Lepidoptera	Lycaenidae	Icaricia shasta	Shasta blue		3						S
		Lepidoptera	Lycaenidae	Lycaeidaes idas	Northern blue		3						S
		Lepidoptera	Lycaenidae	Lycaeides melissa	Melissa blue		3						S
		Lepidoptera	Lycaenidae	Lycaena arota	Tailed copper		3						S
		Lepidoptera	Lycaenidae	Lycaena cupreus	Lustrous copper		2		X				S
		Lepidoptera	Lycaenidae	Lycaena editha	Edith's copper		3						S
		Lepidoptera	Lycaenidae	Lycaena gorgon	Gorgon copper		3						S
		Lepidoptera	Lycaenidae	Lycaena helloides	Purplish copper		3						S
		Lepidoptera	Lycaenidae	Lycaena heteronea	Blue copper		3						S
		Lepidoptera	Lycaenidae	Lycaena mariposa	Mariposa copper		3						S
		Lepidoptera	Lycaenidae	Lycaena nivalis	Lilac-bordered copper		3						S
		Lepidoptera	Lycaenidae	Lycaena rubidus	Ruddy copper		3						S

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		Lepidoptera	Lycaenidae	Mitoura nelsoni	Nelson's Hairstreak		3		X				
		Lepidoptera	Lycaenidae	Phaedrotes piasus	Arrowhead Blue		3		X				
		Lepidoptera	Lycaenidae	Philotes battoides	Square-Spotted Blue		3		X				
		Lepidoptera	Lycaenidae	Plebejus acmon	Acmon Blue		3		X				
		Lepidoptera	Lycaenidae	Plebejus saepiolus	Greenish blue		3						S
		Lepidoptera	Lycaenidae	Satyrium	Hairstreaks		1				X		
		Lepidoptera	Lycaenidae	Satyrium auretorum	Goldhunter's hairstreak		3						S
		Lepidoptera	Lycaenidae	Satyrium behrii	Behr's hairstreak		2		X				S
		Lepidoptera	Lycaenidae	Satyrium californica	California hairstreak		3						S
		Lepidoptera	Lycaenidae	Satyrium fuliginosum	Sooty hairstreak		3						S
		Lepidoptera	Lycaenidae	Satyrium tetra	Mountain-mahogany hairstreak		3						S
		Lepidoptera	Lycaenidae	Satyruim saepium	Hedgerow hairstreak		3						S
		Lepidoptera	Lycaenidae	Satyruim sylvinus	Sylvan hairstreak		3						S
		Lepidoptera	Lycaenidae	Strymon melinus	Gray hairstreak		3						S
		Lepidoptera	Lymantriidae		Tussock Moths		3		X				
		Lepidoptera	Noctuidae		Cutworms		3		X				
		Lepidoptera	Nymphalidae	Adelpha bredowii	California sister		3						S
		Lepidoptera	Nymphalidae	Adelpha bredowii s californica	California sister		1				X		
		Lepidoptera	Nymphalidae	Aglais miberti s furcillata	Milbert's Tortoise Shell		1				X		
		Lepidoptera	Nymphalidae	Basilarchia lorquini	Lorquin's admiral		1				X		
		Lepidoptera	Nymphalidae	Boloria epithore	Pacific fritillary		2		X				S
		Lepidoptera	Nymphalidae	Cercyonis oetus	Small wood nymph		3						S
		Lepidoptera	Nymphalidae	Cercyonis pegala	Common wood nymph		3						S
		Lepidoptera	Nymphalidae	Cercyonis sthenele	Great basin wood nymph		3						S
		Lepidoptera	Nymphalidae	Chlosyne palla	Northern checkerspot		2		X				S
		Lepidoptera	Nymphalidae	Classiana epithore	western meadow fritillary		1				X		
		Lepidoptera	Nymphalidae	Coenonympha tullia ampelos	Ringless common ringlet		3						S
		Lepidoptera	Nymphalidae	Coenonympha tullia california	'California' common ringlet		3						S

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		Lepidoptera	Nymphalidae	Danaus plexippus	Monarch		2		X				S
		Lepidoptera	Nymphalidae	Euphydryas	Common Checkerspot		1				X		
		Lepidoptera	Nymphalidae	Euphydryas chalcedona	Variable checkerspot		3						S
		Lepidoptera	Nymphalidae	Euphydryas eidtha aurilacus	Edith's checkerspot		3						S
		Lepidoptera	Nymphalidae	Euphydryas eidtha monoensis	Mono checkerspot		3						F
		Lepidoptera	Nymphalidae	Junonia coenia	Common buckeye		3						S
		Lepidoptera	Nymphalidae	Limenitis lorquini	Lorquin's admiral		2		X				S
		Lepidoptera	Nymphalidae	Nymphalis antiopa	Mourning Cloak		1				X		
		Lepidoptera	Nymphalidae	Nymphalis californica	California tortoise shell		3		X				S
		Lepidoptera	Nymphalidae	Occidryas editha s nubigena	Cloud-born Checkerspot		1				X		
		Lepidoptera	Nymphalidae	Oeneis ivallda	Ivallda Arctic		3		X				S
		Lepidoptera	Nymphalidae	Oeneis nevadensis	Great arctic		3						S
		Lepidoptera	Nymphalidae	Phyciodes campestris montana	Field crescent		3						S
		Lepidoptera	Nymphalidae	Phyciodes mylitta	Mylitta crescent		2		X				S
		Lepidoptera	Nymphalidae	Phyciodes orseis	California crescent		3						S
		Lepidoptera	Nymphalidae	Polygonia faunus	Green comma		3						S
		Lepidoptera	Nymphalidae	Polygonia gracilis zephyrus	Hoary comma		3						S
		Lepidoptera	Nymphalidae	Polygonia satyrus	Satyr comma		2		X				S
		Lepidoptera	Nymphalidae	Precis coenia	Buckeye		3		X				
		Lepidoptera	Nymphalidae	Speyeria callippe	Callippe fritillary		3						S
		Lepidoptera	Nymphalidae	Speyeria coronis	Coronis fritillary		3						S
		Lepidoptera	Nymphalidae	Speyeria cybele leto	Great spangled fritillary		3						S
		Lepidoptera	Nymphalidae	Speyeria egleis	Egleis Frittillary		1				X		
		Lepidoptera	Nymphalidae	Speyeria hesperis irene	Northwestern fritillary		3						S
		Lepidoptera	Nymphalidae	Speyeria hydaspe	Hydaspe fritillary		3						S
		Lepidoptera	Nymphalidae	Speyeria mormonia arge	Mormon fritillary		3						S
		Lepidoptera	Nymphalidae	Speyeria nokomis ssp.	Carson Valley silverspot		3						F
		Lepidoptera	Nymphalidae	Speyeria zerene	Zerene fritillary		3						S

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		Lepidoptera	Nymphalidae	Thessalia leanira	Leanira checkerspot		3						S
		Lepidoptera	Nymphalidae	Vanessa annebella	West Coast Lady		1				X		
		Lepidoptera	Nymphalidae	Vanessa atalanta	Red Admiral		3		X				
		Lepidoptera	Nymphalidae	Vanessa cardui	Painted Lady		1				X		
		Lepidoptera	Nymphalidae	Vanessa carye	West Coast Lady		3		X				
		Lepidoptera	Nymphalidae	Vanessa viginiensis	American lady		2		X				S
		Lepidoptera	Papilionidae	Battus philenor	Pipevine swallowtail		3						S
		Lepidoptera	Papilionidae	Papilio eurymedon	Black/White Swallow tail		1				X		
		Lepidoptera	Papilionidae	Papilio indra	Indra swallowtail		2		X				S
		Lepidoptera	Papilionidae	Papilio multicaudata	Two-tailed swallowtail		3						S
		Lepidoptera	Papilionidae	Papilio rutulus	Western Tiger swallow tail		1				X		
		Lepidoptera	Papilionidae	Papilio zelicaon	Anise swallowtail		2		X				S
		Lepidoptera	Papilionidae	Parnassius behrii	Sierra Nevada parnassian		3						S
		Lepidoptera	Papilionidae	Parnassius clodius	Clodius parnassian		1				X		
		Lepidoptera	Pieridae	Anthocharis lanceolata	Gray marble		3						S
		Lepidoptera	Pieridae	Anthocharis sara	Pacific orangetip		1				X		
		Lepidoptera	Pieridae	Anthocharis stella	Stella orangetip		3						S
		Lepidoptera	Pieridae	Colias behrii	Behr's Sulfur		3		X				
		Lepidoptera	Pieridae	Colias eurytheme	Orange sulphur		2		X				S
		Lepidoptera	Pieridae	Colias philodice	Alfalfa butterfly		1				X		
		Lepidoptera	Pieridae	Euchloe ausonides	Large marble		3						S
		Lepidoptera	Pieridae	Euchloe coloradensis	Colorado Marble		3		X				
		Lepidoptera	Pieridae	Euchloe hyantis	California marble		3						S
		Lepidoptera	Pieridae	Neophasia menapia	Pine White (butterfly)		1				X		
		Lepidoptera	Pieridae	Pieris marginalis	Margined white		3						S
		Lepidoptera	Pieridae	Pieris protodice	Common White		3		X				
		Lepidoptera	Pieridae	Pieris rapae	Cabbage white		2		X				S
		Lepidoptera	Pieridae	Pieris sisymbrii	California White		3		X				
		Lepidoptera	Pieridae	Pontia beckerii	Becker's white		3						S
		Lepidoptera	Pieridae	Pontia occidentalis	Western white		3						S
		Lepidoptera	Pieridae	Pontia protodice	Checkered white		3						S
		Lepidoptera	Pieridae	Pontia sisymbrii	Spring white		3						S

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		Lepidoptera	Pieridae		Orange Tips/Sufurs		1				X		
		Lepidoptera	Pterophoridae		Plume Moths		3		X				
		Lepidoptera	Pyralidae	Acentria			3					X	
		Lepidoptera	Pyralidae	Crambus			3					X	
		Lepidoptera	Pyralidae	Petrophila			3					X	
		Lepidoptera	Pyralidae	Petrophila truckeealis	Snout moth		3		X				
		Lepidoptera	Pyralidae	Usingeriessa brunnildalis	Snout moth		3		X				
		Lepidoptera	Riodinidae	Apodemia mormo	Mormon Metal-mark		3		X				
		Lepidoptera	Saturniidae		Giant Silkworm Moths		3		X				
		Lepidoptera	Satyridae	Neominois ridingsii	Riding's Satyr		3		X				
		Lepidoptera	Sphingidae		Sphinx Moths		1				X		
		Mallophaga	Mallophaga		Chewing Lice		3		X				
		Mecoptera	Bittacidae		Scorpionflies		3		X				
		Mecoptera	Boreidae		Snow fleas		2	X					
		Megaloptera	Corydalidae	Chauliodes	Dobsonfly		3		X				
		Megaloptera	Corydalidae	Corydalus	Dobsonfly		3		X				
		Megaloptera	Corydalidae	Dysmicohermes crepusculus	Dobsonfly		3		X				
		Megaloptera	Corydalidae	Neohermes			3					X	
		Megaloptera	Corydalidae	Orohermes crepusculus			3					X	
		Megaloptera	Corydalidae	Protochauliodes montivagus	Dobsonfly		3		X				
		Megaloptera	Sialidae	Sialis occidens			2		X			X	
		Megaloptera	Sialidae		Alderflies		3		X				
		Microcoryphia	Machilidae	Mesomachilis	Silverfish		3		X				
		Microcoryphia	Meinertellidae		Jumping bristletails		1				X		
		Neuroptera	Berothidae		Pleasing lacewing		2	X					
		Neuroptera	Chrysopidae		Green lacewings		1				X		
		Neuroptera	Coniopterygidae		Dusky wing		2	X					
		Neuroptera	Hemerobiidae		Brown lacewing		2	X					
		Neuroptera	Myremeleontidae		Ant Lions		1				X		
		Neuroptera	Polystoechotidae		Giant lacewing		2	X					
		Odonata	Aeshnidae	Aeshna multicolor			3		X				
		Odonata	Aeshnidae	Anax junius			3		X				

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		Odonata	Aeshnidae				3					X	
		Odonata	Coenagrionidae	Argia vivida			3		X				
		Odonata	Coenagrionidae	Coenagrion resolutum			3		X				
		Odonata	Coenagrionidae	Ishnura spp.			3		X				
		Odonata	Cordulegastridae	Cordulegaster			3					X	
		Odonata	Corduliidae	Somatochlora semicirclaris			3		X				
		Odonata	Gomphidae	Gomphus confraternus donneri			3		X				
		Odonata	Gomphidae	Gomphus kurilis			1			X			
		Odonata	Gomphidae	Octogomphus			3					X	
		Odonata	Gomphidae	Ophiogomphus			2		X			X	
		Odonata	Libelluidae	Libellula maculata			3		X				
		Odonata	Libelluidae	Libellula pulchella			3		X				
		Orthoptera	Acrididae		Short-horned grasshopper		1				X		
		Orthoptera	Gryllacrididae		Camel crickets and other		1				X		
		Orthoptera	Gryllidae		Crickets		1				X		
		Orthoptera	Tetrigidae		Pygmy grasshoppers		1				X		
		Orthoptera	Tettigoniidae		Long-horned grasshoppers		1				X		
		Phthiraptera			Lice		3		X				
		Plecoptera	Capniidae	Capnia lacustra		X	1			X			
		Plecoptera	Capniidae	Capnia tahoensis			3		X				
		Plecoptera	Capniidae	Paracapnia			3					X	
		Plecoptera	Capniidae	Utacapnia tahoensis		X	1			X			
		Plecoptera	Chloroperlidae	Alloperla			3					X	
		Plecoptera	Chloroperlidae	Bisancora			3					X	
		Plecoptera	Chloroperlidae	Haploperla			3					X	
		Plecoptera	Chloroperlidae	Kathroperla			3					X	
		Plecoptera	Chloroperlidae	Paraperla			3					X	
		Plecoptera	Chloroperlidae	Plumiperla			3					X	
		Plecoptera	Chloroperlidae	Suwallia			3					X	
		Plecoptera	Chloroperlidae	Sweltsa			3					X	

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		Plecoptera	Chloroperlidae				1				X		
		Plecoptera	Leuctridae	Despaxia			3					X	
		Plecoptera	Leuctridae	Leuctra spp.			3		X				
		Plecoptera	Leuctridae	Moselia			3					X	
		Plecoptera	Leuctridae	Paraleuctra			3					X	
		Plecoptera	Leuctridae				1				X		
		Plecoptera	Nemouridae	Amphinemura			3					X	
		Plecoptera	Nemouridae	Capnia new			1			X			
		Plecoptera	Nemouridae	Malenka			3					X	
		Plecoptera	Nemouridae	Nemoura ?			1			X			
		Plecoptera	Nemouridae	Soyedina			3					X	
		Plecoptera	Nemouridae	Visoka			3					X	
		Plecoptera	Nemouridae	Zapada			3					X	
		Plecoptera	Peltoperlidae	Sierraperla			3					X	
		Plecoptera	Peltoperlidae	Soliperla			3					X	
		Plecoptera	Peltoperlidae	Yoraperla			3					X	
		Plecoptera	Peltoperlidae		Roachlike stoneflies		1				X		
		Plecoptera	Perlidae	Acroneuria			1			X			
		Plecoptera	Perlidae	Calineuria			3					X	
		Plecoptera	Perlidae	Claassenia			3					X	
		Plecoptera	Perlidae	Doroneuria			3					X	
		Plecoptera	Perlidae	Hesperoperla hoguei			3					X	
		Plecoptera	Perlidae	Hesperoperla pacifica			3					X	
		Plecoptera	Perlodidae	Arcynopteryx yosemite			3		X				
		Plecoptera	Perlodidae	Calliperla			3					X	
		Plecoptera	Perlodidae	Isogenus spp.			3						
		Plecoptera	Perlodidae	Isoperla			2		X			X	
		Plecoptera	Perlodidae	Kogotus			3					X	
		Plecoptera	Perlodidae	Megarcys			3					X	
		Plecoptera	Perlodidae	Oroperla barbara			3		X			X	
		Plecoptera	Perlodidae	Perlinodes			3					X	
		Plecoptera	Perlodidae	Rickera			3					X	
		Plecoptera	Perlodidae	Setvena			3					X	

Phylum	Class	Order	Family	Scientific name	Common name	Basin endemic	Reliability	Kimsey	Storer & Usinger	Frantz-Cordone	Manley & Schlesinger	NAMC	Other sources
		Plecoptera	Perlodidae	Skwala			3					X	
		Plecoptera	Perlodidae				1					X	
		Plecoptera	Pteronaricidae	Pteronarcella			3					X	
		Plecoptera	Pteronaricidae	Pteronarcys			3					X	
		Plecoptera	Taeniopterygidae	Brachyptera pacifica			3		X				
		Plecoptera	Taeniopterygidae	Brachyptera vanduzeii			3		X				
		Plecoptera	Taeniopterygidae	Taenionema			3					X	
		Plecoptera	Taeniopterygidae	Taeniopteryx			3					X	
		Psocoptera			Bark Lice		3		X				
		Rhaphidioptera	Inocellidae		Snakeflies		1				X		
		Rhaphidioptera	Raphidiidae		Snakeflies		1				X		
		Thysanoptera	Thripidae		Common thrips		1				X		
		Thysanoptera			Thrips		3		X				
		Thysanura	Lepismatidae		Silverfish		1				X		
		Trichoptera	Apataniidae	Apatania			3					X	
		Trichoptera	Apataniidae	Pedomoecus sierra			3					X	
		Trichoptera	Brachycentridae	Amiocentrus			3					X	
		Trichoptera	Brachycentridae	Brachycentrus			3					X	
		Trichoptera	Brachycentridae	Micrasema			3					X	
		Trichoptera	Calamoceratidae	Heteroplectron			3					X	
		Trichoptera	Dipseudopsidae	Phylocentropus			3					X	
		Trichoptera	Glossosomatidae	Agapetus			3					X	
		Trichoptera	Glossosomatidae	Anagapetus			3					X	
		Trichoptera	Glossosomatidae	Glossosoma califica			3		X				
		Trichoptera	Glossosomatidae	Protoptila			3					X	
		Trichoptera	Hydropsychidae	Arctopsyche grandis			2		X			X	
		Trichoptera	Hydropsychidae	Cheumatopsyche			3					X	
		Trichoptera	Hydropsychidae	Hydropsyche			3					X	
		Trichoptera	Hydropsychidae	Parapsyche elsis			3		X				
		Trichoptera	Hydroptilidae	Agraylea			3					X	
		Trichoptera	Hydroptilidae	Hydroptila			1			X			
		Trichoptera	Hydroptilidae	Leucotrichia pictipes			3		X				
		Trichoptera	Hydroptilidae	Ochrotrichia			3					X	

Phylum	Class	Order	Family	Scientific name	Common name	Basin endemic	Reliability	Kimsey	Storer & Usinger	Frantz-Cordone	Manley & Schlesinger	NAMC	Other sources
		Trichoptera	Hydroptilidae	Oxyethira			3					X	
		Trichoptera	Hydroptilidae	Palaeagapetus			3					X	
		Trichoptera	Lepidostomatidae	Lepidostoma			3					X	
		Trichoptera	Lepidostomatidae	Lepidostoma rayneri			3		X				
		Trichoptera	Leptoceridae	Cerclea annulicornis			3		X				
		Trichoptera	Leptoceridae	Nectopsyche			3					X	
		Trichoptera	Leptoceridae	Oecetis			3					X	
		Trichoptera	Limnephilidae	Allocosmoecus			3					X	
		Trichoptera	Limnephilidae	Amphicosmoecus			3					X	
		Trichoptera	Limnephilidae	Cryptochia			3					X	
		Trichoptera	Limnephilidae	Desmona			3					X	
		Trichoptera	Limnephilidae	Dicosmoecus atripes			3		X				
		Trichoptera	Limnephilidae	Ecclisomyia simulata			3		X				
		Trichoptera	Limnephilidae	Hesperophylax			1			X			
		Trichoptera	Limnephilidae	Hydatophylax			3					X	
		Trichoptera	Limnephilidae	Limnephilus			1						
		Trichoptera	Limnephilidae	Limnephilus morrisoni			3		X				
		Trichoptera	Limnephilidae	Limnephilus secludens			3		X				
		Trichoptera	Limnephilidae	Onocosmoecus			3					X	
		Trichoptera	Limnephilidae	Philocasca			3					X	
		Trichoptera	Limnephilidae	Psychoglypha bella			3		X				
		Trichoptera	Limnephilidae	Psychoglypha ormiae			3		X				
		Trichoptera	Limnephiliidae		Northern caddisflies		1				X		
		Trichoptera	Molannidae	Molanna			3					X	
		Trichoptera	Molannidae		Molannids		1				X		
		Trichoptera	Odontoceridae	Parthina			3					X	
		Trichoptera	Philopotamidae	Chimarra			3					X	
		Trichoptera	Philopotamidae	Dolophilodes aequalis			3		X				
		Trichoptera	Philopotamidae	Wormaldia			2		X			X	
		Trichoptera	Phryganeidae	Yphria			3					X	
		Trichoptera	Phryganeidae		Large caddisflies		1				X		
		Trichoptera	Polycentropodidae	Polycentropus variegatus			3		X				
		Trichoptera	Psychomyiidae	Tinodes			3					X	

Phylum	Class	Order	Family	Scientific name	Common name	Basin endemic	Reliability	Kimsey	Storer & Usinger	Frantz-Cordone	Manley & Schlesinger	NAMC	Other sources
		Trichoptera	Rhyacophilidae	Rhyachopila valuma			3		X				
		Trichoptera	Rhyacophilidae				1				X		
		Trichoptera	Sericostomatidae	Gumaga			3					X	
		Trichoptera	Uenoidae	Neophlyax occidentis			3		X				
		Trichoptera	Uenoidae	Neothremma			3					X	
		Trichoptera	Uenoidae	Oligophlebodes			3					X	
Coelenterata	Hydrozoa	Hydroida	Hydridae	Hydra			1			X			
Mollusca	Gastropoda	Basommatophora	Ancylidae	Ferrissia			3					X	
		Basommatophora	Ancylidae	Ferrissia fragilis			1			X			
		Basommatophora	Lymnaeidae	Fossaria			3					X	
		Basommatophora	Lymnaeidae	Fossaria bulimoides			1			X			
		Basommatophora	Lymnaeidae	Lymnaea bulimoides?			1			X			
		Basommatophora	Physidae	Physella virgata			1			X			
		Basommatophora	Planorbidae	Carinifex newberryi			1			X			
		Basommatophora	Planorbidae	Helisoma newberii			1			X			
		Basommatophora	Planorbidae	Menetus			3					X	
		Basommatophora	Planorbidae	Parapholyx effusa			1			X			
		Basommatophora	Planorbidae	Planorbula			3					X	
		Basommatophora	Planorbidae	Vorticifex effusus			1			X			
		Basommatophora	Pleuroceridae	Juga			3					X	
		Mesogastropoda	Hydrobiidae	Littoridina			3		X				
		Stylommatophora	Discidae	Discus whitneyi			3		X				
		Stylommatophora	Helicarionidae	Euconulus fulvus			3		X				
		Stylommatophora	Limacidae	Deroceras laeve	Slugs		3		X				
		Stylommatophora	Punctidae	Punctum californicum			3		X				
		Stylommatophora	Vertiginidae	Vertigo modesta			3		X				
		Stylommatophora	Virtrinidae	Vitrina pellucida			3		X				
		Stylommatophora	Zonitidae	Pristiloma chersinella			3		X				
		Stylommatophora	Zonitidae	Zonitoides arboreus			3		X				
	Pelecypoda	Veneroida	Sphaeriidae	Musculium			1				X		
		Veneroida	Sphaeriidae	Pisidium			1			X			
		Veneroida	Sphaeriidae	Pisidium casertanum	Fingernail clam		3		X				
Nematamorpha					Horsehair worms		3					X	

Phylum	Class	Order	Family	Scientific name	Common name	Basin endemic	Reliability	Kimsey	Storer & Usinger	Frantz-Cordone	Manley & Schlesinger	NAMC	Other sources
Nematoda	Adenophorea	Enoplida	Mononchidae	Cobbonchus pounamua			1			X			
		Enoplida	Mermithidae	Hydromermis or Gastromermis or ?			1			X			
Platyhelminthes	Turbellaria	Tricladida	Dendrocoelidae	Dendrocoelopsis hymanae		X	1			X			
		Tricladida	Planariidae	Dugesia dorotocephala			1						H
		Tricladida	Planariidae	Phagocata tahoena		X	1			X			
		Tricladida	Planariidae	Phagocata crenophila			1						H
		Tricladida	Planariidae	Phagocata morgani morgani			1						H
		Tricladida	Planariidae	Phagocata nicea			1			X			
		Tricladida	Planariidae	Polycelis monticola			1						H
		Tricladida	Planariidae	Polycelis sierrensis			1						
Porifera	Demospongea	Haplosclerina	Spongillidae	Spongilla			1			X			

APPENDIX I

FUNGI OF THE LAKE TAHOE BASIN

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FUNGI OF THE LAKE TAHOE BASIN

Erik M. Holst and Matthew D. Schlesinger

Table I-1—Documented and potential fungi of the Lake Tahoe basin. Sources of information for each taxon are designated with an "X" in the appropriate column. Sources consulted: Arora (1986), Hale and Cole (1988), P. Manley (unpubl. data), Ryan (1990), SFSU (1999b), and Shevock (1996). Reliability codes: 1 = high--documented occurrence; 2 = moderate--potentially occurring based on at least 2 sources; and 3 = low--potentially occurring based on a single source. Harvested species (Foster 1993, M. Taylor, personal communication) are designated with an "X."

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Acarospora chlorophana			X		X			2
Acarospora fuscata			X					3
Acarospora sp.				X				1
Acarospora thamnina					X			1
Agaricus albolutescens						X		3
Agaricus augustus		X						3
Agaricus bernardii		X						3
Agaricus bitorquis		X						3
Agaricus californicus		X						3
Agaricus campestris				X				1
Agaricus hondensis		X						3
Agaricus praeclaresquamosus		X						3
Agaricus silvicola		X				X		2
Agaricus subrutilescens		X						3
Agaricus xanthodermus		X						3
Agrocybe erebia						X		3
Agrocybe pediades						X		3
Agrocybe praecox		X				X		2

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Ahtiana sphaerosporella			X		X			2
Albartellus flettii		X						3
Albatrellus cristatus						X		3
Albatrellus ellisii		X						3
Aleuria aurantia				X				1
Aleurodiscus amorphus						X		3
Alpova diplophloeus						X		3
Alpova olivaceotinctus						X		3
Alpova trappei						X		3
Amanita aspera		X						3
Amanita caesarea		X						3
Amanita calyptrata	X					X		3
Amanita gemmata		X				X		2
Amanita muscaria		X						3
Amanita muscaria var. *formosa*						X		3
Amanita pachycolea		X						3
Amanita pantherina		X				X		2
Amanita spreta						X		3
Amanita vaginata		X				X		2
Amaurochaete ferruginea						X		3
Amillaria ponderosa		X						3
Amnanita calyptrata		X						3
Anomoporia myceliosa						X		3
Anthracobia sp.		X						3
Apostemidium sp.						X		3
Arcangeliella crassa						X		3
Arcangeliella parva						X		3
Arcyria versicolor						X		3
Armillaria albolanaripes		X						3
Armillaria olida		X						3
Armillaria straminea		X						3
Armillariella mellea	X	X						3

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Arrhenia lobata						X		3
Ascobolus carbonarius		X						3
Aspicilia caesiocinera					X			1
Aspicilia sp.				X				1
Astraeus sp.		X						3
Athelia sp.						X		3
Auricularia auricula		X				X		2
Baeospora myriadophylla						X		3
Balsamia magnata						X		3
Basidiomycotina sp.				X				1
Bellermerea alpina					X			1
Bellermerea cinereorufescens					X			3
Belonioscypha culmicola						X		3
Bisporella citrina				X				1
Bolbitius reticulatus						X		3
Boletus barrowsii		X						3
Boletus calopus		X						3
Boletus chrysenteron		X						3
Boletus edulis	X	X						3
Boletus haematinus						X		3
Boletus pinophilus						X		3
Boletus piperatus		X						3
Boletus regius		X				X		2
Boletus rubripes						X		3
Boletus spadiceus		X						3
Boletus subtomentosus		X						3
Boletus truncatus		X						3
Boletus zelleri		X						3
Bondarzewia montana						X		3
Botryobasidium botryosum						X		3
Bovista pila						X		3
Bovista plumbea						X		3

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Brauniellula nancyae		X						3
Brefeldia maxima				X				1
Bryoria abbreviata					X			1
Bryoria fremontii			X					3
Bryoria oregana			X					3
Buellia punctata					X			1
Buellia sp.				X				1
Byroria abbreviata			X					3
Calbovista subsculpta				X				1
Callistosporium luteo-olivacaeum		X						3
Calocybe ionides						X		3
Calocybe onychina						X		3
Calomyxa metallica						X		3
Calopaca pelodella					X			1
Caloscypha fulgens		X				X		2
Calvatia booniana				X				1
Calvatia fumosa						X		3
Calvatia gigantea	X	X						3
Calvatia lycoperdoides						X		3
Calvatia sculpta	X			X				1
Calvatia subcretacea						X		3
Candelaria concolor			X					3
Candelariella rosulans				X	X			1
Cantharellus cibaruis	X	X						3
Cantharellus subalbidus				X				1
Ceratiomyxa fruticulosa						X		3
Ceriporiopsis aneirina						X		3
Cheilymenia fimicola						X		3
Cheilymenia stercorea						X		3
Chlorociboria aeruginascens						X		3
Choiromyces alveolatus		X				X		2
Chromosera cyanophylla						X		3

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Chroogomphus sp.		X						3
Chrysomphalina aurantiaca						X		3
Ciboria rufofusca						X		3
Cladonia fimbriata					X			1
Cladonia sp.				X				1
Clathrus archeri		X						3
Clavaria vermicularis		X						3
Clavulina eristata		X						3
Clavulina pyxidata		X						3
Clitocybe albirhiza		X				X		2
Clitocybe atrobrunnea						X		3
Clitocybe deceptiva		X						3
Clitocybe dilatata		X						3
Clitocybe gibba						X		3
Clitocybe glacialis						X		3
Clitocybe inversa		X				X		2
Clitocybe mutabilis						X		3
Clitocybe nebularis		X						3
Clitocybe nuda		X						3
Clitocybe sclerotoidea		X						3
Clitocybe squamulosa						X		3
Clitocybe subconnexa		X						3
Clitopilus prunulus		X						3
Collybia albipilata		X						3
Collybia bakerensis						X		3
Collybia butyracea		X						3
Collybia dryophila		X						3
Collybia fuscopurpurea		X				X		2
Collybia maculata						X		3
Collybia tuberosa				X				1
Collybia verna						X		3
Coltricia cinnamomea						X		3

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Coltricia perennis						X		3
Comatricha aequalis						X		3
Comatricha nigra						X		3
Comatricha subcaespitosa						X		3
Comatricha suksdorfii						X		3
Conocybe filaris						X		3
Coprinus atramentarius		X				X		2
Coprinus comatus	X	X				X		2
Coprinus lagopus						X		3
Coprinus micaceus		X				X		2
Coprinus plicatilis						X		3
Corinarius phoeniceus		X						3
Corticum sp.						X		3
Cortinarius cinnamomeus		X						3
Cortinarius glaucopus		X				X		2
Cortinarius magnivelatus						X		3
Cortinarius mucosus		X						3
Cortinarius obtusus		X						3
Cortinarius verrucisporus						X		3
Crepidotus fimbriatus						X		3
Cribaria argillacea						X		3
Cribaria tenella						X		3
Crucibulum laeve						X		3
Cryptoporus volvatus				X				1
Cudonia monticola		X				X		2
Cyanthicula turbinata						X		3
Cyathus olla						X		3
Cyphelium lucidum					X			1
Cyphelium pinicola					X			1
Cyptotrama chrysopeplum		X						3
Dacrymyces palmatus				X				1
Dacrymyces stillatus						X		3

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Daedalea juniperinus		X						3
Dasycyphus acuum						X		3
Dasycyphus bicolor						X		3
Dasycyphus nivens						X		3
Dasycyphus nudipes var. *minor*						X		3
Dasycyphus succineus						X		3
Dasyscyphus virgineus				X				1
Dendrophora erumpens						X		3
Dentinum sp.		X						3
Dermatocarpon miniatum				X	X			1
Dermatocarpon moulinsii							X	3
Dermatocarpon reticulatum			X		X			2
Dermocybe aurantiobasis						X		3
Dermocybe aureifolius var. *hesperia*						X		3
Dermocybe malicorius						X		3
Dermocybe neskowinensis						X		3
Destuntzia rubra						X		3
Destuntzia saylorii						X		3
Diderma niveum						X		3
Didymium dubium						X		3
Dimelaena oreina							X	3
Discina perlata						X		3
Discoitis venosa		X				X		2
Echinodontium tinctorium		X				X		2
Elaphomyces anthracinus						X		3
Elaphomyces granulatus						X		3
Elaphomyces muricatus						X		3
Elasmomyces russuloides						X		3
Elytroderma deformans						X		3
Endogone flammicorona						X		3
Endogone lactiflua						X		3
Endogone pisiformis						X		3

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Endoptychum depressum		X						3
Enerthenema melanospermum						X		3
Entoloma rhodopolium		X						3
Exdiopsis sp.						X		3
Flammulaster sp.						X		3
Flammulina velutipes		X				X		2
Floccularia albolanaripes						X		3
Fomitopsis cajanderi		X						3
Fomitopsis pinicola				X				1
Fuligo cinerea						X		3
Fuligo intermedia						X		3
Fuligo septica						X		3
Galerina autumnalis						X		3
Galerina heterocystis						X		3
Galerina polytrichoides						X		3
Galerina subtruncata						X		3
Ganoderma applanalum		X				X		2
Ganoderma tsugae						X		3
Gastroboletus sp.						X		3
Gastroboletus turbinatus		X				X		2
Gautieria candida						X		3
Gautieria monticola						X		3
Gautieria pterosperma nom. prov.		X						3
Geastrum quadrifidum						X		3
Geastrum sp.		X						3
Genabea cerebriformis						X		3
Genea harkenessii						X		3
Genea intermedia						X		3
Geopora cooperi		X				X		2
Geopyxis carbonaria						X		3
Gloeophllum striatum		X						3
Gloephyllum sepiarium						X		3

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Godronia sp.						X		3
Gomphidius sp.		X						3
Guepiniopsis alpinus				X				1
Gymnomyces yubaensis nom. prov.						X		3
Gymnopilus sapineus		X						3
Gynmopilus spectabilis		X						3
Gyromitra esculenta		X				X		2
Gyromitra gigas				X				1
Gyromitra montanum						X		3
Gyromitra sp.				X				1
Gyrornitra gigas		X						3
Hebeloma avellaneum						X		3
Hebeloma crustuliniforme						X		3
Hebeloma sinapizans		X				X		2
Heboloma mesophaeum						X		3
Helicogloea sp.						X		3
Helvelia lacunosa		X						3
Helvella leucomelanea						X		3
Helvella leucopus		X						3
Helvella leucornelaena		X						3
Hemimycena delectabilis						X		3
Hemitrichia abietina						X		3
Hemitrichia clavata				X				1
Hemitrichia montana						X		3
Henningsomyces candidus						X		3
Hericium abietis		X						3
Hericium ramosum		X						3
Herpotrichia coulteri						X		3
Herpotrichia juniperi						X		3
Heterobasidion annosum						X		3
Heterotextus alpinus						X		3
Hohenbuehelia petaloides						X		3

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Humaria hemisphaerica						X		3
Hydnellum sp.		X						3
Hydnotria cerebriformis						X		3
Hydnotrya variiformis						X		3
Hygrocybe conica						X		3
Hygrophoropsis aurantiaca		X						3
Hygrophorus agathosmus		X						3
Hygrophorus caeruleus						X		3
Hygrophorus camarophyllus						X		3
Hygrophorus chrysodon						X		3
Hygrophorus erubescens		X						3
Hygrophorus gliocyclus		X						3
Hygrophorus goetzii		X				X		2
Hygrophorus hypothejus		X						3
Hygrophorus marzuolus		X				X		2
Hygrophorus purpurascens		X				X		2
Hygrophorus subalpinus		X				X		2
Hymenochaete sp.						X		3
Hymenocyphus repandus						X		3
Hymenogaster sublilacinus						X		3
Hypholoma capnoides						X		3
Hypholoma fasciculare						X		3
Hypocenomyce sclaris					X			1
Hypocrea sp.						X		3
Hypogymnia imshaugii				X	X			1
Hypogymnia metaphysodes							X	3
Hypogymnia sp.			X					3
Hypomyces aurantius						X		3
Hysterangium coriaceum						X		3
Hysterangium crassum						X		3
Inocybe chelanensis						X		3
Inocybe geophylla		X				X		2

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Inocybe sororia		X						3
Inonotus circinatus						X		3
Inonotus tomentosus		X						3
Ishnoderma resinosum						X		3
Kriegeria alutipes						X		3
Kuehneromyces vernalis						X		3
Laccaria pumila						X		3
Lachnellula arida						X		3
Lactarius alnicola						X		3
Lactarius chrysorheus		X						3
Lactarius controversus		X						3
Lactarius deliciousus	X	X						3
Lactarius indigo		X						3
Lactarius rubrilacteus		X						3
Lactarius rufus		X						3
Lactarius subflammeus						X		3
Lactarius vinaceorufescens						X		3
Laetiporus sulphureus	X	X				X		2
Lamproderma arcyrioides						X		3
Lamproderma atrosporum						X		3
Lamproderma carestiae						X		3
Lamproderma sauteri						X		3
Lecanora cenisia					X			1
Lecanora cf. polytropa					X			1
Lecanora muralis			X					3
Lecanora pseudomellea					X			1
Lecanora saligna					X			1
Lecanora sierrae					X			3
Leccinum sp.		X						3
Lecidea auriculata					X			1
Lecidea sp.				X				1
Lecidea syncarpa					X			3

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Lentaria byssiseda						X		3
Lentinellus montanus		X				X		2
Lentinus ponderosus		X						3
Leocarpus fragilis						X		3
Lepiota clypeolaria		X						3
Lepiota fusispora						X		3
Lepiota naucina		X						3
Lepiota rachodes		X						3
Leptogium californicum					X			1
Letharia columbiana				X				1
Letharia vulpina				X	X			1
Leucoagaricus naucinus						X		3
Leucopaxillus albissimus		X						3
Leucopaxillus amarus		X						3
Leucophleps magnata						X		3
Leucophleps spinospora						X		3
Licea viriabilis						X		3
Lophodermium pinastri						X		3
Lycogala epidendrum				X				1
Lycoperdon perlatum						X		3
Lyophyllum connatum						X		3
Lyophyllum decastes		X				X		2
Lyophyllum montanum		X						3
Marasmillus cadidus		X						3
Marasmius sp.		X						3
Martellia fulvispora						X		3
Megacollybia platyphylla						X		3
Melanelia disjuncta			X					3
Melanelia elegantula				X	X			1
Melanelia subolivacea					X			1
Melanogaster variegatus						X		3
Melanoleuca brevipes						X		3

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Melanoleuca evenosa						X		3
Melanoleuca graminicola		X						3
Melanoleuca melaleuca		X				X		2
Melanoleuca microspora						X		3
Merulius tremellosus						X		3
Microstoma floccosa				X				1
Mitrula elegans						X		3
Mollisia ventosa						X		3
Morchella elata	X					X		3
Morchella esculenta	X					X		3
Mycena acicula						X		3
Mycena adonis						X		3
Mycena aff. alcalina						X		3
Mycena amicta						X		3
Mycena griseoviridis		X				X		2
Mycena hudsoniana						X		3
Mycena overholizii		X				X		2
Mycena pura						X		3
Mycena purpureofusca						X		3
Mycena speirea						X		3
Mycena tenerrima						X		3
Mycenastrum corium						X		3
Mycoacia sp.						X		3
Mycolevis siccigleba						X		3
Myxomphalia maura		X						3
Naematoloma fasciculare		X						3
Naucoria escharoides						X		3
Naucoria scolecina		X						3
Nectria sp.						X		3
Nidula candida						X		3
Nidula niveo-tomentosa						X		3
Nivatogastrium nubigenum		X				X		2

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Nolanea cetrata						X		3
Nolanea holoconiota						X		3
Nolanea verna var. *isodiametrica*						X		3
Noleana verna				X				1
Oligonema shweinitzii						X		3
Oligoporus caesius						X		3
Oligosporus leucospongia						X		3
Omphalina epichysium						X		3
Omphalina postii						X		3
Otidea sp.		X						3
Oxyporus nobilissimus		X						3
Pachyleperium carbonicola						X		3
Panaeolus campanulatus						X		3
Parmelia sulcata				X				1
Parmeliella cyanolepra					X			1
Parmeliopsis ambigua			X		X			2
Paxillus panuoides						X		3
Pellicularia sp.						X		3
Peltigera canina				X				1
Peltigera collina					X			1
Peltigera rufescens				X				1
Peniphora cinera						X		3
Peziza badioconfusa				X				1
Peziza domiciliana						X		3
Peziza echinospora						X		3
Peziza praetervisa		X				X		2
Peziza proteana		X						3
Peziza repandum						X		3
Peziza vesiculosa						X		3
Peziza violacea		X				X		2
Phaeolus alboluteus		X						3
Phaeolus schweinitzii		X				X		2

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Phanerochate sp.						X		3
Phellinus ferruginosus						X		3
Phellinus hartigii						X		3
Phellinus igniarius		X				X		2
Phellinus pini		X						3
Phlebia livida						X		3
Pholiota aurvella		X						3
Pholiota brunnescens		X						3
Pholiota carbonaria		X						3
Pholiota destruens		X						3
Pholiota fulvozonata		X						3
Pholiota highlandensis		X				X		2
Pholiota igniarius		X						3
Pholiota spumosa		X				X		2
Pholiota terrestris		X						3
Phyllosporus rhodoxanthus						X		3
Phyllotopsis nidulans		X				X		2
Physarum diderma						X		3
Physarum luteolum						X		3
Physarum nutans						X		3
Physarum viride						X		3
Physcia dubia					X			1
Physcia phaea					X			1
Physcia sp.				X				1
Phytoconis ericetorum						X		3
Pisolithus tinctorius		X				X		2
Pithya cupressina						X		3
Placynthiella oligotropha					X			1
Plectania nanfeldtii		X				X		2
Pleurotus dryinus		X						3
Pleurotus ostreatus				X				1
Plicaria sp.		X						3

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Pluteus atromarginatus		X						3
Pluteus cervinus		X				X		2
Pluteus petasatus						X		3
Polypore sp.				X				1
Polyporus badius		X				X		2
Polyporus elegans				X				1
Polyporus varius				X				1
Poria sp.		X						3
Porotrichia metallica						X		3
Protoparmelia badia					X			1
Psathyrelia carbonicola		X						3
Psathyrella candolleana						X		3
Psathyrella ellenae var. *yubaensis*						X		3
Pseudephebe minuscula			X					3
Pseudephebe pubescens				X	X			1
Pseudohydnum gelatinosum						X		3
Pseudoplectania nigrella		X						3
Pseudotis abietina						X		3
Psilocybe montanum						X		3
Psyscia tenella			X					3
Psysconia detersa			X					3
Pulvinula sp.		X						3
Pycnoporellus alboluteus						X		3
Pyronema domesticum						X		3
Pyronema omphalodes		X						3
Radiigera atrogleba						X		3
Ramaria abietina						X		3
Ramaria botrytis		X						3
Ramaria cartilaginea						X		3
Ramaria coulterae						X		3
Ramaria magnipes var. *alidior*						X		3
Ramaria magnipes var. *magnipes*						X		3

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Ramaria rasilispora var. *scatesiana*	X					X		3
Ramaria rasilispora var. *rasilispora*	X					X		3
Ramaria rubricarnata var. *pallida*						X		3
Ramaria rubricarnata var. *verna*						X		3
Ramaria rubrievanescens						X		3
Ramaria rubripermanens						X		3
Ramaria thiersii						X		3
Resupinatus applicatus						X		3
Reticularia olivacea						X		3
Rhizina undulata		X						3
Rhizocarpon bolanderi					X			1
Rhizocarpon geographicum				X	X			1
Rhizocarpon grande					X			1
Rhizocarpon lecanorium					X			1
Rhizocarpon reparium					X			1
Rhizocarpon superficiale					X			3
Rhizoplaca chrysoleuca				X	X			1
Rhizoplaca glaucophana							X	3
Rhizoplaca melanophthalma				X	X			1
Rhizopogon subcaerulescens						X		3
Rhodocybe nitellina						X		3
Rhodoeybe nuciolens		X						3
Ricknella fibula						X		3
Rozites caperata		X						3
Russual basifurcata						X		3
Russula aeruginea		X						3
Russula albonigra		X						3
Russula alutacea		X						3
Russula brevipes		X						3
Russula emetica		X						3
Russula integra		X						3
Russula placita		X						3

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Russula sororia		X						3
Russula xerampelina	X	X				X		2
Rutstroemia elatina						X		3
Sarcodon sp.						X		3
Sarcoscypha coccinea		X						3
Sarcosoma sp.		X				X		2
Sarcosphaera crassa				X				1
Scieroderma citrinum		X						3
Scieroderma geaster		X						3
Scleroderma cepa		X						3
Sclerotinia tuberosa				X				1
Sclerotinia veratri						X		3
Scutellinia scutellata				X				1
Sebacina sp.						X		3
Sepultaria sumneriana						X		3
Serpula lacrimans						X		3
Sistotrema sp.						X		3
Sparassis crispa	X	X						3
Sphaerobulus stellatus						X		3
Sporostatia testudinea					X			3
Staurothele fuscocuprea					X			1
Steccherinum sp.						X		3
Stemonitis splendens						X		3
Stereum hirsutum		X						3
Strobilarius albipilatus		X						3
Strobilurus trullisatus		X						3
Stropharia ambigua		X						3
Stropharia kauffmanii		X						3
Stropharius riparia						X		3
Suillus brevipes						X		3
Suillus caerulescens		X						3
Suillus lakei		X						3

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Suillus ponderosus		X						3
Suillus pseudobrevipes						X		3
Taphrina occidentalis						X		3
Tarzetta cupularis		X						3
Tephromela armeniaca					X			3
Thaxterogaster pingue						X		3
Thelephora terrestris						X		3
Thiersia utriculatus nom. prov.						X		3
Thisoplaca marginalis							X	3
Trametes versicolor				X				1
Trapeliopsis grandulosa					X			1
Trappea darkeri						X		3
Tremella sp.						X		3
Trichaptum abietinum						X		3
Trichaptum biforme						X		3
Trichaptum fuscoviolaceum						X		3
Trichia botrytis						X		3
Trichia varia						X		3
Tricholoma flavovirens		X						3
Tricholoma imbricatum		X						3
Tricholoma leucopyllum		X						3
Tricholoma pessundatum		X						3
Tricholoma populinum		X						3
Tricholoma saponaceum		X				X		2
Tricholoma squarrulosum		X						3
Tricholoma terreum		X						3
Tricholoma vaccinum		X						3
Tricholoma vernaticum						X		3
Tricholoma zelleri		X						3
Tricholomopsis rutilans		X						3
Truncocolumellia citrina		X						3
Truncospora demidoffii		X						3

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Tubaria sp.						X		3
Tuber gibbosum		X						3
Tuber monticola						X		3
Tuberales				X				1
Tuckermannopsis merrillii			X		X			1
Tuckermannopsis orbata			X					3
Tuckermannopsis platyphylla				X	X			1
Tulostoma sp.		X						3
Tulsanella violea						X		3
Tympanis sp.						X		3
Typhula sp.						X		3
Tyromyces amarus		X						3
Tyromyces leucospongia				X				1
Umbilicaria hyperborea				X	X			1
Umbilicaria krascheninnikovii			X		X			2
Umbilicaria phaea				X	X			1
Umbilicaria polyphylla					X			1
Umbilicaria torrefacta			X				X	3
Umbilicaria virginis			X		X			2
Unguicularia sp.						X		3
Usnea sp.				X				1
Verpa bohemica		X						3
Verpa conica		X				X		2
Vesiculomyces citrinus						X		3
Vestergrenopsis elaeina					X			1
Volvarielia speciosa		X						3
Waynea stoechadiana							X	3
Weraroa cucullata						X		3
Xanothoparmelia mexicana			X		X			2
Xanothoria elegans			X		X			2
Xanthoparmelia				X				1
Xanthoparmelia mexicana			X					3

Scientific Name	Harvest	Arora	Hale & Cole	Manley	Ryan	SFSU	Shevock	Reliability
Xanthoparmelia taractica			X					3
Xanthoria sp.				X				1
Xeromphalina campanella						X		3

Appendix J

Historical Changes in Vertebrate Species Composition

APPENDIX J

HISTORICAL CHANGES IN VERTEBRATE SPECIES COMPOSITION

J. Shane Romsos, Matthew D. Schlesinger, and Patricia N. Manley

Table J-1—Bird species occurrence in the Lake Tahoe basin from 1860 through the present based on documented sightings and collections.[a]

Common Name	Scientific Name	Comstock Era (1860-1900)	Post-Comstock Era (1900-1960)	Urbanization Era (1960-present)	Lost[b]	Gained
Cooper's Hawk	*Accipiter cooperii*		X	X		
Northern Goshawk	*Accipiter gentilis*		X	X		
Sharp-shinned Hawk	*Accipiter striatus*		X	X		
Spotted Sandpiper	*Actitis macularia*		X	X		
Western/Clark's Grebe	*Aechmophorus occidentalis/clarkii*		X	X		
Red-winged Blackbird	*Agelaius phoeniceus*	X	X	X		
Wood Duck	*Aix sponsa*	X	X	X		
Northern Pintail	*Anas acuta*		X	X		
American Wigeon	*Anas americana*	X	X	X		
Northern Shoveler	*Anas clypeata*	X	X	X		
Green-winged Teal	*Anas crecca*	X	X	X		
Cinnamon Teal	*Anas cyanoptera*		X	X		
Mallard	*Anas platyrhynchos*	X	X	X		
Gadwall	*Anas strepera*		X	X		
American Pipit	*Anthus rubescens*			X		
Western Scrub Jay	*Aphelocoma californica*		X	X		
Golden Eagle	*Aquila chrysaetos*		X	X		
Great Blue Heron	*Ardea herodias*	X	X	X		
Lesser Scaup	*Aythya affinis*		X	X		
Ring-necked Duck	*Aythya collaris*	X	X	X		
Greater Scaup	*Aythya marila*			X		
Canvasback	*Aythya valisineria*		X	X		
Cedar Waxwing	*Bombycilla cedrorum*		X	X		
Canada Goose	*Branta canadensis*	X	X	X		

Common Name	Scientific Name	Comstock Era (1860-1900)	Post-Comstock Era (1900-1960)	Urbanization Era (1960-present)	Lost[b]	Gained
Great Horned Owl	*Bubo virginianus*		X	X		
Bufflehead	*Bucephala albeola*		X	X		
Common Goldeneye	*Bucephala clangula*		X	X		
Barrow's Goldeneye	*Bucephala islandica*	X	X	X		
Red-tailed Hawk	*Buteo jamaicensis*		X	X		
California Quail[c]	*Callipepla californica*		X	X		Yes
Anna's Hummingbird	*Calypte anna*			X		
Pine Siskin	*Carduelis pinus*	X	X	X		
Lesser Goldfinch	*Carduelis psaltria*	X	X	X		
Cassin's Finch	*Carpodacus cassinii*		X	X		
House Finch	*Carpodacus mexicanus*	X	X	X		
Purple Finch	*Carpodacus purpureus*	X	X	X		
Turkey Vulture	*Cathartes aura*		X	X		
Hermit Thrush	*Catharus guttatus*		X	X		
Swainson's Thrush	*Catharus ustulatus*		X	X		
Canyon Wren	*Catherpes mexicanus*	X	X		Maybe	
Brown Creeper	*Certhia americana*		X	X		
Belted Kingfisher	*Ceryle alcyon*	X	X	X		
Killdeer	*Charadrius vociferus*	X	X	X		
Common Nighthawk	*Chordeiles minor*	X	X	X		
American Dipper	*Cinclus mexicanus*	X	X	X		
Northern Harrier	*Circus cyaneus*	X	X	X		
Marsh Wren	*Cistothorus palustris*	X	X	X		
Evening Grosbeak	*Coccothraustes vespertinus*		X	X		
Northern Flicker	*Colaptes auratus*	X	X	X		
Band-tailed Pigeon	*Columba fasciata*		X	X		
Rock Dove[c]	*Columba livia*			X		Yes
Olive-sided Flycatcher	*Contopus cooperi*	X	X	X		
Western Wood-pewee	*Contopus sordidulus*		X	X		
American Crow	*Corvus brachyrhynchos*		X	X		
Common Raven	*Corvus corax*			X		Maybe
Steller's Jay	*Cyanocitta stelleri*	X	X	X		
Tundra Swan	*Cygnus columbianus*		X	X		
Blue Grouse	*Dendragapus obscurus*	X	X	X		
Yellow-rumped Warbler	*Dendroica coronata*		X	X		

Common Name	Scientific Name	Comstock Era (1860-1900)	Post-Comstock Era (1900-1960)	Urbanization Era (1960-present)	Lost[b]	Gained
Hermit Warbler	*Dendroica occidentalis*	X	X	X		
Yellow Warbler	*Dendroica petechia*	X	X	X		
Pileated Woodpecker	*Dryocopus pileatus*	X	X	X		
Pacific-slope Flycatcher	*Empidonax difficilis*			X		
Hammond's Flycatcher	*Empidonax hammondii*	X	X	X		
Dusky Flycatcher	*Empidonax oberholseri*		X	X		
Willow Flycatcher	*Empidonax traillii*		X	X		
Horned Lark	*Eremophila alpestris*	X	X	X		
Brewer's Blackbird	*Euphagus cyanocephalus*		X	X		
Peregrine Falcon	*Falco peregrinus*		X		Maybe	
American Kestrel	*Falco sparverius*		X	X		
American Coot	*Fulica americana*	X	X	X		
Common Snipe	*Gallinago gallinago*		X	X		
Common Loon	*Gavia immer*	X	X	X		
Northern Pygmy-owl	*Glaucidium gnoma*	X	X	X		
Bald Eagle	*Haliaeetus leucocephalus*	X	X	X		
Barn Swallow	*Hirundo rustica*	X	X	X		
Varied Thrush	*Ixoreus naevius*		X	X		
Dark-eyed Junco	*Junco hyemalis*		X	X		
California Gull	*Larus californicus*	X	X	X		
Ring-billed Gull	*Larus delawarensis*	X	X	X		
Gray-crowned Rosy Finch	*Leucosticte tephrocotis*	X	X	X		
Hooded Merganser	*Lophodytes cucullatus*		X	X		
Red Crossbill	*Loxia curvirostra*		X	X		
Lewis's Woodpecker	*Melanerpes lewis*	X	X		Maybe	
Wild Turkey[c]	*Meleagris gallopavo*			X		Yes
Lincoln's Sparrow	*Melospiza lincolnii*	X	X	X		
Song Sparrow	*Melospiza melodia*		X	X		
Common Merganser	*Mergus merganser*		X	X		
Brown-headed Cowbird	*Molothrus ater*			X		Yes
Townsend's Solitaire	*Myadestes townsendi*		X	X		
Clark's Nutcracker	*Nucifraga columbiana*	X	X	X		
Black-crowned Night-heron	*Nycticorax nycticorax*	X	X	X		
Macgillivray's Warbler	*Oporornis tolmiei*	X	X	X		
Mountain Quail	*Oreortyx pictus*	X	X	X		

Common Name	Scientific Name	Comstock Era (1860-1900)	Post-Comstock Era (1900-1960)	Urbanization Era (1960-present)	Lost[b]	Gained
Western Screech-owl	*Otus kennicottii*			X		
Ruddy Duck	*Oxyura jamaicensis*		X	X		
Osprey	*Pandion haliaetus*	X	X	X		
House Sparrow[c]	*Passer domesticus*		X	X		Yes
Savannah Sparrow	*Passerculus sandwichensis*		X		Maybe	
Fox Sparrow	*Passerella iliaca*		X	X		
Lazuli Bunting	*Passerina amoena*		X	X		
American White Pelican	*Pelecanus erythrorhynchos*	X	X	X		
Cliff Swallow	*Petrochelidon pyrrhonota*	X	X	X		
Black-headed Grosbeak	*Pheucticus melanocephalus*		X	X		
Black-billed Magpie	*Pica pica*	X	X	X		
White-headed Woodpecker	*Picoides albolarvatus*		X	X		
Black-backed Woodpecker	*Picoides arcticus*	X	X	X		
Downy Woodpecker	*Picoides pubescens*			X		Maybe
Hairy Woodpecker	*Picoides villosus*	X	X	X		
Pine Grosbeak	*Pinicola enucleator*		X	X		
Green-tailed Towhee	*Pipilo chlorurus*		X	X		
Spotted Towhee	*Pipilo maculatus*		X	X		
Western Tanager	*Piranga ludoviciana*	X	X	X		
Eared Grebe	*Podiceps nigricollis*	X	X	X		
Pied-billed Grebe	*Podilymbus podiceps*		X	X		
Mountain Chickadee	*Poecile gambeli*		X	X		
Sora	*Porzana carolina*		X	X		
Bushtit	*Psaltriparus minimus*		X	X		
Ruby-crowned Kinglet	*Regulus calendula*		X	X		
Golden-crowned Kinglet	*Regulus satrapa*		X	X		
Bank Swallow	*Riparia riparia*			X		
Rock Wren	*Salpinctes obsoletus*		X	X		
Rufous Hummingbird	*Selasphorus rufus*	X	X	X		
Mountain Bluebird	*Sialia currucoides*		X	X		
Western Bluebird	*Sialia mexicana*	X	X	X		
Red-breasted Nuthatch	*Sitta canadensis*		X	X		
White-breasted Nuthatch	*Sitta carolinensis*	X	X	X		
Pygmy Nuthatch	*Sitta pygmaea*	X	X	X		
Red-breasted Sapsucker	*Sphyrapicus ruber*		X	X		

Common Name	Scientific Name	Comstock Era (1860-1900)	Post-Comstock Era (1900-1960)	Urbanization Era (1960-present)	Lost[b]	Gained
Williamson's Sapsucker	*Sphyrapicus thyroideus*		X	X		
Chipping Sparrow	*Spizella passerina*	X	X	X		
Calliope Hummingbird	*Stellula calliope*		X	X		
Forster's Tern	*Sterna forsteri*	X	X	X		
Spotted Owl	*Strix occidentalis*			X		Maybe
Western Meadowlark	*Sturnella neglecta*		X	X		
European Starling[c]	*Sturnus vulgaris*			X		Yes
Tree Swallow	*Tachycineta bicolor*	X	X	X		
Violet-green Swallow	*Tachycineta thalassina*	X	X	X		
House Wren	*Troglodytes aedon*		X	X		
Winter Wren	*Troglodytes troglodytes*		X	X		
American Robin	*Turdus migratorius*	X	X	X		
Orange-crowned Warbler	*Vermivora celata*	X	X	X		
Nashville Warbler	*Vermivora ruficapilla*	X	X	X		
Cassin's Vireo	*Vireo cassinii*	X	X	X		
Warbling Vireo	*Vireo gilvus*		X	X		
Wilson's Warbler	*Wilsonia pusilla*	X	X	X		
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	X	X	X		
Mourning Dove	*Zenaida macroura*		X	X		
White-crowned Sparrow	*Zonotrichia leucophrys*		X	X		

Notes:
[a] Data sources included Orr and Moffitt (1971), Keane and Morrison (1994), Manley and Schlesinger (in prep.), and USFS (unpubl. data). Because there was virtually no documentation of bird occurrence prior to the arrival of Euro-American settlers, no attempt was made to "guess" at bird species occurrence during the Native American Era. However, in situations where a bird was not recorded between 1901 and 1959, but was recorded before and after this time period, it was assumed that that bird species occurred between 1901 and 1959.
[b] Losses and gains determined by reviewing the pattern of presence by era, resident status, exotic status, and population trends.
[c] Exotic species

Table J-2—Mammal species occurrence in the Lake Tahoe basin (1902 through 1998) based on documented sightings and collections. [a]

Common Name	Scientific Name	Post-Comstock Era (1900-1960)	Urbanization Era (1960-present)	Lost[b]	Gained
Pallid bat	*Antrozous pallidus*		X		
Mountain beaver	*Aplodontia rufa*	X	X		
Coyote	*Canis latrans*	X	X		
Beaver[c]	*Castor canadensis*		X		Yes
Big brown bat	*Eptesicus fuscus*	X	X		
Porcupine	*Erethizon dorsatum*	X	X		
Mountain lion	*Felis concolor*	X	X		
Bobcat	*Felis rufus*	X	X		
Northern flying squirrel	*Glaucomys sabrinus*	X	X		
Wolverine	*Gulo gulo*	X		Maybe	
Silver-haired bat	*Lasionycteris noctivagans*	X	X		
Hoary bat	*Lasiurus cinereus*	X			
Sierra Nevada snowshoe hare	*Lepus americanus tahoensis*	X	X		
Black-tailed hare	*Lepus californicus*	X			
White-tailed hare	*Lepus townsendii*	X			
River otter	*Lutra canadensis*	X	X		
Yellow-bellied marmot	*Marmota flaviventris*	X	X		
Marten	*Martes americana*	X	X		
Fisher	*Martes pennanti*	X	X		
Striped skunk	*Mephitis mephitis*	X	X		
Long-tailed vole	*Microtus longicaudus*	X	X		
Montane vole	*Microtus montanus*	X	X		
Ermine	*Mustela erminea*	X	X		
Long-tailed weasel	*Mustela frenata*	X	X		
Mink	*Mustela vison*	X	X		
California myotis	*Myotis californicus*		X		
Long-eared myotis	*Myotis evotis*	X	X		
Little brown myotis	*Myotis lucifugus*	X	X		
Fringed myotis	*Myotis thysanodes*	X	X		
Yuma myotis	*Myotis yumanensis*	X	X		

Common Name	Scientific Name	Post-Comstock Era (1900-1960)	Urbanization Era (1960-present)	Lost[b]	Gained
Bushy-tailed woodrat	*Neotoma cinerea*	X	X		
Desert woodrat	*Neotoma lepida*		X		
Pika	*Ochotona princeps*	X	X		
Mule deer	*Odocoileus hemionus*	X	X		
Muskrat	*Ondatra zibethicus*	X	X		
Mountain sheep	*Ovis canadensis californiana*			Maybe	
Brush mouse	*Peromyscus boylii*	X	X		
Canyon mouse	*Peromyscus crinitus*	X		Maybe	
Deer mouse	*Peromyscus maniculatus*	X	X		
Pinyon mouse	*Peromyscus truei*	X	X		
Heather vole	*Phenacomys intermedius*	X		Maybe	
Western pipistrelle	*Pipistrellus hesperus*		X		
Raccoon	*Procyon lotor*	X	X		
Broad-footed mole	*Scapanus latimanus*	X	X		
Western gray squirrel	*Sciurus griseus*		X		Maybe
Dusky shrew	*Sorex monticolus*	X	X		
Water shrew	*Sorex palustris*	X	X		
Trowbridge's shrew	*Sorex trowbridgii*	X	X		
Vagrant shrew	*Sorex vagrans*	X	X		
California ground squirrel	*Spermophilus beecheyi*	X	X		
Belding's ground squirrel	*Spermophilus beldingi*	X	X		
Golden-mantled ground squirrel	*Spermophilus lateralis*	X	X		
Western spotted skunk	*Spilogale gracilis*	X	X		
Nuttall's cottontail	*Sylvilagus nuttallii*	X	X		
Brazilian (Mexican) free-tailed bat	*Tadarida brasiliensis*		X		
Yellow-pine chipmunk	*Tamias amoenus*	X	X		
Least chipmunk	*Tamias minimus*		X		
Long-eared chipmunk	*Tamias quadrimaculatus*	X	X		
Allen's chipmunk	*Tamias senex*	X	X		
Lodgepole chipmunk	*Tamias speciosus*	X	X		
Douglas' squirrel	*Tamiasciurus douglasii*	X	X		
Badger	*Taxidea taxus*	X	X		

Common Name	Scientific Name	Post-Comstock Era (1900-1960)	Urbanization Era (1960-present)	Lost[b]	Gained
Mountain pocket gopher	*Thomomys monticola*	X	X		
Black bear	*Ursus americanus*	X	X		
Grizzly bear	*Ursus arctos*	X		Yes	
Sierra Nevada red fox	*Vulpes vulpes necator*		X	Yes	
Western jumping mouse	*Zapus princeps*	X	X		

Notes:
[a] Data sources included Grinnell et al. (1937), Orr (1949), Keane and Morrison (1994), Manley and Schlesinger in prep., USFS (unpubl. data). We did not find written documentation of mammal occurrence prior to 1901.
[b] Losses and gains determined by reviewing the pattern of presence by era, resident status, exotic status, and population trends.
[c] Exotic species.

Table J-3—Amphibian and reptile species occurrence in the Lake Tahoe basin from 1900 to the present based on documented sightings and collections.[a]

Common Name	Scientific Name	Post-Comstock Era (1900-1960)	Urbanization Era (1960-present)	Lost[b]	Gained
Amphibians					
Long-toed salamander	*Ambystoma macrodactylum*	X	X		
Western toad	*Bufo boreas*	X	X		
Pacific treefrog	*Hyla regilla*	X	X		
Bullfrog[c]	*Rana catesbeiana*	?	X		Yes
Mountain yellow-legged frog	*Rana muscosa*	X	X		
Northern leopard frog[d]	*Rana pipiens*	X		Maybe	
Reptiles					
Rubber boa	*Charina bottae*	X	X		
Southern alligator lizard	*Elgaria multicarinata*		X		
Northern aligator lizard	*Gerrhonotus coeruleus*	X	X		
Sagebrush lizard	*Sceloporus graciosus*	X	X		
Western fence lizard	*Sceloporus occidentalis*	X	X		
Western terrestrial garter snake	*Thamnophi elegans*	X	X		
Western aquatic garter snake	*Thamnophis couchii*	X	X		
Common garter snake	*Thamnophis sirtalis*		X		

Notes:
[a] Sources consulted included Museum of Vertebrate Zoology, University of California, Berkeley, CA., Keane and Morrison (1994), and Manley and Schlesinger (in prep).
[b] Losses and gains determined by reviewing the pattern of presence by era, resident status, exotic status, and population trends.
[c] Exotic species.
[d] Possible exotic species.

Table J-4—Fish species occurrence in the Lake Tahoe basin from pre-1860 to the present based on documented sightings and collections.[a]

Common Name	Scientific Name	Exotic	Prehistoric Era (pre 1860)	Comstock Era (1860-1900)	Post-Comstock Era (1901-1960)	Urbanization Era (1961-present)	Lost[b]	Gained[b]
Goldfish	*Carassius auratus*	Y				X		Yes
Tahoe sucker	*Catostomus tahoensis*			X	X	X		
Lake whitefish	*Coregonus clupeaformis*	Y		X	X			Yes
Piute sculpin	*Cottus beldingi*			X	X	X		
Carp	*Cyprinus carpio*	Y				X		Yes
Mosquito fish	*Gambusia affinis*	Y				X		Yes
Tui chub	*Gila bicolor*		X	X	X	X		
Brown bullhead	*Ictalurus nebulosis*	Y				X		Yes
Bluegill	*Lepomis macrochirus*	Y				X		Yes
Largemouth bass	*Micropterus salmoides*	Y				X		Yes
Smallmouth bass	*Mircopterus dolomieui*	Y				X		Yes
Golden shiner	*Notemigonus crysoleucas*	Y				X		Yes
Golden trout	*Oncorhynchus aquabonita*	Y		X	X	X		Yes
Lahontan cutthroat trout	*Oncorhynchus clarkii henshawi*		X	X	X	X	Yes[c]	
Rainbow trout	*Oncorhynchus mykiss*	Y			X	X		Yes
Kokanee salmon	*Oncorhynchus nerka kennerlyi*	Y			X	X		Yes
Chinook salmon	*Oncorhynchus tshawytscha*	Y		X	X			Yes
White crappie	*Pomoxis annularis*	Y				X		Yes
Black crappie	*Pomoxis nigromaculatus*	Y				X		Yes
Mountain whitefish	*Prosopium williamsoni*		X	X	X	X		
Speckled dace	*Rhinichthys osculus*		X	X	X	X		
Lahontan redside shiner	*Richardsonius egregius*		X	X	X	X		
Atlantic salmon	*Salmo salar*	Y		X	X			Yes
German brown trout	*Salmo trutta*	Y			X	X		Yes
Brook trout	*Salvelinus fontinalis*	Y		X	X	X		Yes
Mackinaw (lake) trout	*Salvelinus namaycush*	Y		X	X	X		Yes
Arctic grayling	*Thymallus arcticus*	Y		X	X			Yes

Notes:
[a] Data sources included Miller (1951), Moyle (1976), Beauchamp et al. (1994), Tahoe Regional Planning Agency (1971a), Cordone et al. (1971), Cordone (1986, letter to Tahoe Regional Planning Agency), Shade (personal communication), Bezzone (personal communication), Lehr (personal communication), and Manley and Schlesinger (in prep).
[b] Losses and gains determined by reviewing the pattern of presence by era, resident status, exotic status, and population trends.
[c] Lahontan cutthroat trout were extirpated and subsequently reintroduced.

APPENDIX K

FOCAL VASCULAR PLANT SPECIES OF THE LAKE TAHOE BASIN

APPENDIX K

FOCAL VASCULAR PLANT SPECIES OF THE LAKE TAHOE BASIN

Patricia N. Manley and Matthew D. Schlesinger

Table K-1—Focal vascular plants of the Lake Tahoe basin. Criteria responsible for focal designation are indicated. Species are listed in alphabetical order by scientific name.

		Ecological Criteria				Cultural Criteria	
Scientific name	**Common name**	**T,E,SC**	**Rare**	**Endemic**	**Exotic**	**Harvest**	**Agency Emphasis**
Abies concolor	White fir					CH	
Abies magnifica var. *magnifica*	California red fir					CH	
Agrostis humilis	Mountain bentgrass		X				
Arabis rigidissima var. *demota*	Galena Creek rockcress	X	X	X			X
Arnica sororia	Twin arnica		X				
Asplenium trichomanes-ramosum	Green spleenwort		X				
Aster alpigenus var. *andersonii*	Anderson's aster						X
Astragalus austiniae	Austin's milkvetch			X			
Astragalus whitneyi var. *lenophyllus*	Balloon pod milkvetch			X			
Botrychium ascendens	Trianglelobe moonwort		X				X
Bromus tectorum	Cheatgrass				X		
Calocedrus decurrens	Incense cedar					CH	
Carduus acanthoides	Plumeless thistle				X		
Carduus nutans	Musk Thistle				X		
Carex davyi	Davy's sedge			X			
Carex limosa	Mud sedge		X				
Carex mariposana	Mariposa sedge						X
Centaurea diffusa	Diffuse knapweed				X		
Centaurea maculosa	Spotted knapweed				X		
Cirsium vulgare	Bullthistle				X		

		Ecological Criteria				Cultural Criteria	
Scientific name	**Common name**	**T,E,SC**	**Rare**	**Endemic**	**Exotic**	**Harvest**	**Agency Emphasis**
Clarkia virgata	Sierra clarkia			X			
Cytisus scoparius	Scotch Broom				X		
Draba asterophora var. *asterophora*	Lake Tahoe draba		X	X			X
Draba asterophora var. *macrocarpa*	Cup Lake draba	X	X	X			X
Epilobium howellii	Epilobium		X	X			X
Epilobium oreganum	Oregon fireweed	X					X
Equisetum paulstre	Marsh horsetail		X				
Erigeron miser	Starved fleabane		X	X			X
Erigeron petrophilus var. *sierrensis*	Sierra fleabane			X			
Eriogonum ovalifolium var. *eximium*	Brown-margined buckwheat					M	
Eriogonum ovalifolium var. *vineum*			X				
Eriogonum umbellatum var. *torreyanum*	Torrey buckwheat	X	X	X		M	X
Hypericum perforatum	Klamathweed				X		
Ivesia sericoleuca	Plumas mousetail	X		X			X
Ivesia webberi	Webber's ivesia	X	X				X
Lepidium latifolium	Tall whitetop				X		
Lewisia longipetala	Long-petaled lewisia	X	X	X		WH	X
Linaria genistifolia ssp. *dalmatica*	Dalmatian toadflax				X		
Myriophyllum spicatum	Eurasian watermilfoil				X		HC
Onopordum acanthium ssp. *acanthium*	Scotch Thistle				X		
Penstemon personatus	Close-throated beardtongue		X	X			X
Perideridia bacigalupii	Bacigalupi's perideridia			X			
Pinus albicaulis	Whitebark pine		P				
Pinus contorta ssp. *murrayana*	Lodgepole pine					CH	
Pinus jeffreyi	Jeffrey pine					CH	
Pinus lambertiana	Sugar pine					CH	
Pinus monticola	Western white pine					CH	
Pinus ponderosa	Ponderosa pine					CH	
Potamogeton epihydrus ssp. *nuttallii*	Ribbonleaf pondweed		X				
Rorippa subumbellata	Tahoe yellow cress	X	X	X			X
Scheuchzeria palustris ssp. *americana*	American Scheuchzeria		X				X
Scirpus subterminalis	Water bulrush		X				

		Ecological Criteria				Cultural Criteria	
Scientific name	**Common name**	**T,E,SC**	**Rare**	**Endemic**	**Exotic**	**Harvest**	**Agency Emphasis**
Scutellaria galericulata	Marsh skullcap		X			M	
Solidago gigantea	Smooth goldenrod		X			M	
Tonestus eximius	Lake Tahoe serpentweed			X			
Viola pinetorum ssp. *grisea*	Grey-leaved violet		X				X
Viola tomentosa	Woolly violet		X	X			

Notes:
T, E, SC: Federal and/or State Threatened or Endangered or Species of Special Concern
Rare: Limited occurrence or highly restricted occurrence according to CalFlora (Dennis 1995) (X); population decline (P)
Endemic: Endemic to Truckee River basin or rare Sierra Nevada endemic (Shevock 1996)
Exotic: Exotic species considered invasive and potentially ecologically detrimental (X)
Harvest: CH = Commercial harvest (Parsons 1999); M = medicinal use (Chatfield 1997; Anderson 1993; Beckstrom-Sternberg et al. 1995a, 1995b; Blackburn and Anderson 1993; Hill 1972; LaLande 1993) and rare ; WH = Washoe harvest (Rucks 1999)
Agency emphasis: USDA Forest Service sensitive (USDA 1998) or TRPA sensitive (TRPA 1982); human conflict species (HC)

APPENDIX L

DESIGNATION OF FOCAL VERTEBRATE SPECIES FOR THE LAKE TAHOE BASIN

APPENDIX L

DESIGNATION OF FOCAL VERTEBRATE SPECIES FOR THE LAKE TAHOE BASIN

Patricia N. Manley and Matthew D. Schlesinger

Candidates for Focal Species Status

Only species presumed to have established populations in the basin and those considered extirpated or potentially extirpated were considered as candidates for focal species status. The criteria used for determining candidate species differed among vertebrate groups based on the source of the data. The specific criteria used to identify candidate focal species are described below for each vertebrate group.

Birds

We omitted all birds listed as "accidental" on the Lake Tahoe basin bird list (Eastern Sierra Interpretive Association ca. 1993); further, we omitted any bird species considered no more common than "rare" in any season, unless that species was detected at more than one site by Manley and Schlesinger (in prep). We included species that were not included in Eastern Sierra Interpretive Association (ca. 1993) only if they were detected at more than one site by Manley and Schlesinger (in prep). We omitted two additional species, the Horned Grebe and Semipalmated Plover; both species are listed in Eastern Sierra Interpretive Association (ca. 1993) as "occasional" in one or more seasons but have not been recorded recently and are not included in the Sierra All Species Information (SASI) database (USDA 1999b). We recognize the limitations of using abundance categories not based on systematic sampling. However, no such studies have occurred here in the basin. Therefore, we used the classifications in Eastern Sierra Interpretive Association (ca. 1993) to approximate the relative abundance of bird species. The following extirpated and potentially extirpated species were candidates for focal species status: Peregrine Falcon, Savannah Sparrow, Lewis's Woodpecker, and Canyon Wren.

Mammals

We included species from Orr (1949), Manley and Schlesinger (in prep.), Tatum (1998a, 1998b), and Pierson (1998), as these sources provided the only verified recent sightings of mammals in the basin. The following extirpated and potentially extirpated species were candidates for focal species status: Mountain sheep, heather vole, canyon mouse, white-tailed hare, wolverine, Sierra Nevada red fox, and grizzly bear.

Amphibians and Reptiles

We included species detected by Keane and Morrison (1994) and Manley and Schlesinger (in prep), as these studies provided the only verified recent sightings of herpetofauna in the basin. The northern leopard frog, which has apparently been extirpated from the basin, was also a candidate for focal species status.

Fish

We included all fish species from the list of current species because all of these species are suspected to have self-supporting populations in the basin. Four extirpated species, Arctic grayling, Atlantic salmon, chinook salmon, and lake whitefish were not considered candidates because they were introduced to the basin (Cordone 1986).

Vulnerability Analysis Using the Sierra All Species Information Database

The Sierran All Species Information (SASI) database (USDA 1999b) was developed for the Sierra Nevada Monitoring Strategy as a tool to facilitate a vulnerability analysis for Sierra Nevada vertebrates (Keane and Zielinski in prep). The database represents a combination of fields populated from the literature and fields populated from questionnaires distributed to individuals with expertise on particular Sierran taxa. We used the following variables populated from the literature: AQUATIC, HABSPECALLACT, LSOGDEP, MOBILITY, and RNGSIZE (Table L-1). We used the following variables populated from questionnaires: POPSIZE, POPTREND, and RNGCHG (Table L-1). For questionnaire-derived variables, each major taxonomic group (birds, mammals, and reptiles/amphibians) was addressed by an expert on Sierran species and all responses were reviewed by the authors of the database. The following variable descriptions are adapted from USDA (1999b); information not relevant to species in our analyses has been omitted.

AQUATIC (Aquatic Association) - Describes species association with aquatic habitat.

(1) Terrestrial

(2) Semi-aquatic

(3) Aquatic

Assigning Aquatic status: Processes and Assumptions

1. All data were derived from the CWHR species notes (Zeiner et al. 1988, Zeiner et al. 1990a, Zeiner et al. 1990b).

2. If a species' entire life cycle required being in or on water, and if their prey base consisted solely of aquatic species, they were considered aquatic. Bird species that are shore nesters were still considered aquatic if they nested within 60 m of a body of water. Species were semi-aquatic if only part of their life cycle required water and/or their prey base consisted of both terrestrial and aquatic species.

3. If the CWHR species notes for herpetofauna stated that eggs are deposited in water, larvae are aquatic and adults are terrestrial, these species were given a semi-aquatic status.

4. If the CWHR species notes for herpetofauna stated that eggs are deposited in water, larvae may transform into terrestrial adults or may remain as neotenic adults, these species were given a semi-aquatic status.

HABSPECALLACT (Habitat Specificity [Liberal]) - Proportion of CWHR vegetation type-structural/canopy cover classes (Mayer and Laudenslayer 1988) ranked with a low, medium, or high index value relative to the total number of classes possible in the Sierra Nevada for a species.

(1) Very habitat specific (High vulnerability)

(2) Moderately habitat specific (Moderate vulnerability)

(3) Habitat generalist (Low vulnerability)

Assigning Habitat Specificity (Liberal): Process and Assumptions

1. All values were calculated from the CWHR database (CDFG 1998a). This database contains feeding, reproductive, and cover habitat suitability values (H=high, M=moderate, L=low, null=not present/applicable), as well as an index value (the highest value of feeding, reproductive, and cover), for each seral stage of each habitat a species occurs in. Within the study area, there are 49 CWHR habitat types, each containing from 7 to 18 seral stages, for a total of 563 possible habitat type/seral stage combinations.

2. The frequency distribution of the habitat specificity values for species in the basin was examined for the two most conspicuous breaks. Species with values ranging from 0-0.3 were categorized as 'very habitat specific', those ranging from 0.3-0.6 were 'moderately habitat specific', and 0.6-1 were 'habitat generalists.'

Table L-1—Variables from the Sierran All Species Information (SASI) database (USDA 1999b) used in focal species analyses. CWHR information was obtained from CDFG (1998a).

Variable Name	Description	Scores	Definitions of Scores
AQUATIC	Aquatic association	1	Terrestrial
		2	Semi-aquatic
		3	Aquatic
HABSPECALL	Habitat specificity (discrete)	1	Habitat generalist (proportion of CWHR seral stages used 0.6 - 1.0)
		2	Moderately habitat specific (proportion of CWHR seral stages used 0.3 - 0.6)
		3	Very habitat specific (proportion of CWHR seral stages used 0.0 - 0.3)
HABSPECALLACT	Habitat specificity (continuous)	0-1	Proportion of CWHR seral stages used
LSOGDEP	Late-seral old growth association	1	Indicates that species population in the Sierra Nevada requires LSOG habitat
		2	Indicates that species uses LSOG habitat but is not dependent upon it
		3	Indicates that species does not use LSOG habitat significantly
MOBILITY	Mobility/dispersal capability	1	Flier
		2	High-mobility non-flier
		3	Low-mobility non-flier
POPSIZE	Sierra Nevada population size	1	Species has not been reported for a number of years but may still exist
		2	1-100 adults
		3	101-1,000 adults, or population size is unknown but suspected to be small
		4	1,001-10,000 adults
		5	>10,000 adults, or population size is unknown but suspected to be large
POPTREND	Sierra Nevada population trend	1	Population size known to be decreasing
		2	Trend unknown but population size suspected to be decreasing
		3	Population formerly experienced serious declines but is presently stable
		4	Population size stable or suspected to be stable or increasing
		5	Population size known to be increasing
RNGCHG	Sierra Nevada range change	1	Area occupied suspected to have declined by 90-100%
		2	Area occupied suspected to have declined by 50-89%
		3	Area occupied unknown but suspected to have declined by ≥ 50%
		4	Area occupied suspected to have declined by 1-49%
		5	Area occupied unknown but suspected to have declined by ≤ 50%
		6	Area occupied suspected to be stable or has increased
RNGSIZE	Home range size	1	Small (1 - 1000 m^2)
		2	Medium (1,001 - 400,000 m^2)
		3	Large (> 400,000 m^2)

LSOGDEP (Late Seral/Old Growth Association) - Describes species' dependency on late seral/old growth (LSOG) habitat in the Sierra Nevada based on SNEP classification (Graber 1996). Two species' classifications were changed by the database authors from category 2 or 3 to category 1: the Red Crossbill and the marten.

(1) Indicates that species population in the Sierra Nevada requires LSOG habitat.

(2) Indicates that species uses LSOG habitat but is not dependent upon it.

(3) Indicates that species does not use LSOG habitat significantly.

MOBILITY (Mobility/Dispersal Capability) - Defines the relative ability of a taxon to move in response to daily and seasonal needs, reproductive needs, and/or in response to habitat disturbance.

(1) Low-mobility non-fliers (High vulnerability)

(2) High-mobility non-fliers (Moderate vulnerability)

(3) Flier (Low vulnerability)

Assigning Mobility/Dispersal Capability status: Process and Assumptions

1. All data were derived by terrestrial species team consensus.

2. All amphibians, reptiles, and mammals in the orders Insectivora, Lagomorpha, and Rodentia (with the exception of *Castor canadensis*, due to its ability to relocate between watersheds) were considered 'low mobility non-fliers' based largely because as herbivores or insectivores their foods do not require extensive mobility to locate.

3. All other mammals (with the exception of bats) were considered 'high mobility non-fliers' due to either their carnivorous diets or high mobility characteristics.

4. 'Flier' status was given to all birds and bats.

POPSIZE (Sierra Nevada Population Size) - The estimated number of adults of the species throughout the Sierra Nevada.

(1) Species has not been reported for a number of years but may still exist (High imperilment)

(2) 1-100 individuals (High imperilment)

(3) 101-1,000 individuals, or population size is unknown but suspected to be small (Moderate imperilment)

(4) 1,001-10,000 individuals (Low imperilment)

(5) >10,000 individuals, or population size is unknown but suspected to be large (Low imperilment)

POPTREND (Sierra Nevada Population Trend) - Overall trend in the number of individuals of the species throughout the Sierra Nevada since 1900, or later depending on the date of the earliest information for the species.

(1) Population size known to be decreasing (High imperilment)

(2) Trend unknown but population size suspected to be decreasing (Moderate imperilment)

(3) Population formerly experienced serious declines but is presently stable (Moderate imperilment)

(4) Population size stable or suspected to be stable or increasing (Low imperilment)

(5) Population size known to be increasing (Low imperilment)

RNGCHG (Sierra Nevada Range Change) - Percent change in the area occupied by the species since historic times. This is an estimate of change in the proportion of the total range that is occupied or utilized; it may or may not equal the change in total range. For example, a species may still be found throughout its historic range yet within that range it may currently occupy only 50% of the area historically occupied.

(1) Area occupied suspected to have declined by 90-100% (High imperilment)

(2) Area occupied suspected to have declined by 50-89% (High imperilment)

(3) Area occupied unknown but suspected to have declined by >50% (High imperilment)

(4) Area occupied suspected to have declined by 1-49% (Moderate imperilment)

(5) Area occupied unknown but suspected to have declined by <50% (Moderate imperilment)

(6) Area occupied suspected to be stable or has increased (Low imperilment)

RNGSIZE (Home Range Size) - Describes home range size of species in 3 categories.

(1) Small (Low vulnerability)

(2) Medium (Moderate vulnerability)

(3) Large (High vulnerability)

Assigning Home Range classes: Process and Assumptions

1. All data were derived from the CWHR species notes, with the exception of *Martes americana* and *M. pennanti* (Ruggiero et al. 1994), and *Ursus arctos* (Pasitschniak-Arts 1993).

2. Amphibians, reptiles, mammals and birds were included in the same database and subjected to the same analyses.

3. Home ranges given as linear measurements (in the cases of many amphibians) were converted to areas by assuming the linear distances were the diameters of circles.

4. If no data were available for home range, then values listed under 'territory' were used. This was done for birds and, to a lesser extent, mammals, and was infrequent.

5. If home range was given for many states, values from California were used, regardless if these values were not the maximum or minimum stated values. This occurred only a few times.

6. More than one value for home range was often provided. In these cases a column was created for the maximum value and one for the minimum value. Thus, the database authors were prepared to conduct analyses on each set of numbers if necessary.

7. When the CWHR species notes reported a home range of "several hectares" or "several meters", the authors assigned a value of 3. This occurred on only a few occasions.

8. Densities of group living/social species were presented as per capita.

Classification:

1. Each species was designated as having a "small," "medium," or "large" home range on the basis of the following method. The authors created bins (ranges) to examine the frequency distribution of home range values for all species for which they were reported (about 50% of the herps, 64% of the mammals, and 82% of the birds). The authors did this twice: once using the "maximum and only" column (uses either the max value or the only value provided for the species) and once using the "minimum and only" column. These distributions were examined for natural breaks and selected the column that had the most conspicuous breaks. The authors then took these columns and combined all taxa, and repeated the above step to examine the frequency distribution. Species with home ranges from 1 - 1000 m^2 were classified as "small", those with ranges from 1,001 - 400,000 m^2 were "moderate", and those greater than 400,000 m^2 were considered "large".

2. Species for which no home range data were provided (n = 126) were not included in the analyses described above. Further literature review produced no additional data, necessitating the use of the following criteria to classify those 'unknown' species:

a) If an unknown species had one or more congenerics in the database that were all assigned to a single home range class, the unknown species was assigned the same class as its congenerics.

b) If an unknown species had congenerics in the database assigned to more than one home range class, the species was placed with the majority class and/or with the class for which the body sizes were most similar.

c) If the only congenerics in the CWHR species notes with home range data occurred outside the Sierra Nevada, and they had similar body size, these data were used to assign the unknown species to a home range class.

d) Species for which there were no congenerics in California were considered on a family level. If confamilials occurred either in the database or the CWHR species notes and were of similar body size, these data were used to classify an unknown species.

e) For herpetofauna, particularly the reptiles, text within the home range section of the CWHR species notes was used to classify unknown species. Statements such as "probably small" and "probably sedentary" resulted in a "small" classification. Statements such as "possible to see several individuals in a hectare" resulted in a "moderate" classification.

f) Sixteen of the 30 snake species met none of the criteria mentioned above. Using the 14 species that the authors could classify, a mean was generated for the body size (cm) of species within each home range class (small=65.74; moderate=108.17; large=140.83). The authors assumed a positive relationship between body size and home range class and assigned the 16 species to a home range class according to which mean their body sizes were nearest.

Appendix M

Imperilment and Vulnerability of Lake Tahoe Basin Terrestrial Vertebrates

APPENDIX M

IMPERILMENT AND VULNERABILITY OF LAKE TAHOE BASIN TERRESTRIAL VERTEBRATES

Patricia N. Manley and Matthew D. Schlesinger

Table M-1—Terrestrial vertebrate species of the Lake Tahoe Basin with their scores on variables used in identifying potentially imperiled and potentially vulnerable species. Data are from the Sierra All Species Information database (USDA 1999b). See Appendix L for variable descriptions.

Common Name	Scientific Name	Population Size	Population Trend	Range Change	Habitat Specificity	Mobility	Home Range	Aquatic	Old Forest
Birds									
Cooper's Hawk	*Accipiter cooperii*	4	4	5	0.715	3	2	1	3
Northern Goshawk	*Accipiter gentilis*	4	2	5	0.674	3	3	1	1
Sharp-shinned Hawk	*Accipiter striatus*	4	2	5	0.836	3	2	1	2
Spotted Sandpiper	*Actitis macularia*	4	2	4	0.087	3	2	2	3
Western/Clark's Grebe	*Aechmophorus occidentalis/clarkii*	4	2	4	0.060	3	2	3	3
Red-winged Blackbird	*Agelaius phoeniceus*	5	4	6	0.111	3	3	1	3
Wood Duck	*Aix sponsa*	2	4	4	0.285	3	3	2	3
Northern Pintail	*Anas acuta*	3	3	4	0.117	3	3	2	3
American Wigeon	*Anas americana*	3	4	4	0.076	3	2	2	3
Northern Shoveler	*Anas clypeata*	2	3	4	0.072	3	2	3	3
Green-winged Teal	*Anas crecca*	3	4	4	0.126	3	2	2	3
Cinnamon Teal	*Anas cyanoptera*	5	4	4	0.104	3	2	2	3
Mallard	*Anas platyrhynchos*	4	4	4	0.175	3	3	2	3
Gadwall	*Anas strepera*	5	4	4	0.115	3	2	2	3
American Pipit	*Anthus rubescens*	4	4	6	0.115	3	2	1	3
Western Scrub Jay	*Aphelocoma coerulescens*	5	1	6	0.410	3	2	1	3

Common Name	Scientific Name	Population Size	Population Trend	Range Change	Habitat Specificity	Mobility	Home Range	Aquatic	Old Forest
Golden Eagle	*Aquila chrysaetos*	3	4	5	0.813	3	3	1	3
Great Blue Heron	*Ardea herodias*	3	4	4	0.426	3	3	2	3
Lesser Scaup	*Aythya affinis*	3	3	4	0.074	3	2	2	3
Ring-necked Duck	*Aythya collaris*	3	3	4	0.037	3	2	3	3
Greater Scaup	*Aythya marila*	2	4	6	0.007	3	2	3	3
Canvasback	*Aythya valisineria*	3	3	4	0.044	3	3	3	3
Cedar Waxwing	*Bombycilla cedrorum*	5	4	6	0.539	3	1	1	3
Canada Goose	*Branta canadensis*	5	4	4	0.094	3	3	2	3
Great Horned Owl	*Bubo virginianus*	4	4	6	0.884	3	3	1	3
Bufflehead	*Bucephala albeola*	3	4	4	0.122	3	2	2	3
Common Goldeneye	*Bucephala clangula*	3	4	6	0.063	3	3	2	3
Barrow’s Goldeneye	*Bucephala islandica*	1	1	1	0.024	3	2	3	3
Red-tailed Hawk	*Buteo jamaicensis*	4	4	6	0.880	3	3	1	3
California Quail	*Callipepla californica*	5	4	5	0.754	3	2	1	3
Anna’s Hummingbird	*Calypte anna*	5	4	6	0.445	3	2	1	3
Pine Siskin	*Carduelis pinus*	5	4	6	0.536	3	2	1	3
Lesser Goldfinch	*Carduelis psaltria*	5	1	6	0.520	3	2	1	3
Cassin’s Finch	*Carpodacus cassinii*	5	4	6	0.344	3	2	1	1
House Finch	*Carpodacus mexicanus*	5	1	6	0.523	3	2	1	3
Purple Finch	*Carpodacus purpureus*	5	4	6	0.428	3	2	1	1
Turkey Vulture	*Cathartes aura*	4	4	6	0.838	3	3	1	3
Hermit Thrush	*Catharus guttatus*	5	4	6	0.744	3	2	1	2
Swainson’s Thrush	*Catharus ustulatus*	3	1	2	0.461	3	2	1	3
Canyon Wren	*Catherpes mexicanus*	5	4	6	0.159	3	2	1	3
Brown Creeper	*Certhia americana*	5	4	6	0.378	3	2	1	1
Belted Kingfisher	*Ceryle alcyon*	5	1	5	0.150	3	3	2	3
Killdeer	*Charadrius vociferus*	5	2	6	0.124	3	2	2	3
Common Nighthawk	*Chordeiles minor*	5	2	5	0.705	3	3	1	3
American Dipper	*Cinclus mexicanus*	5	4	6	0.129	3	2	2	3
Northern Harrier	*Circus cyaneus*	3	3	5	0.424	3	3	1	3
Marsh Wren	*Cistothorus palustris*	3	4	6	0.063	3	1	1	3

Common Name	Scientific Name	Population Size	Population Trend	Range Change	Habitat Specificity	Mobility	Home Range	Aquatic	Old Forest
Evening Grosbeak	*Coccothraustes vespertinus*	5	2	6	0.618	3	2	1	1
Northern Flicker	*Colaptes auratus*	5	4	6	0.904	3	2	1	3
Band-tailed Pigeon	*Columba fasciata*	5	1	4	0.394	3	2	1	2
Rock Dove	*Columba livia*	3	4	6	0.028	3	2	1	3
Olive-sided Flycatcher	*Contopus cooperi*	5	1	4	0.468	3	2	1	2
Western Wood-pewee	*Contopus sordidulus*	5	1	5	0.703	3	2	1	3
American Crow	*Corvus brachyrhynchos*	5	4	6	0.296	3	2	1	3
Common Raven	*Corvus corax*	5	5	6	0.932	3	3	1	3
Steller's Jay	*Cyanocitta stelleri*	5	1	6	0.628	3	2	1	2
Tundra Swan	*Cygnus columbianus*	3	4	4	0.083	3	3	2	3
Blue Grouse	*Dendragapus obscurus*	5	2	5	0.415	3	2	1	2
Yellow-rumped Warbler	*Dendroica coronata*	5	4	6	0.896	3	2	1	3
Hermit Warbler	*Dendroica occidentalis*	5	4	6	0.507	3	2	1	1
Yellow Warbler	*Dendroica petechia*	5	4	6	0.587	3	2	1	2
Pileated Woodpecker	*Dryocopus pileatus*	3	4	6	0.195	3	3	1	1
Pacific-slope Flycatcher	*Empidonax difficilis*	5	4	6	0.373	3	2	1	3
Hammond's Flycatcher	*Empidonax hammondii*	5	4	6	0.207	3	2	1	2
Dusky Flycatcher	*Empidonax oberholseri*	5	4	6	0.595	3	2	1	3
Willow Flycatcher	*Empidonax traillii*	3	2	1	0.090	3	2	1	2
Horned Lark	*Eremophila alpestris*	5	2	5	0.119	3	2	1	3
Brewer's Blackbird	*Euphagus cyanocephalus*	5	4	6	0.634	3	3	1	3
Peregrine Falcon	*Falco peregrinus*	2	4	6	0.831	3	3	1	3
American Kestrel	*Falco sparverius*	4	2	6	0.923	3	3	1	3
American Coot	*Fulica americana*	5	5	6	0.094	3	2	2	3
Common Snipe	*Gallinago gallinago*	3	2	4	0.051	3	2	2	3
Common Loon	*Gavia immer*	3	2	6	0.023	3	2	3	3
Northern Pygmy-owl	*Glaucidium gnoma*	4	4	6	0.580	3	2	1	2
Bald Eagle	*Haliaeetus leucocephalus*	3	5	5	0.831	3	2	2	3
Barn Swallow	*Hirundo rustica*	5	4	6	0.694	3	2	1	3
Varied Thrush	*Ixoreus naevius*	3	4	6	0.463	3	2	1	2
Dark-eyed Junco	*Junco hyemalis*	5	2	6	0.801	3	2	1	3

Common Name	Scientific Name	Population Size	Population Trend	Range Change	Habitat Specificity	Mobility	Home Range	Aquatic	Old Forest
California Gull	*Larus californicus*	3	5	6	0.113	3	3	2	3
Ring-billed Gull	*Larus delawarensis*	4	5	6	0.115	3	3	2	3
Gray-crowned Rosy Finch	*Leucosticte arctoa*	3	4	6	0.078	3	2	1	3
Hooded Merganser	*Lophodytes cucullatus*	3	4	6	0.071	3	3	3	3
Red Crossbill	*Loxia curvirostra*	5	4	6	0.275	3	3	1	3
Lewis's Woodpecker	*Melanerpes lewis*	3	2	5	0.660	3	2	1	3
Wild Turkey	*Meleagris gallopavo*	5	4	6	0.492	3	3	1	3
Lincoln's Sparrow	*Melospiza lincolnii*	3	4	6	0.250	3	2	1	3
Song Sparrow	*Melospiza melodia*	5	4	6	0.419	3	2	1	3
Common Merganser	*Mergus merganser*	3	4	6	0.119	3	3	2	3
Brown-headed Cowbird	*Molothrus ater*	5	1	6	0.753	3	2	1	3
Townsend's Solitaire	*Myadestes townsendi*	5	2	6	0.328	3	2	1	3
Clark's Nutcracker	*Nucifraga columbiana*	5	4	6	0.314	3	3	1	3
Black-crowned Night-heron	*Nycticorax nycticorax*	3	4	4	0.351	3	3	2	3
Macgillivray's Warbler	*Oporornis tolmiei*	5	4	6	0.223	3	2	1	3
Mountain Quail	*Oreortyx pictus*	5	4	6	0.722	3	3	1	3
Western Screech-owl	*Otus kennicottii*	4	2	5	0.804	3	2	1	3
Ruddy Duck	*Oxyura jamaicensis*	3	4	4	0.063	3	2	3	3
Osprey	*Pandion haliaetus*	3	4	6	0.850	3	3	2	3
House Sparrow	*Passer domesticus*	5	4	6	0.122	3	1	1	3
Savannah Sparrow	*Passerculus sandwichensis*	5	4	6	0.158	3	1	1	3
Fox Sparrow	*Passerella iliaca*	5	5	6	0.568	3	2	1	3
Lazuli Bunting	*Passerina amoena*	5	2	6	0.381	3	2	1	3
American White Pelican	*Pelecanus erythrorhynchos*	3	1	4	0.047	3	3	3	3
Cliff Swallow	*Petrochelidon pyrrhonota*	5	5	6	0.463	3	3	1	3
Black-headed Grosbeak	*Pheucticus melanocephalus*	5	2	6	0.575	3	2	1	3
Black-billed Magpie	*Pica pica*	5	4	6	0.117	3	2	1	3
White-headed Woodpecker	*Picoides albolarvatus*	5	5	6	0.365	3	2	1	1
Black-backed Woodpecker	*Picoides arcticus*	3	4	6	0.065	3	2	1	2
Downy Woodpecker	*Picoides pubescens*	5	4	6	0.714	3	2	1	3
Hairy Woodpecker	*Picoides villosus*	5	4	6	0.644	3	2	1	2

Common Name	Scientific Name	Population Size	Population Trend	Range Change	Habitat Specificity	Mobility	Home Range	Aquatic	Old Forest
Pine Grosbeak	*Pinicola enucleator*	3	4	6	0.136	3	2	1	3
Green-tailed Towhee	*Pipilo chlorurus*	5	4	6	0.298	3	2	1	3
Spotted Towhee	*Pipilo erythrophthalmus*	5	4	6	0.538	3	2	1	3
Western Tanager	*Piranga ludoviciana*	5	4	6	0.595	3	2	1	3
Eared Grebe	*Podiceps nigricollis*	4	2	4	0.039	3	2	3	3
Pied-billed Grebe	*Podilymbus podiceps*	3	2	4	0.039	3	2	3	3
Mountain Chickadee	*Poecile gambeli*	5	2	6	0.596	3	2	1	3
Sora	*Porzana carolina*	3	4	4	0.028	3	2	2	3
Bushtit	*Psaltriparus minimus*	5	4	6	0.525	3	2	1	3
Ruby-crowned Kinglet	*Regulus calendula*	5	4	6	0.742	3	2	1	3
Golden-crowned Kinglet	*Regulus satrapa*	5	2	6	0.472	3	2	1	2
Bank Swallow	*Riparia riparia*	4	2	5	0.287	3	2	1	3
Rock Wren	*Salpinctes obsoletus*	5	4	6	0.365	3	2	1	3
Rufous Hummingbird	*Selasphorus rufus*	5	2	6	0.744	3	2	1	3
Mountain Bluebird	*Sialia currucoides*	5	4	6	0.319	3	2	1	3
Western Bluebird	*Sialia mexicana*	5	2	6	0.449	3	2	1	3
Red-breasted Nuthatch	*Sitta canadensis*	5	4	6	0.408	3	2	1	1
White-breasted Nuthatch	*Sitta carolinensis*	5	2	6	0.557	3	2	1	2
Pygmy Nuthatch	*Sitta pygmaea*	5	4	6	0.259	3	2	1	1
Red-breasted Sapsucker	*Sphyrapicus ruber*	5	1	4	0.570	3	2	1	2
Williamson’s Sapsucker	*Sphyrapicus thyroideus*	5	4	6	0.159	3	2	1	2
Chipping Sparrow	*Spizella passerina*	5	1	4	0.575	3	2	1	3
Calliope Hummingbird	*Stellula calliope*	5	4	6	0.452	3	2	1	3
Forster’s Tern	*Sterna forsteri*	3	1	4	0.106	3	2	3	3
Spotted Owl	*Strix occidentalis*	4	2	5	0.307	3	3	1	1
Western Meadowlark	*Sturnella neglecta*	5	4	6	0.337	3	2	1	3
European Starling	*Sturnus vulgaris*	5	4	6	0.696	3	3	1	3
Tree Swallow	*Tachycineta bicolor*	5	4	6	0.559	3	2	1	2
Violet-green Swallow	*Tachycineta thalassina*	5	2	6	0.811	3	2	1	3
House Wren	*Troglodytes aedon*	5	4	6	0.355	3	2	1	3
Winter Wren	*Troglodytes troglodytes*	3	2	6	0.246	3	2	1	1

Common Name	Scientific Name	Population Size	Population Trend	Range Change	Habitat Specificity	Mobility	Home Range	Aquatic	Old Forest
American Robin	*Turdus migratorius*	5	1	6	0.769	3	2	1	2
Orange-crowned Warbler	*Vermivora celata*	5	4	6	0.687	3	2	1	3
Nashville Warbler	*Vermivora ruficapilla*	5	4	6	0.607	3	2	1	3
Cassin's Vireo	*Vireo cassinii*	5	4	6	0.571	3	2	1	3
Warbling Vireo	*Vireo gilvus*	5	5	6	0.580	3	2	1	3
Wilson's Warbler	*Wilsonia pusilla*	5	2	5	0.701	3	2	1	3
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	5	4	6	0.053	3	3	1	3
Mourning Dove	*Zenaida macroura*	5	2	6	0.744	3	3	1	3
White-crowned Sparrow	*Zonotrichia leucophrys*	5	1	2	0.548	3	2	1	3
Mammals									
Pallid bat	*Antrozous pallidus*	4	2	5	0.833	3	3	1	3
Mountain beaver	*Aplodontia rufa*	5	2	4	0.341	1	1	1	2
Coyote	*Canis latrans*	4	4	6	0.923	2	3	1	3
Beaver	*Castor canadensis*	4	3	2	0.456	2	2	2	3
Big brown bat	*Eptesicus fuscus*	5	4	5	0.962	3	3	1	3
Porcupine	*Erethizon dorsatum*	5	4	5	0.724	1	2	1	2
Mountain lion	*Felis concolor*	4	4	6	0.879	2	3	1	3
Bobcat	*Felis rufus*	4	4	6	0.920	2	3	1	3
Northern flying squirrel	*Glaucomys sabrinus*	5	2	5	0.341	1	2	1	1
Wolverine	*Gulo gulo*	1	1	2	0.369	2	3	1	2
Silver-haired bat	*Lasionycteris noctivagans*	4	2	5	0.827	3	2	1	2
Snowshoe hare	*Lepus americanus*	5	2	4	0.122	1	2	1	3
Black-tailed hare	*Lepus californicus*	5	3	5	0.703	1	2	1	3
White-tailed hare	*Lepus townsendii*	5	1	2	0.154	1	2	1	3
River otter	*Lutra canadensis*	3	2	5	0.152	2	3	2	3
Yellow-bellied marmot	*Marmota flaviventris*	5	4	5	0.385	1	2	1	3
Marten	*Martes americana*	4	2	5	0.369	2	3	1	2
Fisher	*Martes pennanti*	3	2	3	0.223	2	3	1	1
Striped skunk	*Mephitis mephitis*	4	4	6	0.793	2	3	1	3
Long-tailed vole	*Microtus longicaudus*	5	4	5	0.515	1	2	1	3

Common Name	Scientific Name	Population Size	Population Trend	Range Change	Habitat Specificity	Mobility	Home Range	Aquatic	Old Forest
Montane vole	*Microtus montanus*	5	4	6	0.428	1	1	1	3
Ermine	*Mustela erminea*	4	2	5	0.460	2	2	1	2
Long-tailed weasel	*Mustela frenata*	4	2	6	0.907	2	2	1	3
Mink	*Mustela vison*	3	2	5	0.191	2	3	2	3
California myotis	*Myotis californicus*	5	4	5	0.909	3	3	1	3
Long-eared myotis	*Myotis evotis*	4	2	5	0.937	3	3	1	3
Little brown myotis	*Myotis lucifugus*	4	2	5	0.941	3	3	1	2
Fringed myotis	*Myotis thysanodes*	3	2	5	0.872	3	3	1	3
Yuma myotis	*Myotis yumanensis*	5	4	6	0.969	3	3	1	2
Bushy-tailed woodrat	*Neotoma cinerea*	5	2	5	0.598	1	1	1	3
Desert woodrat	*Neotoma lepida*	5	2	4	0.477	1	2	1	2
Pika	*Ochotona princeps*	5	4	6	0.298	1	2	1	3
Mule deer	*Odocoileus hemionus*	5	2	6	0.921	2	3	1	3
Muskrat	*Ondatra zibethicus*	5	2	2	0.140	1	2	3	3
Mountain sheep	*Ovis canadensis*	3	1	1	0.060	2	3	1	3
Brush mouse	*Peromyscus boylii*	5	4	6	0.586	1	2	1	3
Canyon mouse	*Peromyscus crinitus*	5	4	5	0.337	1	2	1	3
Deer mouse	*Peromyscus maniculatus*	5	4	5	0.920	1	2	1	3
Pinyon mouse	*Peromyscus truei*	5	4	6	0.550	1	2	1	3
Heather vole	*Phenacomys intermedius*	5	4	5	0.328	1	2	1	3
Western pipistrelle	*Pipistrellus hesperus*	4	4	5	0.772	3	3	1	3
Raccoon	*Procyon lotor*	4	4	6	0.891	2	3	1	3
Broad-footed mole	*Scapanus latimanus*	5	4	4	0.332	1	2	1	3
Western gray squirrel	*Sciurus griseus*	5	2	5	0.513	1	2	1	2
Dusky shrew	*Sorex monticolus*	5	3	4	0.252	1	1	1	2
Water shrew	*Sorex palustris*	5	2	4	0.209	1	1	2	2
Trowbridge's shrew	*Sorex trowbridgii*	5	4	6	0.291	1	2	1	2
Vagrant shrew	*Sorex vagrans*	5	4	4	0.468	1	2	1	2
California ground squirrel	*Spermophilus beecheyi*	5	5	6	0.776	1	2	1	3
Belding's ground squirrel	*Spermophilus beldingi*	5	2	5	0.241	1	2	1	3
Golden-mantled ground squirrel	*Spermophilus lateralis*	5	4	5	0.611	1	2	1	3

Common Name	Scientific Name	Population Size	Population Trend	Range Change	Habitat Specificity	Mobility	Home Range	Aquatic	Old Forest
Western spotted skunk	*Spilogale gracilis*	4	4	6	0.737	2	3	1	3
Nuttall's cottontail	*Sylvilagus nuttallii*	3	2	4	0.088	1	2	1	3
Brazilian free-tailed bat	*Tadarida brasiliensis*	5	2	5	0.879	3	3	1	3
Yellow-pine chipmunk	*Tamias amoenus*	5	4	4	0.595	1	2	1	3
Least chipmunk	*Tamias minimus*	5	4	4	0.108	1	2	1	3
Long-eared chipmunk	*Tamias quadrimaculatus*	5	4	4	0.111	1	2	1	3
Allen's chipmunk	*Tamias senex*	5	4	4	0.714	1	2	1	3
Lodgepole chipmunk	*Tamias speciosus*	5	4	4	0.124	1	2	1	3
Douglas' squirrel	*Tamiasciurus douglasii*	5	4	5	0.266	1	2	1	2
Badger	*Taxidea taxus*	3	2	4	0.474	2	3	1	3
Mountain pocket gopher	*Thomomys monticola*	5	4	6	0.314	1	2	1	3
Black bear	*Ursus americanus*	3	2	4	0.660	2	3	1	2
Grizzly bear	*Ursus arctos*	1	1	1	-	2	3	1	2
Red fox	*Vulpes vulpes*	2	5	6	0.424	2	3	1	2
Western jumping mouse	*Zapus princeps*	5	4	5	0.380	1	2	1	2
Amphibians									
Long-toed salamander	*Ambystoma macrodactylum*	5	4	6	0.435	1	3	2	3
Western toad	*Bufo boreas*	4	1	4	0.770	1	3	2	3
Pacific treefrog	*Hyla regilla*	5	1	6	0.912	1	1	2	3
Bullfrog	*Rana catesbeiana*	5	4	6	0.573	1	1	2	3
Mountain yellow-legged frog	*Rana muscosa*	5	1	1	0.410	1	1	2	3
Northern leopard frog	*Rana pipiens*	2	3	1	0.296	1	1	2	3
Reptiles									
Rubber boa	*Charina bottae*	5	2	5	0.433	2	1	1	2
Northern alligator lizard	*Elgaria coerulea*	5	4	6	0.531	1	1	1	3
Southern alligator lizard	*Elgaria multicarinata*	5	4	6	0.509	1	1	1	3
Sagebrush lizard	*Sceloporus graciosus*	5	4	6	0.284	1	1	1	3
Western fence lizard	*Sceloporus occidentalis*	5	4	6	0.724	1	1	1	3
Western aquatic garter snake	*Thamnophis couchii*	5	2	5	0.603	2	1	2	2
Western terrestrial garter snake	*Thamnophis elegans*	5	1	4	0.728	2	1	1	3

Common Name	Scientific Name	Population Size	Population Trend	Range Change	Habitat Specificity	Mobility	Home Range	Aquatic	Old Forest
Common garter snake	*Thamnophis sirtalis*	5	2	6	0.646	2	1	1	3

APPENDIX N

FOCAL VERTEBRATES OF THE LAKE TAHOE BASIN

APPENDIX N

FOCAL VERTEBRATES OF THE LAKE TAHOE BASIN

Patricia N. Manley and Matthew D. Schlesinger

Table N-1—Focal vertebrates of the Lake Tahoe Basin. Criteria responsible for focal designation are indicated. See below for field definitions.

		Ecological Criteria					Cultural Criteria			
Common Name	**Scientific Name**	**Extirp**	**T, E, SC**	**Pop**	**Life History**	**Exotic/ Endem**	**Harvest**	**Watchable**	**Human Conflict**	**Agency Emphasis**
Birds										
Cooper's Hawk	*Accipiter cooperii*		X							
Northern Goshawk	*Accipiter gentilis*		X		O					X
Sharp-shinned Hawk	*Accipiter striatus*		X							
Red-winged Blackbird	*Agelaius phoeniceus*				X					
Wood Duck	*Aix sponsa*			X	X					
Northern Pintail	*Anas acuta*				X					
Northern Shoveler	*Anas clypeata*			X						
Mallard	*Anas platyrhynchos*				X			X		
American Pipit	*Anthus rubescens*				X					
Western Scrub Jay	*Aphelocoma coerulescens*			X						
Golden Eagle	*Aquila chrysaetos*		X							X
Great Blue Heron	*Ardea herodias*				X					
Greater Scaup	*Aythya marila*			X						
Canvasback	*Aythya valisineria*				X					
Canada Goose	*Branta canadensis*				X			X	X	
Common Goldeneye	*Bucephala clangula*				X					
Barrow's Goldeneye	*Bucephala islandica*		X	X						
California Quail	*Callipepla californica*					X				
Lesser Goldfinch	*Carduelis psaltria*			X						
Cassin's Finch	*Carpodacus cassinii*				O					
House Finch	*Carpodacus mexicanus*			X						
Purple Finch	*Carpodacus purpureus*				O					

Common Name	Scientific Name	Ecological Criteria					Cultural Criteria			
		Extirp	**T, E, SC**	**Pop**	**Life History**	**Exotic/ Endem**	**Harvest**	**Watchable**	**Human Conflict**	**Agency Emphasis**
Swainson's Thrush	*Catharus ustulatus*			X						
Canyon Wren	*Catherpes mexicanus*	X			X					
Brown Creeper	*Certhia americana*				O					
Belted Kingfisher	*Ceryle alcyon*			X	X					
Northern Harrier	*Circus cyaneus*		X							
Marsh Wren	*Cistothorus palustris*				X					
Evening Grosbeak	*Coccothraustes vespertinus*				O					
Band-tailed Pigeon	*Columba fasciata*			X						
Rock Dove	*Columba livia*				X	X			X	
Olive-sided Flycatcher	*Contopus cooperi*			X						
Western Wood-pewee	*Contopus sordidulus*			X						
American Crow	*Corvus brachyrhynchos*				X					
Steller's Jay	*Cyanocitta stelleri*			X						
Tundra Swan	*Cygnus columbianus*				X					
Blue Grouse	*Dendragapus obscurus*						X			
Hermit Warbler	*Dendroica occidentalis*				O					
Yellow Warbler	*Dendroica petechia*		X							
Pileated Woodpecker	*Dryocopus pileatus*				X,O					
Hammond's Flycatcher	*Empidonax hammondii*				X					
Willow Flycatcher	*Empidonax traillii*		X	X	X					X
Horned Lark	*Eremophila alpestris*				X					
Peregrine Falcon	*Falco peregrinus*	X	X	X				X		X
Common Snipe	*Gallinago gallinago*			X						
Common Loon	*Gavia immer*		X							
Bald Eagle	*Haliaeetus leucocephalus*		X					X		X
California Gull	*Larus californicus*		X		X				X	
Ring-billed Gull	*Larus delawarensis*				X				X	
Gray-crowned Rosy Finch	*Leucosticte arctoa*				X					
Hooded Merganser	*Lophodytes cucullatus*				X					
Red Crossbill	*Loxia curvirostra*				X,O					
Lewis's Woodpecker	*Melanerpes lewis*	X		X						
Wild Turkey	*Meleagris gallopavo*					X				
Lincoln's Sparrow	*Melospiza lincolnii*				X					
Common Merganser	*Mergus merganser*				X					
Brown-headed Cowbird	*Molothrus ater*			X		P				
Black-crowned Night-heron	*Nycticorax nycticorax*				X					

		Ecological Criteria					Cultural Criteria			
Common Name	**Scientific Name**	**Extirp**	**T, E, SC**	**Pop**	**Life History**	**Exotic/ Endem**	**Harvest**	**Watchable**	**Human Conflict**	**Agency Emphasis**
MacGillivray's Warbler	*Oporornis tolmiei*				X					
Mountain Quail	*Oreortyx pictus*						X			
Osprey	*Pandion haliaetus*		X		X			X		X
House Sparrow	*Passer domesticus*				X	X				
Savannah Sparrow	*Passerculus sandwichensis*	X			X					
American White Pelican	*Pelecanus erythrorhynchos*		X	X	X					
Black-billed Magpie	*Pica pica*				X					
White-headed Woodpecker	*Picoides albolarvatus*				O					
Black-backed Woodpecker	*Picoides arcticus*				X					
Pine Grosbeak	*Pinicola enucleator*				X					
Green-tailed Towhee	*Pipilo chlorurus*				X					
Pied-billed Grebe	*Podilymbus podiceps*			X						
Bank Swallow	*Riparia riparia*		X		X					
Red-breasted Nuthatch	*Sitta canadensis*				O					
Pygmy Nuthatch	*Sitta pygmaea*				X,O					
Red-breasted Sapsucker	*Sphyrapicus ruber*			X						
Williamson's Sapsucker	*Sphyrapicus thyroideus*				X					
Chipping Sparrow	*Spizella passerina*			X						
Forster's Tern	*Sterna forsteri*			X						
Spotted Owl	*Strix occidentalis*		X		O					X
European Starling	*Sturnus vulgaris*					X				
Winter Wren	*Troglodytes troglodytes*				X,O					
American Robin	*Turdus migratorius*			X						
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*				X					
White-crowned Sparrow	*Zonotrichia leucophrys*			X						
Mammals										
Pallid bat	*Antrozous pallidus*		X							X
Mountain beaver	*Aplodontia rufa*		X							
Cow	*Bos* sp.					D				
Domestic dog	*Canis familiaris*					D				
Coyote	*Canis latrans*							X	X	
Beaver	*Castor canadensis*			X		X			X	
Horse	*Equus sp.*					D				
Mule	*Equus sp.*					D				
Domestic cat	*Felis domesticus*					D				
Northern flying squirrel	*Glaucomys sabrinus*				X,O					

Common Name	Scientific Name	Ecological Criteria					Cultural Criteria			
		Extirp	T, E, SC	Pop	Life History	Exotic/ Endem	Harvest	Watchable	Human Conflict	Agency Emphasis
Wolverine	*Gulo gulo*	X	X	X	X					X
Llama	*Lama glama*					D				
Sierra Nevada snowshoe hare	*Lepus americanus tahoensis*		X		X					
White-tailed hare	*Lepus townsendii*	X	X	X	X					
River otter	*Lutra canadensis*			X	X					
Yellow-bellied marmot	*Marmota flaviventris*				X					
Marten	*Martes americana*				X,O					X
Fisher	*Martes pennanti*		X	X	X,O					X
Long-tailed vole	*Microtus longicaudus*				X					
Mink	*Mustela vison*			X	X					
Long-eared myotis	*Myotis evotis*		X							
Fringed myotis	*Myotis thysanodes*		X	X						
Yuma myotis	*Myotis yumanensis*		X							
Desert woodrat	*Neotoma lepida*				X					
Pika	*Ochotona princeps*				X					
Mule deer	*Odocoileus hemionus*						X	X		X
Muskrat	*Ondatra zibethicus*			X	X					
Mountain sheep	*Ovis canadensis californiana*	X	X	X	X			X		X
Brush mouse	*Peromyscus boylii*				X					
Canyon mouse	*Peromyscus crinitus*	X			X					
Pinyon mouse	*Peromyscus truei*				X					
Heather vole	*Phenacomys intermedius*	X			X					
Raccoon	*Procyon lotor*								X	
Broad-footed mole	*Scapanus latimanus*				X					
Western gray squirrel	*Sciurus griseus*				X				X	
Dusky shrew	*Sorex monticolus*				X					
Water shrew	*Sorex palustris*				X					
Trowbridge's shrew	*Sorex trowbridgii*				X					
Vagrant shrew	*Sorex vagrans*				X					
California ground squirrel	*Spermophilus beecheyi*								X	
Belding's ground squirrel	*Spermophilus beldingi*				X					
Nuttall's cottontail	*Sylvilagus nuttallii*			X	X					
Yellow-pine chipmunk	*Tamias flaviventris*				X					
Least chipmunk	*Tamias minimus*				X					
Long-eared chipmunk	*Tamias quadrimaculatus*				X	E				
Lodgepole chipmunk	*Tamias speciosus*		X		X					

Common Name	Scientific Name	Ecological Criteria					Cultural Criteria			
		Extirp	T, E, SC	Pop	Life History	Exotic/ Endem	Harvest	Watchable	Human Conflict	Agency Emphasis
Douglas squirrel	*Tamiasciurus douglasii*				X				X	
Badger	*Taxidea taxus*			X	X					
Mountain pocket gopher	*Thomomys monticola*				X					
Black bear	*Ursus americanus*			X			X	X	X	
Grizzly bear	*Ursus arctos*	X	X	X						
Sierra Nevada red fox	*Vulpes vulpes necator*	X	X	X	X					X
Western jumping mouse	*Zapus princeps*				X					
Amphibians										
Long-toed salamander	*Ambystoma macrodactylum*				X					
Western toad	*Bufo boreas*			X	X					
Pacific treefrog	*Hyla regilla*			X	X					
Bullfrog	*Rana catesbeiana*				X	X				
Mountain yellow-legged frog	*Rana muscosa*		X	X	X					X
Northern leopard frog	*Rana pipiens*	X	X	X	X	X?				X
Reptiles										
Sagebrush lizard	*Sceloporus graciosus*				X					
W. aquatic garter snake	*Thamnophis couchii*				X					
W. terrestrial garter snake	*Thamnophis elegans*			X						
Fish										
Goldfish	*Carassius auratus*					X				
Carp	*Cyprinus carpio*					X				
Mosquito fish	*Gambusia affinis*					X				
Lahontan Lake tui chub	*Gila bicolor pectinifer*		X							X
Brown bullhead	*Ictalurus nebulosis*					X				
Bluegill	*Lepomis macrochirus*					X				
Smallmouth bass	*Micropterus dolomieui*					X	X			
Largemouth bass	*Micropterus salmoides*					X	X			
Golden shiner	*Notemigonus crysoleucas*					X				
Golden trout	*Oncorhynchus aquabonita*					X	X			
Lahontan cutthroat trout	*Oncorhynchus clarkii henshawi*	X	X	X						
Rainbow trout	*Oncorhynchus mykiss*					X	X			
Kokanee salmon	*Oncorhynchus nerka kennerlyi*					X	X	X		
White crappie	*Pomoxis annularis*					X				
Black crappie	*Pomoxis nigromaculatus*					X				
Mountain whitefish	*Prosopium williamsoni*			X						

Common Name	Scientific Name	Ecological Criteria					Cultural Criteria			
		Extirp	T, E, SC	Pop	Life History	Exotic/ Endem	Harvest	Watchable	Human Conflict	Agency Emphasis
German brown trout	*Salmo trutta*					X	X			
Brook trout	*Salvelinus fontinalis*					X	X			
Mackinaw (lake) trout	*Salvelinus namaycush*					X	X			

Notes:
Extirp: Extirpated or potentially extirpated
T, E, SC: Federal or State Threatened, Endangered, or Special Concern
Pop: vulnerable due to small population size, declining population, and/or contracted range
Life-history: X = potentially vulnerable due to high habitat specificity, low mobility, and/or large home range; O = potentially vulnerable due to dependence on old forests
Exotic/Endem = introduced to the Lake Tahoe basin (X), Domesticated (D), Native ecological pest (P), or endemic to Sierra Nevada (E)
Harvest = potentially hunted, trapped, fished, or otherwise harvested within the basin
Watchable = potentially viewed for pleasure by public
Human conflict = "pest" or "nuisance" species
Agency emphasis = USDA Forest Service sensitive or TRPA special interest

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 35º. 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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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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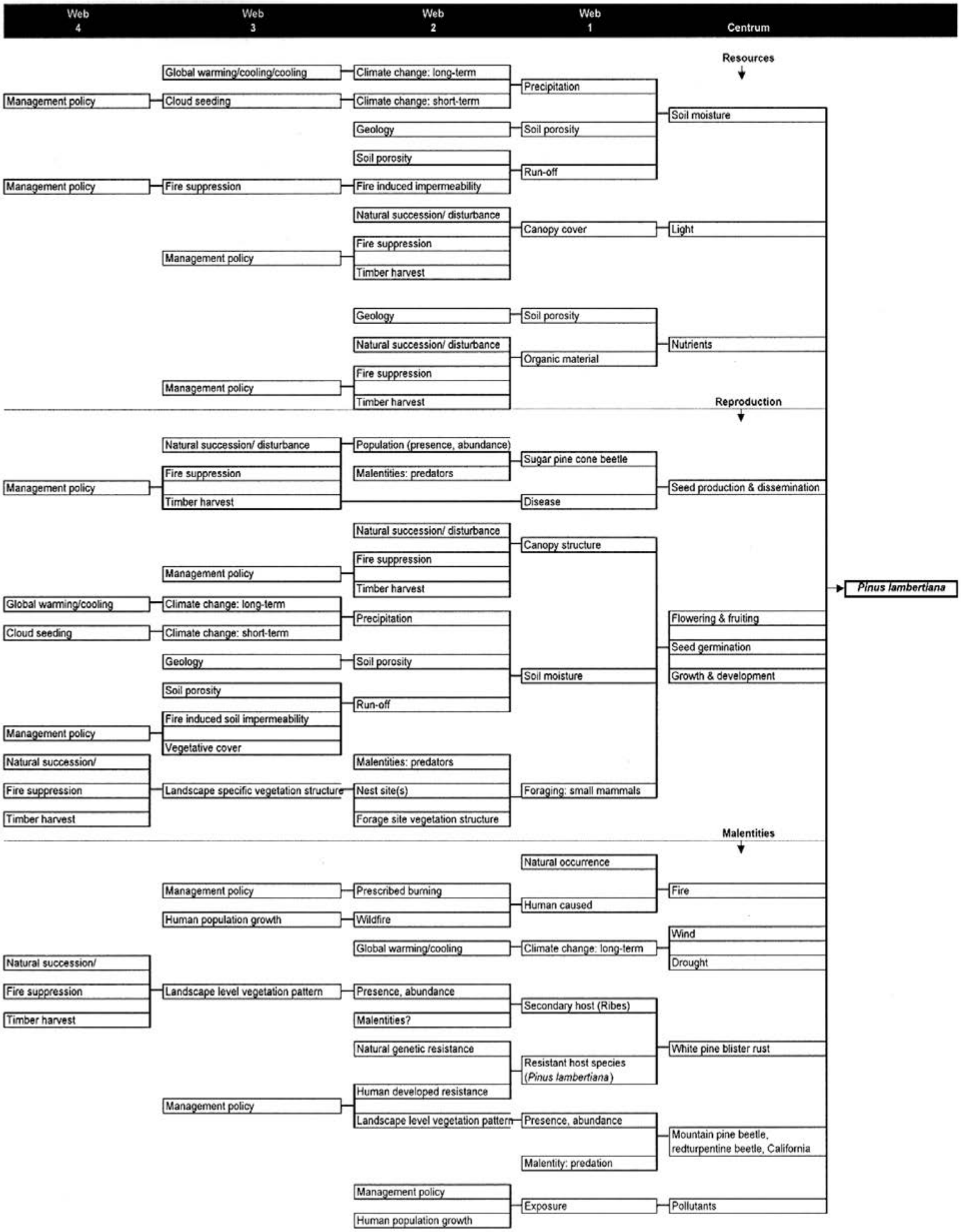

Figure O-1—Envirogram for the sugar pine (*Pinus lambertiana*).

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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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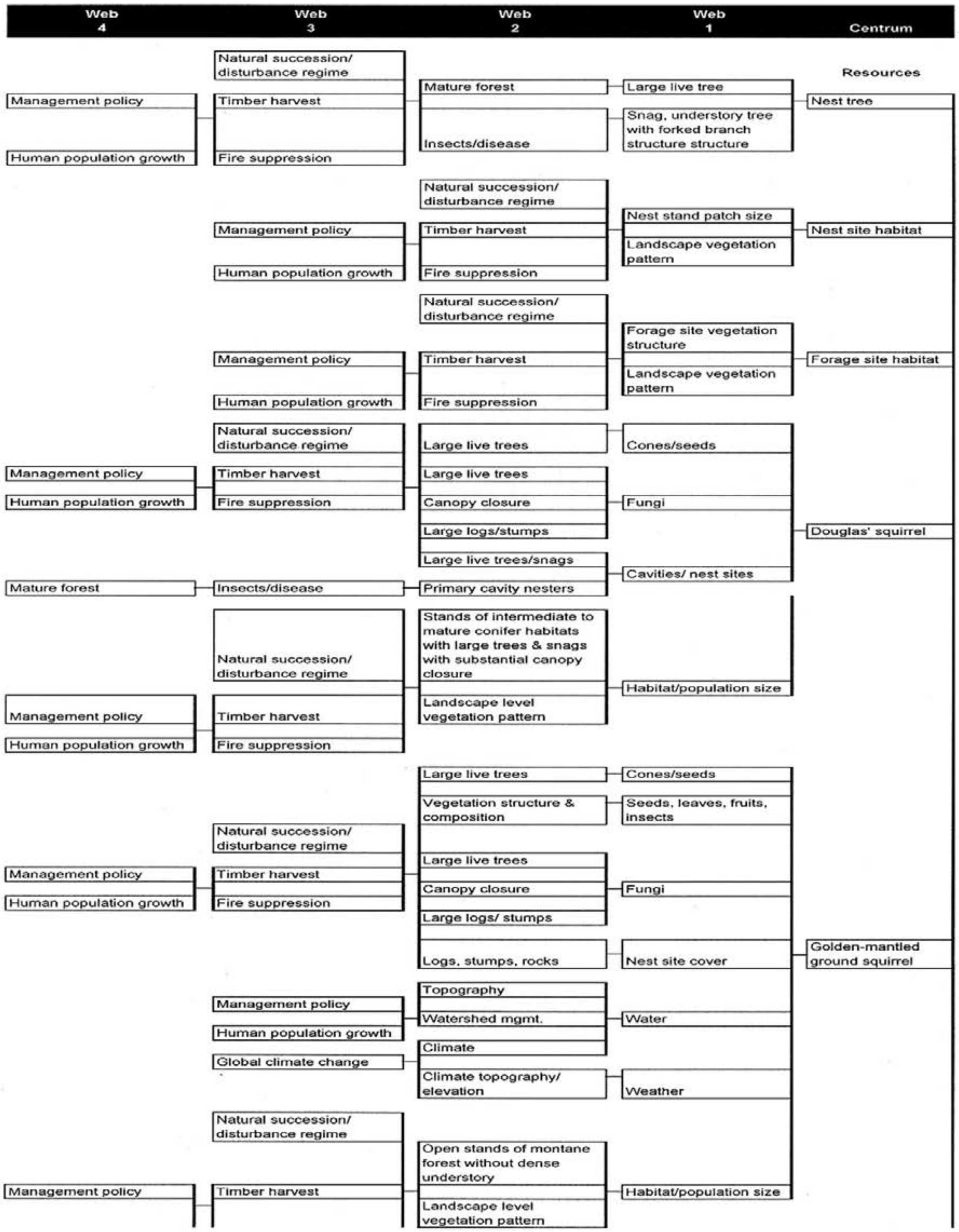


Figure O-2—Envirogram for the Northern Goshawk (*Accipiter gentilis*) (page 1 of 4).

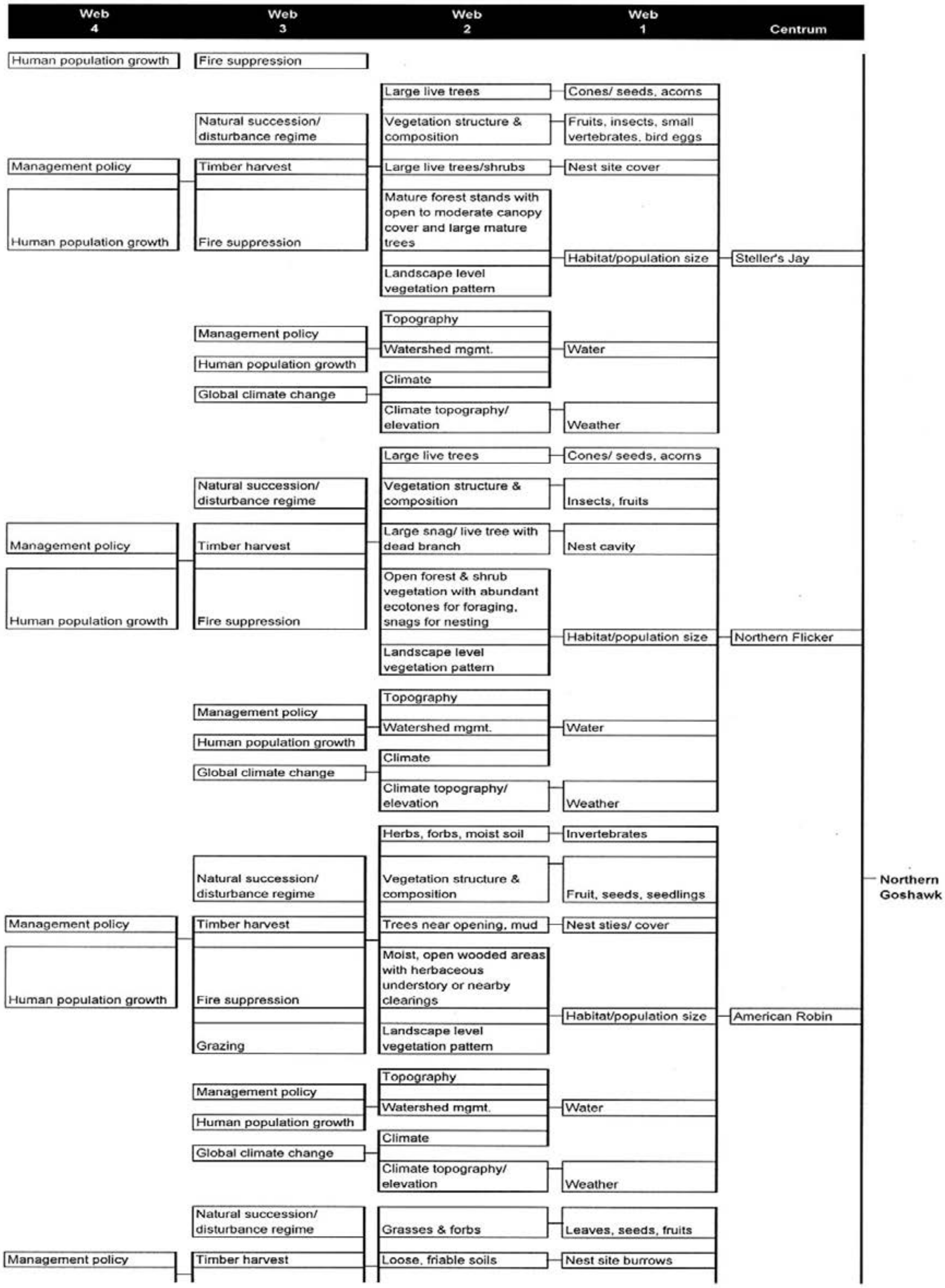


Figure O-2—Envirogram for the Northern Goshawk (*Accipiter gentilis*) (page 2 of 4).

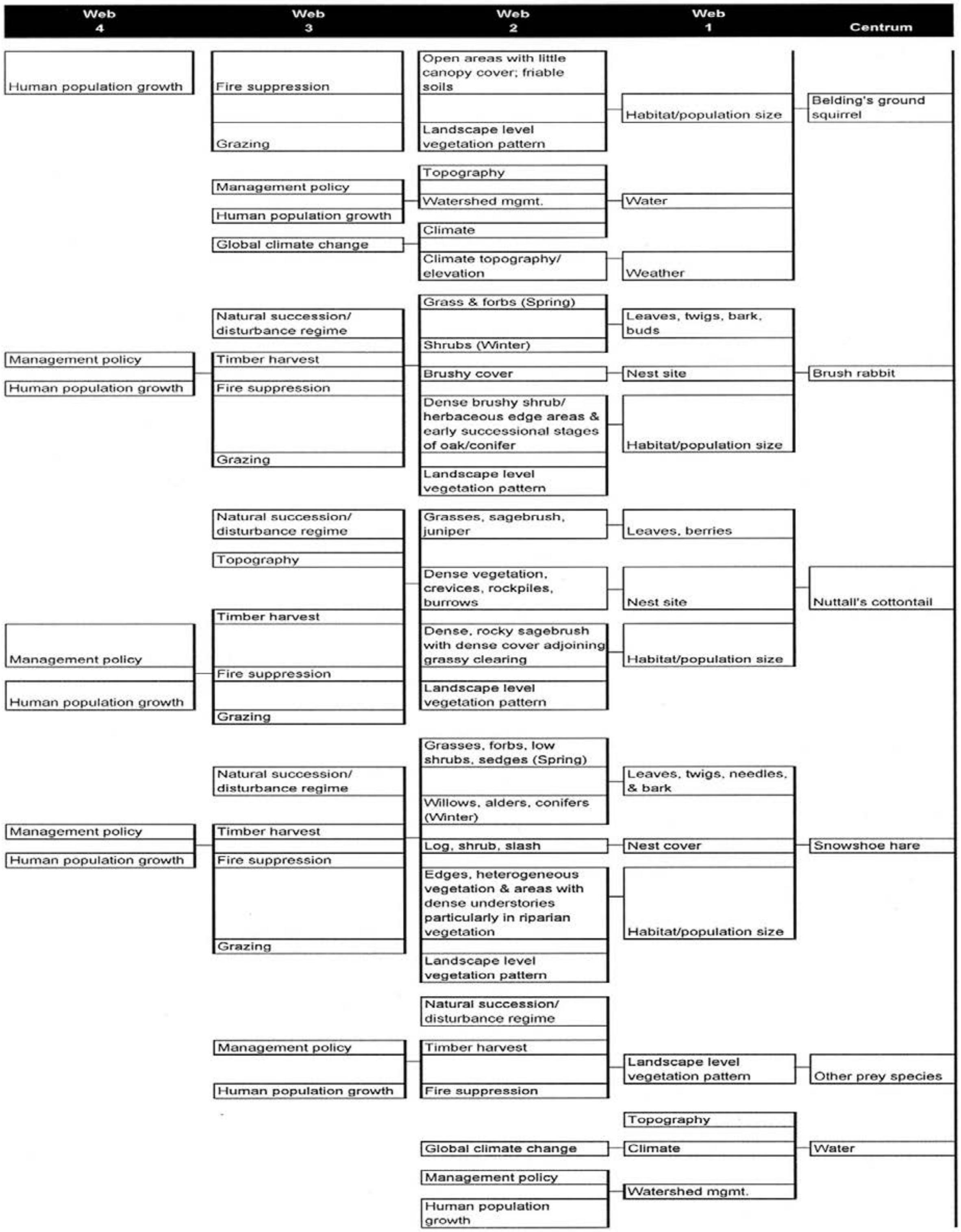
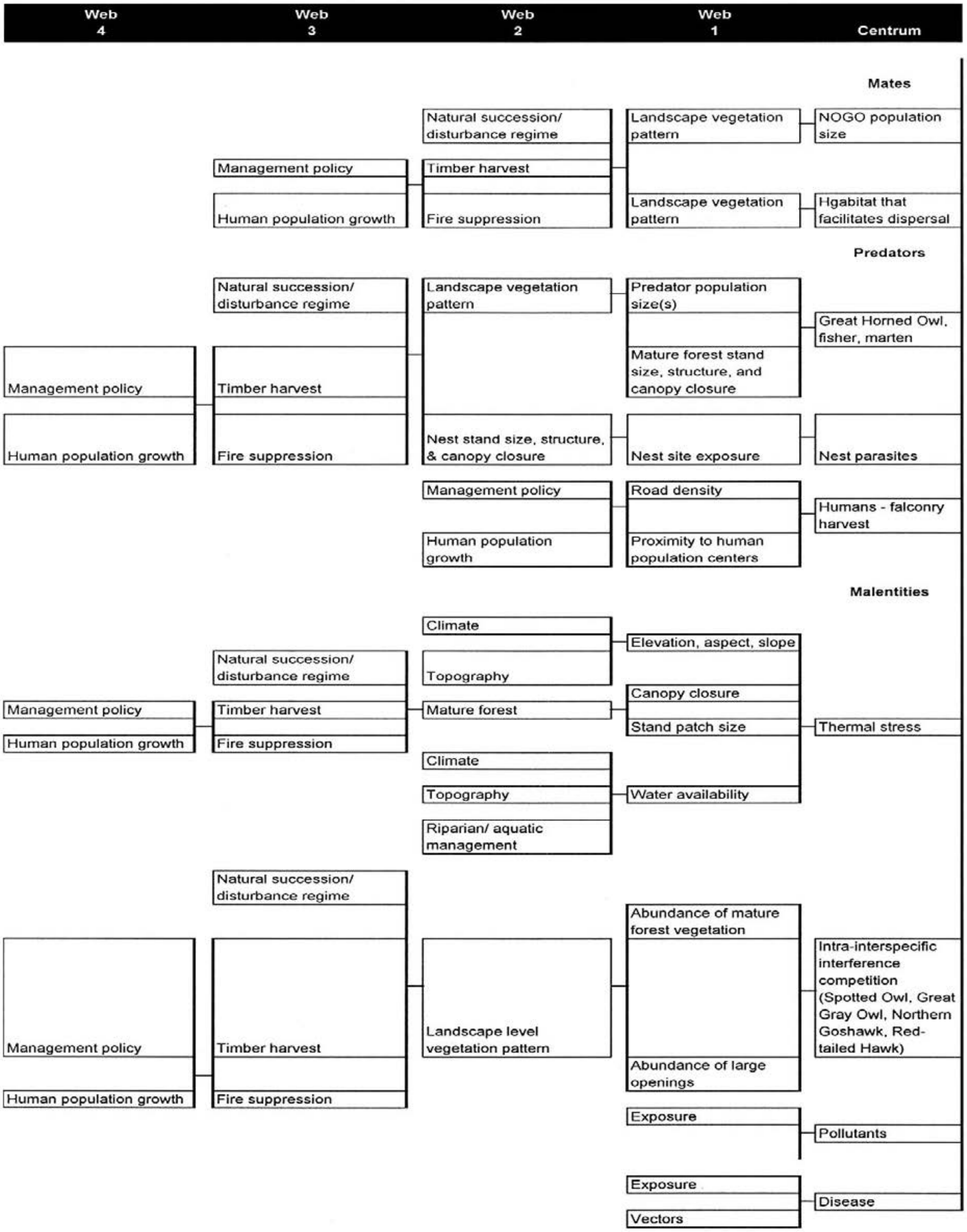


Figure O-2—Envirogram for the Northern Goshawk (*Accipiter gentilis*) (page 3 of 4).



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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 $\geq$ 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^{o} 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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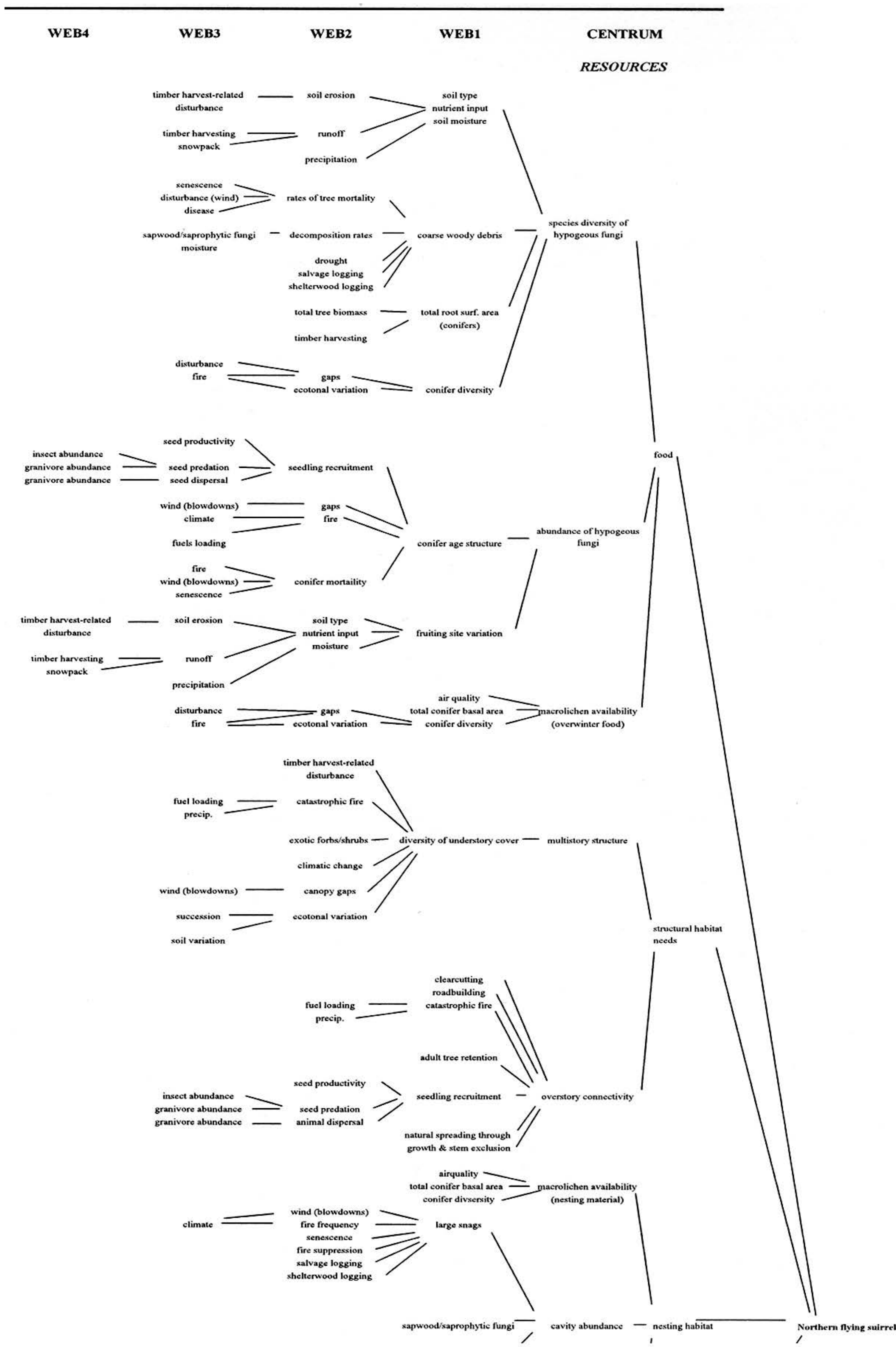

Figure O-3—Envirogram for the northern flying squirrel (*Glaucomys sabrinus*) (page 1 of 2).

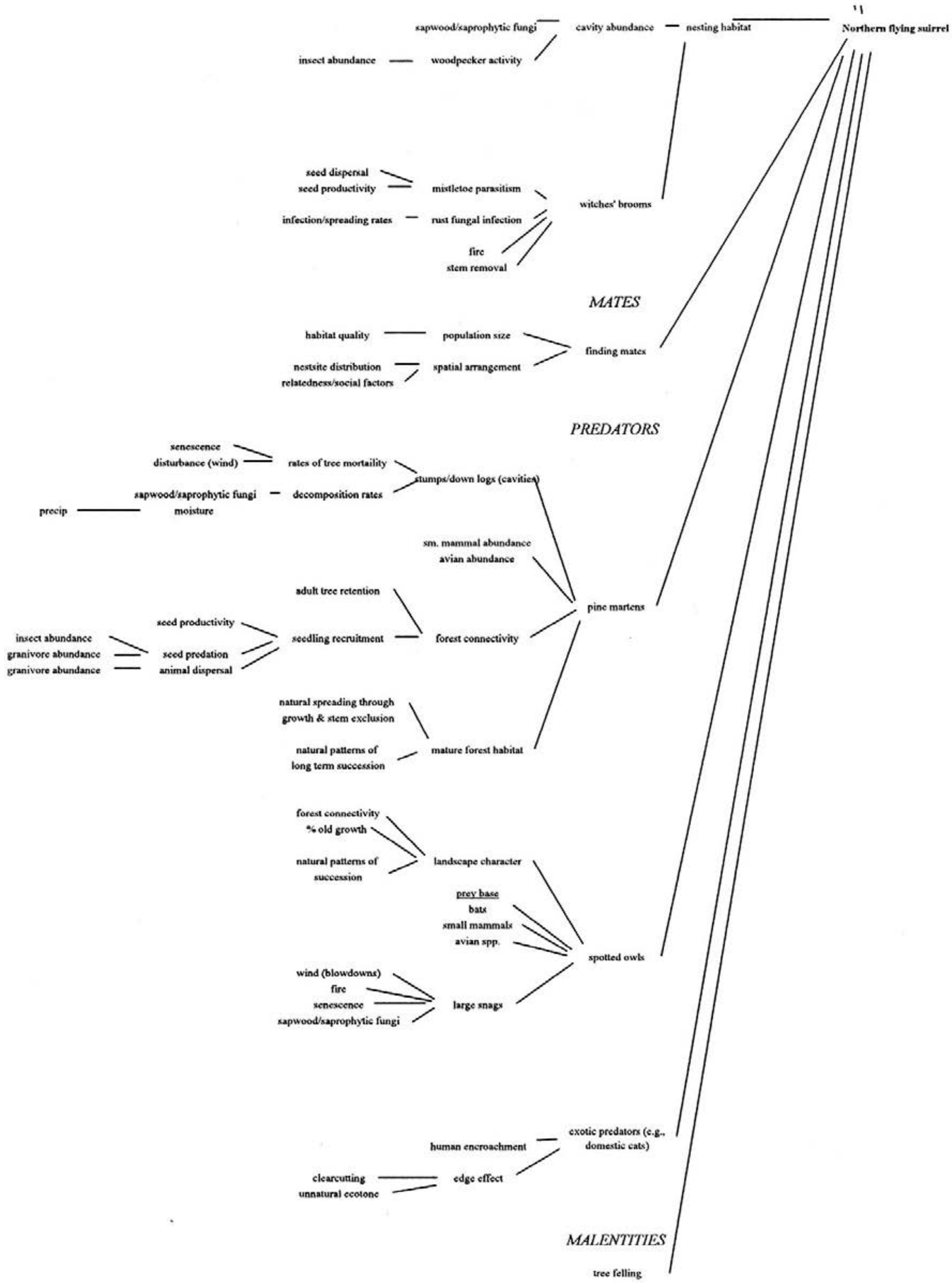

Figure O-3—Envirogram for the northern flying squirrel (*Glaucomys sabrinus*) (page 2 of 2).

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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.

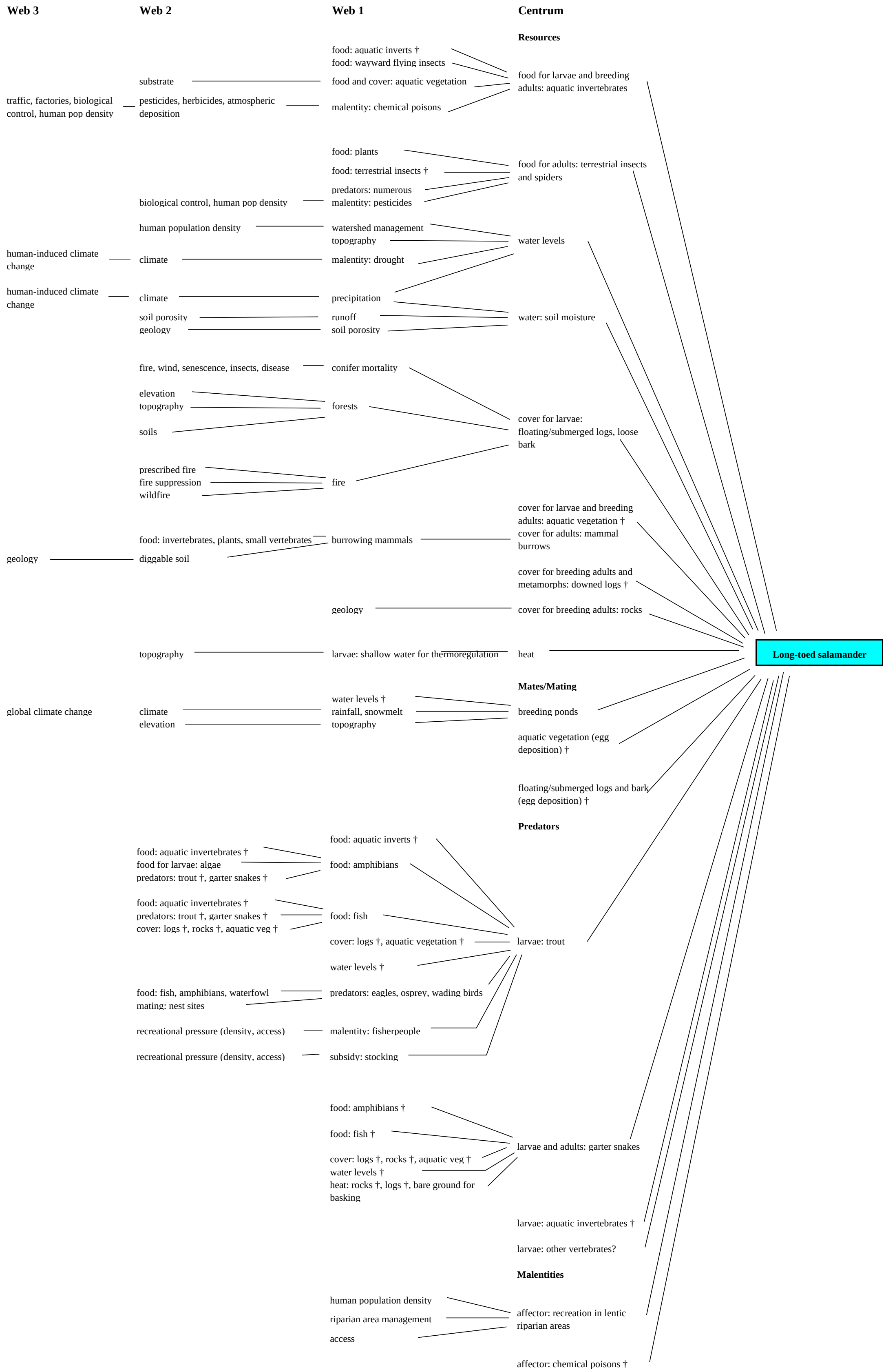

Figure O-4—Envirogram for the long-toed salamander (*Ambystoma macrodactylum*). A † indicates that that branch of the web was expanded above in the envirogram.

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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).

[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 ^{o} C (60 ^{o}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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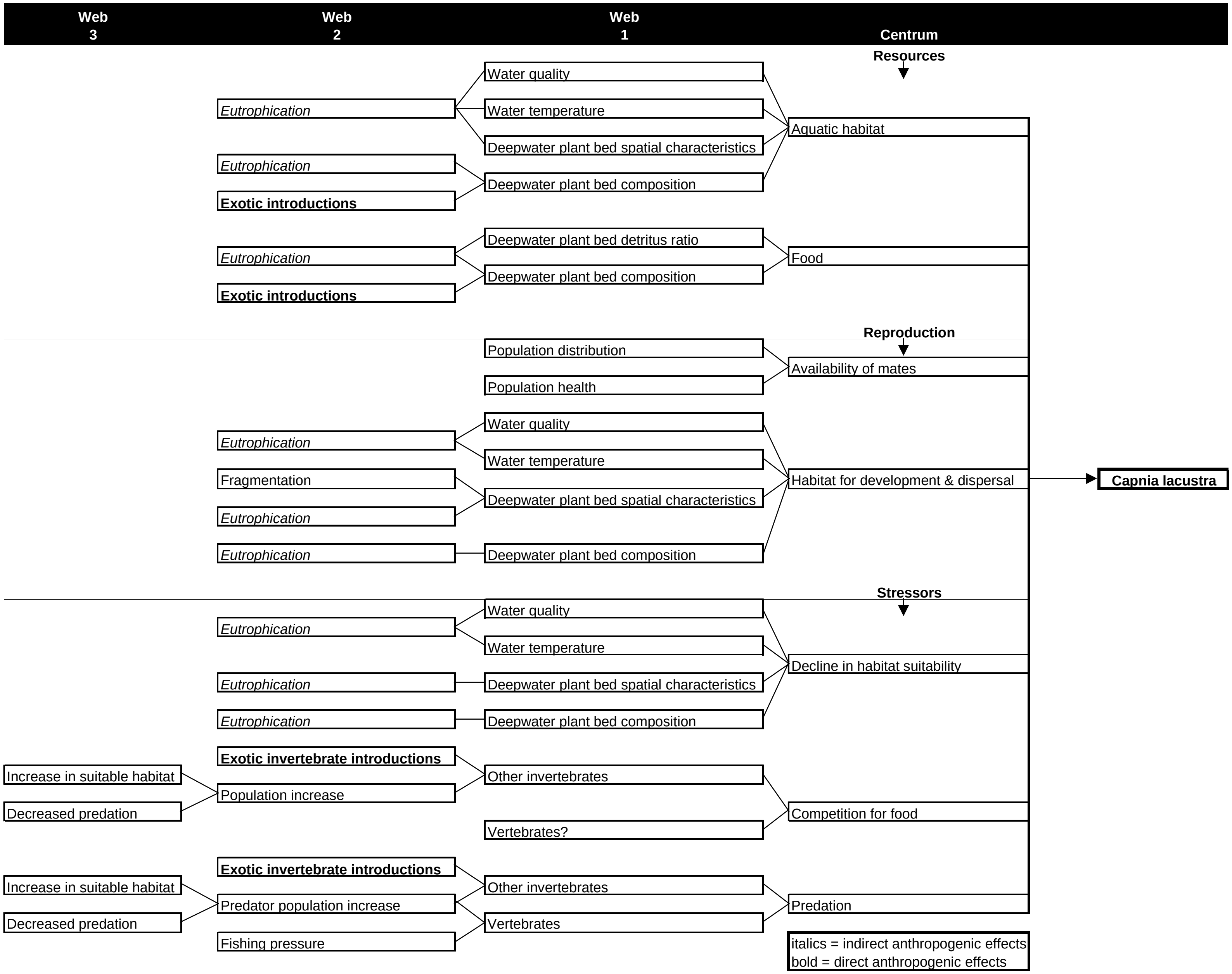

Figure O-5—Envirogram for the Lake Tahoe benthic stonefly (*Capnia lacustra*).

APPENDIX P

BIOLOGISTS QUERIED IN DETERMINING SELECT FOCAL SPECIES

APPENDIX P

BIOLOGISTS QUERIED IN DETERMINING SELECT FOCAL SPECIES

Matthew D. Schlesinger

Table P-1—Local biologists queried in determining select focal vertebrate and vascular plant species—those species of highest interest to local management agencies and interest groups.

Agency/Organization	Respondent(s)	Vertebrates	Vascular Plants
California Department of Fish and Game	Daniel Hintz	X	X
California State Lands Commission	Maurya Falkner		X
California State Parks and Recreation	Gary Walter	X	X
California Tahoe Conservancy	Rick Robinson/Victor Insera/Peter Maholland	X	X
League to Save Lake Tahoe	Dave Roberts	X	X
Nevada Division of Wildlife	Larry Neel	X	
Tahoe Regional Planning Agency	Shane Romsos	X	
Tahoe Regional Planning Agency	Colleen Shade		X
US Fish and Wildlife Service	Stephanie Byers	X	X
US Forest Service, El Dorado National Forest	Dirk Rodriguez		X
US Forest Service, Lake Tahoe Basin Management Unit	Kevin Laves	X	X

APPENDIX Q

RECOMMENDED CONSERVATION FOR FOCAL SPECIES

APPENDIX Q

RECOMMENDED CONSERVATION FOR FOCAL SPECIES

Patricia N. Manley and Matthew D. Schlesinger

Table Q-1—Recommended conservation for focal species. Species are sorted by taxonomic group and are accompanied by the criteria for their identification as focal species.[a] Potential threats and conservation options are identified.

Common Name	Scientific Name	Criteria[a]	Potential Threats or Impacts	Conservation Ideas
Vascular Plants				
White fir	*Abies concolor*	HV	Genetic pollution from restocking; altered fire regime	Use seedlings grown from local seeds
California red fir	*Abies magnifica* var. *magnifica*	HV	Genetic pollution from restocking	Use seedlings grown from local seeds
Mountain bentgrass*	*Agrostis humilis**	RA	Uncertain	Map and protect all discovered occurrences
Galena Creek rockcress*	*Arabis rigidissima* var. *demota*	SC,RA,EN, AE	Uncertain	Map and protect known and newly discovered occurrences; Truckee River basin endemic
Twin arnica	*Arnica soroia*	RA	Uncertain	Map and protect all discovered occurrences
Green spleenwort	*Asplenium trichomanes-ramosum*	RA	Uncertain	Map and protect known and newly discovered occurrences
Anderson's aster	*Aster alpigenus* var. *andersonii*	AE	Uncertain	Map and protect known and newly discovered occurrences
Austin's milkvetch*	*Astragalus austiniae*	EN	Uncertain	Map and protect known and newly discovered occurrences
Balloon pod milkvetch	*Astragalus whitneyi* var. *lenophyllus*	EN	Uncertain	Map and protect known and newly discovered occurrences
Trianglelobe moonwort	*Botrychium ascendens*	RA,AE	Uncertain	Map and protect all discovered occurrences

Common Name	Scientific Name	Criteria[a]	Potential Threats or Impacts	Conservation Ideas
Cheatgrass	*Bromus tectorum*	EX	Impacts: competes with native grasses and forbs	Avoid burning in shrubby areas in areas with < 20 cm of precipitation per year
Incense cedar	*Calocedrus decurrens*	HV	Genetic pollution from restocking	Use seedlings grown from local seeds
Plumeless thistle	*Carduus acanthoides*	EX	Uncertain	Eradicate when encountered
Musk thistle	*Carduus nutans*	EX	Competes with native forbs	Awareness and education
Davy's sedge	*Carex davyi*	EN	Uncertain	Map and protect all discovered occurrences
Mud sedge	*Carex limosa*	RA	Bog disturbance	Map and protect all discovered occurrences; protection of sphagnum bogs should protect this species
Mariposa sedge*	*Carex mariposana*	AE	Uncertain	Map and protect known and newly discovered occurrences
Diffuse knapweed	*Centaurea diffusa*	EX	Impacts: competes with native grasses and forbs	Eradicate immediately when encountered
Spotted knapweed	*Centaurea maculosa*	EX	Impacts: competes with native grasses and forbs	Eradicate immediately when encountered; poisonsous
Bullthistle*	*Cirsium vulgare*	EX	Impacts: competes with native forbs	Eradicate when encountered
Sierra clarkia	*Clarkia virgata*	EN	Uncertain	Map and protect all discovered occurrences
Scotch broom	*Cytisus scoparius*	EX	Impacts: competes with native plants	Eradicate when encountered
Lake Tahoe draba*	*Draba asterophora* var. *asterophora*	RA,EN,AE	Recreation	Map and protect known and newly discovered occurrences
Cup Lake draba*	*Draba asterophora* var. *macrocarpa*	SC,RA,EN, AE	Uncertain	Map and protect known and newly discovered occurrences
Subalpine fireweed*	*Epilobium howellii*	RA,EN,AE	Uncertain	Map and protect all discovered occurrences
Oregon fireweed	*Epilobium oreganum*	SC,AE	Uncertain	Map and protect all discovered occurrences
Marsh horsetail	*Equisetum palustre*	RA	Uncertain	Map and protect known and newly discovered occurrences
Starved fleabane	*Erigeron miser*	RA,EN,AE	Rock climbers	Map and protect all discovered occurrences; increase awareness with rock climbers
Sierra fleabane	*Erigeron petrophilus* var. *sierrensis*	EN	Uncertain	Map and protect all discovered occurrences

Common Name	Scientific Name	Criteria[a]	Potential Threats or Impacts	Conservation Ideas
Brown-margined buckwheat	*Eriogonum ovalifolium* var. *eximium*	HV	Uncertain	Map and protect known and newly discovered occurrences
Buckwheat	*Eriogonum ovalifolium* var. *vineum*	RA	Uncertain	Map and protect known and newly discovered occurrences
Torrey buckwheat*	*Eriogonum umbellatum* var. *torreyanum*	SC,RA,EN, HV,AE	Uncertain	Map and protect known and newly discovered occurrences
Klamathweed	*Hypericum perforatum*	EX	Impacts: competes with native plants	Eradicate when encountered, avoid use of commercial gravel
Plumas mousetail	*Ivesia sericoleuca*	SC,EN,AE	Grazing	Map and protect all discovered occurrences
Webber's ivesia	*Ivesia webberi*	SC,RA,AE	Uncertain	Map and protect known and newly discovered occurrences
Tall whitetop*	*Lepidium latifolium*	EX	Impacts: competes with native plants	Eradicate immediately when encountered
Long-petaled lewisia*	*Lewisia longipetala*	SC,RA,EN, HV,AE	Uncertain	Map and protect known and newly discovered occurrences
Dalmation toadflax	*Linaria genistifolia* ssp. *dalmatica*	EX	Impacts: competes with native plants	Eradicate when encountered
Eurasian watermilfoil*	*Myriophyllum spicatum*	EX,HC	Impacts: chokes out native aquatic vegetation, snags boat propellers	Follow conservation strategies being developed for the control of this species
Scotch thistle	*Onopordum acanthium* ssp. *acanthium*	EX	Impacts: competes with native plants	Eradicate when encountered
Close-throated beardtongue	*Penstemon personatus*	RA,EN,AE	Uncertain	Map and protect all discovered occurrences
Bacigalupi's perideridia	*Perideridia bacigalupii*	EN	Uncertain	Awareness and education
Whitebark pine	*Pinus albicaulis*	PO	Disease; climate change	Awareness and education
Lodgepole pine	*Pinus contorta* ssp. *murrayana*	HV	Genetic pollution from restocking; altered fire regime	Use seedlings grown from local seeds
Jeffrey pine	*Pinus jeffreyi*	HV	Genetic pollution from restocking; altered fire regime	Use seedlings grown from local seeds
Sugar pine	*Pinus lambertiana*	HV	Genetic pollution from restocking; altered fire regime; blister rust	Use seedlings grown from local seeds
Western white pine	*Pinus monticola*	HV	Genetic pollution from restocking; altered fire regime; blister rust	Use seedlings grown from local seeds

Common Name	Scientific Name	Criteria[a]	Potential Threats or Impacts	Conservation Ideas
Ponderosa pine	*Pinus ponderosa*	HV	Genetic pollution from restocking	Use seedlings grown from local seeds
Ribbonleaf pondweed	*Potamogeton epihydrus nuttallii*	RA	Uncertain	Awareness and education
Tahoe yellow cress*	*Rorippa subumbellata*	SE,SC,RA, EN,AE	Human use and development along the south shore	California State Lands Commission may have a conservation strategy for this species; Truckee River basin endemic
American scheuchzeria	*Scheuchzeria palustris americana*	RA,AE	Uncertain	Map and protect all discovered occurrences
Water bulrush*	*Scirpus subterminalis*	RA	Uncertain	Map and protect known and newly discovered occurrences
Marsh skullcap	*Scutellaria galericulata*	RA,HV	Uncertain	Map and protect known and newly discovered occurrences
Smooth goldenrod	*Solidago gigantea*	RA,HV	Uncertain	Map and protect all discovered occurrences
Lake Tahoe serpentweed	*Tonestus eximius*	EN	Uncertain	Map and protect known and newly discovered occurrences
Grey-leaved violet	*Viola pinetorum grisea*	RA,AE	Uncertain	Map and protect known and newly discovered occurrences
Wooly violet	*Viola tomentosa*	RA,EN	Uncertain	Map and protect all discovered occurrences
Nonvascular Plants				
Moss	*Andreaea nivalis*	RA	Unknown	Awareness and education
Moss	*Bruchia bolanderi*	RA	Unknown	Awareness and education
Moss	*Campylium stellatum*	RA	Unknown	Awareness and education
Moss	*Distichium inclinatum*	RA	Unknown	Awareness and education
Moss	*Grimma mixleyi*	RA	Unknown	Awareness and education
Moss	*Grimmia hamulosa*	RA,EN	Unknown	Awareness and education
Moss	*Hydrogrimmia mollis*	RA	Unknown	Awareness and education
Moss	*Lescuraea pallida*	RA	Unknown	Awareness and education
Moss	*Mnium arizonicum*	RA	Unknown	Awareness and education
Moss	*Myurella julacea*	RA	Unknown	Awareness and education
Moss	*Orthotrichum euryphyllum*	RA	Unknown	Awareness and education
Moss	*Orthotrichum spjutii*	RA,EN	Unknown	Awareness and education

Common Name	Scientific Name	Criteria[a]	Potential Threats or Impacts	Conservation Ideas
Moss	*Polytrichum sexangulare*	RA	Unknown	Awareness and education
Moss	*Racomitrium hispanicum*	RA	Unknown	Awareness and education
Moss	*Tayloria serrata*	RA	Unknown	Awareness and education
Moss	*Tortula californica*	RA	Unknown	Awareness and education
Birds				
Cooper's Hawk	*Accipiter cooperii*	SC	Uncertain	Protect discovered nest sites from management disturbance
Northern Goshawk*	*Accipiter gentilis*	SC,LH,AE	Forest management practices	Protect nest sites and foraging areas
Sharp-shinned Hawk	*Accipiter striatus*	SC	Uncertain	Protect discovered nest sites from management disturbance
Red-winged Blackbird	*Agelaius phoeniceus*	LH	Grazing	Manage riparian habitats to support dependent species
Wood Duck	*Aix sponsa*	PO,LH	Behavioral modification from human presence	Protect sensitive foraging and potential breeding sites (marshes)
Northern Pintail	*Anas acuta*	LH	Behavioral modification from human presence	Protect sensitive foraging and potential breeding sites (marshes)
Northern Shoveler	*Anas clypeata*	PO	Behavioral modification from human presence	Protect sensitive foraging and potential breeding sites (marshes)
Mallard	*Anas platyrhynchos*	LH,WA	Behavioral modification from human presence	Protect sensitive foraging and potential breeding sites (marshes)
American Pipit	*Anthus rubescens*	LH	Unknown	Awareness and education
Western Scrub Jay	*Aphelocoma coerulescens*	PO	Uncertain	Awareness and education
Golden Eagle	*Aquila chrysaetos*	SC,AE	Behavioral modification from human presence	Protect all discovered nest sites
Great Blue Heron	*Ardea herodias*	LH	Behavioral modification from human presence	Protect sensitive foraging and potential breeding sites (marshes)
Greater Scaup	*Aythya marila*	PO	Behavioral modification from human presence	Protect sensitive foraging and potential breeding sites (marshes)
Canvasback	*Aythya valisineria*	LH	Behavioral modification from human presence	Protect sensitive foraging and potential breeding sites (marshes)
Canada Goose	*Branta canadensis*	LH,WA, HC	Behavioral modification from human presence, Impacts: lawn damage	Protect sensitive foraging and potential breeding sites (marshes)
Common Goldeneye	*Bucephala clangula*	LH	Behavioral modification from human presence	Protect sensitive foraging and potential breeding sites (marshes)

Common Name	Scientific Name	Criteria[a]	Potential Threats or Impacts	Conservation Ideas
Barrow's Goldeneye	*Bucephala islandica*	SC,PO	Behavioral modification from human presence	Protect sensitive foraging and potential breeding sites (marshes)
California Quail	*Callipepla californica*	EX	Unknown	Awareness and education
Lesser Goldfinch	*Carduelis psaltria*	PO	Uncertain	Awareness and education
Cassin's Finch	*Carpodacus cassinii*	LH	Forest management practices	Manage old forests to support dependent species
House Finch	*Carpodacus mexicanus*	PO	Uncertain	Awareness and education
Purple Finch	*Carpodacus purpureus*	LH	Forest management practices	Manage old forests to support dependent species
Swainson's Thrush	*Catharus ustulatus*	PO	Uncertain	Develop conservation measures
Canyon Wren	*Catherpes mexicanus*	ET,LH	Uncertain	Define habitat requirements and evaluate enhancement opportunities
Brown Creeper	*Certhia americana*	LH	Forest management practices	Manage old forests to support dependent species
Belted Kingfisher	*Ceryle alcyon*	PO,LH	Behavioral modification from human presence	Protect sensitive foraging and potential breeding sites (marshes)
Northern Harrier	*Circus cyaneus*	SC	Uncertain	Protect discovered nest sites from management disturbance
Marsh Wren	*Cistothorus palustris*	LH	Unknown	Develop conservation and restoration strategies for marshes and associated riparian habitats
Evening Grosbeak	*Coccothraustes vespertinus*	LH	Forest management practices	Manage old forests to support dependent species
Band-tailed Pigeon	*Columba fasciata*	PO	Uncertain	Awareness and education
Rock Dove	*Columba livia*	LH,EX,HC	Impacts: fecal deposition	Awareness and education
Olive-sided Flycatcher	*Contopus cooperi*	PO	Uncertain	Awareness and education
Western Wood-pewee	*Contopus sordidulus*	PO	Uncertain	Awareness and education
American Crow	*Corvus brachyrhynchos*	LH	Uncertain	Awareness and education
Steller's Jay	*Cyanocitta stelleri*	PO	Uncertain	Awareness and education
Tundra Swan	*Cygnus columbianus*	LH	Behavioral modification	Protect sensitive foraging and potential breeding sites (marshes)
Blue Grouse	*Dendragapus obscurus*	HV	Overharvest	Awareness and education
Hermit Warbler	*Dendroica occidentalis*	LH	Forest management practices	Manage old forests to support dependent species

Common Name	Scientific Name	Criteria[a]	Potential Threats or Impacts	Conservation Ideas
Yellow Warbler	*Dendroica petechia*	SC	Brown-headed Cowbird nest parasitism and cow disturbance	Reduce or eliminate grazing pressure around yellow warbler nests and habitat
Pileated Woodpecker*	*Dryocopus pileatus*	LH	Forest management practices	Manage old forests to support dependent species, including many large trees and snags
Hammond's Flycatcher	*Empidonax hammondii*	LH	Uncertain	Awareness and education
Willow Flycatcher*	*Empidonax traillii*	SE,PO,LH, AE	Brown-headed Cowbird nest parasitism and cow disturbance	Elimination of grazing from some low-elevation meadows, possible cowbird trapping
Horned Lark	*Eremophila alpestris*	LH	Unknown	Manage sagebrush to support dependent species
Peregrine Falcon	*Falco peregrinus*	ET,SE,PO, WA,AE	Behavioral modification from human presence	Reintroduction
Common Snipe	*Gallinago gallinago*	PO	Grazing	Protect sensitive foraging and potential breeding sites (marshes, wet meadows)
Common Loon	*Gavia immer*	SC	Behavioral modification from human presence	Protect sensitive foraging and potential breeding sites (marshes)
Bald Eagle*	*Haliaeetus leucocephalus*	FT,SE,WA, AE	Behavioral modification from human presence	Protection of all nest sites and wintering habitat
California Gull	*Larus californicus*	SC,LH,HC	Uncertain	Awareness and education
Ring-billed Gull	*Larus delawarensis*	LH,HC	Impacts: fecal deposition	Awareness and education
Gray-crowned Rosy Finch	*Leucosticte arctoa*	LH	Uncertain	Awareness and education
Hooded Merganser	*Lophodytes cucullatus*	LH	Behavioral modification	Protect sensitive foraging and potential breeding sites (marshes)
Red Crossbill	*Loxia curvirostra*	LH	Forest management practices	Manage old forests to support dependent species
Lewis's Woodpecker	*Melanerpes lewis*	ET,PO	Forest management practices	If detected, develop and implement habitat management direction
Wild Turkey	*Meleagris gallopavo*	EX	Unknown	Awareness and education
Lincoln's Sparrow	*Melospiza lincolnii*	LH	Grazing	Manage riparian habitats to support dependent species
Common Merganser	*Mergus merganser*	LH	Behavioral modification	Protect sensitive foraging and potential breeding sites (marshes)
Brown-headed Cowbird	*Molothrus ater*	PO,EX	Impacts: parasitism of songbirds	Trapping and removal of individuals if population continues to grow
Black-crowned Night-heron	*Nycticorax nycticorax*	LH	Behavioral modification	Protect sensitive foraging and potential breeding sites (marshes)

Common Name	Scientific Name	Criteria[a]	Potential Threats or Impacts	Conservation Ideas
MacGillivray's Warbler	*Oporornis tolmiei*	LH	Grazing	Manage riparian habitats to support dependent species
Mountain Quail	*Oreortyx pictus*	HV	Overharvest	Awareness and education
Osprey*	*Pandion haliaetus*	SC,LH, WA,AE	Behavioral modification from human presence, shorline development	Protect sensitive foraging and potential breeding sites (marshes)
House Sparrow	*Passer domesticus*	LH,EX	Impacts: competes with native cavity-nesters	Awareness and education
Savannah Sparrow	*Passerculus sandwichensis*	ET,LH	Unknown	Manage sagebrush and juniper to support dependent species
American White Pelican	*Pelecanus erythrorhynchos*	SC,PO,LH	Behavioral modification from human presence	Protect sensitive foraging and potential breeding sites (marshes)
Black-billed Magpie	*Pica pica*	LH	Grazing	Awareness and education
White-headed Woodpecker	*Picoides albolarvatus*	LH	Forest management practices	Manage old forests to sustain dependent species
Black-backed Woodpecker	*Picoides arcticus*	LH	Forest management practices	Awareness and education
Pine Grosbeak	*Pinicola enucleator*	LH	Grazing	Manage riparian habitats to support dependent species
Green-tailed Towhee	*Pipilo chlorurus*	LH	Uncertain	Awareness and education
Pied-billed Grebe	*Podilymbus podiceps*	PO	Behavioral modification from human presence	Protect sensitive foraging and potential breeding sites (marshes)
Bank Swallow	*Riparia riparia*	ST,LH	Stream bank erosionUncertain	Protect nest sites where discovered, and manage riparian habitats to support associated species
Red-breasted Nuthatch	*Sitta canadensis*	LH	Forest management practices	Manage old forests to support dependent species
Pygmy Nuthatch	*Sitta pygmaea*	LH	Forest management practices	Manage old forests to support dependent species
Red-breasted Sapsucker	*Sphyrapicus ruber*	PO	Forest management practices	Awareness and education
Williamson's Sapsucker	*Sphyrapicus thyroideus*	LH	Forest management practices	Awareness and education
Chipping Sparrow	*Spizella passerina*	PO	Uncertain	Awareness and education
Forster's Tern	*Sterna forsteri*	PO	Unknown	Protect nesting areas from grazing and human disturbance
Spotted Owl*	*Strix occidentalis*	SC,LH,AE	Forest management practices	Protect nest sites and foraging areas
European Starling	*Sturnus vulgaris*	EX	Impacts: competes with native cavity-nesters	Awareness and education

Common Name	Scientific Name	Criteria[a]	Potential Threats or Impacts	Conservation Ideas
Winter Wren	*Troglodytes troglodytes*	LH	Forest management practices, Grazing	Manage old-forests to sustain dependent species
American Robin	*Turdus migratorius*	PO	Cowbird nest parasitism	Awareness and education
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	LH	Behavioral modification from human presence	Awareness and education
White-crowned Sparrow	*Zonotrichia leucophrys*	PO	Grazing	Awareness and education
Mammals				
Pallid bat	*Antrozous pallidus*	SC	Uncertain	Protect nests and roosts when discovered
Mountain beaver	*Aplodontia rufa*	SC	Grazing	Reduce grazing in riparian areas known to be occupied
Cow	*Bos* sp.	EXD	Impacts: riparian and meadow vegetation, soil compaction	Awareness and education
Domestic dog	*Canis familiaris*	EXD	Impacts: predatory on small birds and mammals	Awareness and education
Coyote	*Canis latrans*	HC,WA	Impacts: predatory on small pets	Educate people to reduce conflicts
Beaver	*Castor canadensis*	PO,EX,HC	Impacts: channel alteration, disruption of natural hydrologic regime	Trapping and removal of individuals from the most sensitive watersheds
Horse	*Equus* sp.	EXD	Impacts: riparian and meadow vegetation, soil compaction; spread non-native grass seeds through feces	Awareness and education
Mule	*Equus* sp.	EXD	Impacts: riparian and meadow vegetation, soil compaction; spread non-native grass seeds through feces	Awareness and education
Domestic cat	*Felis domesticus*	EXD	Impacts: predatory on small birds and mammals	Awareness and education
Northern flying squirrel*	*Glaucomys sabrinus*	LH	Forest management practices	Forest management that results in many large conifers and snags
Wolverine	*Gulo gulo*	ET,ST,SC, PO,LH,AE	Uncertain	If detected, develop and implement measures to reduce disturbance
Llama	*Lama glama*	EXD	Impacts: riparian and meadow vegetation, soil compaction; spread non-native grass seeds through feces	Awareness and education

Common Name	Scientific Name	Criteria[a]	Potential Threats or Impacts	Conservation Ideas
Sierra Nevada snowshoe hare	*Lepus americanus tahoensis*	SC,LH	Uncertain	Protect foraging areas where discovered
White-tailed hare	*Lepus townsendii*	ET,SC,PO, LH	Uncertain	Develop management considerations if occurrence is documented
River otter	*Lutra canadensis*	PO,LH	Grazing	Protect denning sites where discovered
Yellow-bellied marmot	*Marmota flaviventris*	LH	Grazing	Protect denning sites where discovered
Marten*	*Martes americana*	LH,AE	Forest management practices	Develop management considerations for locations where species is detected
Fisher	*Martes pennanti*	SC,PO,LH, AE	Human population density, forest management practices	Maintain movement corridors throughout basin
Long-tailed vole	*Microtus longicaudus*	LH	Uncertain	Manage riparian habitat and meadows to support associated species
Mink	*Mustela vison*	PO,LH	Grazing	Protect denning sites when discovered
Long-eared myotis	*Myotis evotis*	SC	Uncertain	Protect nests and roosts when discovered
Fringed myotis	*Myotis thysanodes*	SC,PO	Uncertain	Protect nests and roosts when discovered
Yuma myotis	*Myotis yumanensis*	SC	Uncertain	Protect nests and roosts when discovered
Desert woodrat	*Neotoma lepida*	LH	Uncertain	Protect middens currently in use
Pika	*Ochotona princeps*	LH	Uncertain	Awareness and education
Mule deer	*Odocoileus hemionus*	WA,HV, AE	Human presence	Awareness and education
Muskrat	*Ondatra zibethicus*	PO,LH	Unknown	Protect denning and feeding areas from disturbance where discovered
Mountain sheep	*Ovis canadensis californiana*	ET,FE,ST, PO,LH, WA,AE	Disease, predation	Reintroduction
Brush mouse	*Peromyscus boylii*	LH	Uncertain	Awareness and education
Canyon mouse	*Peromyscus crinitus*	ET,LH	Uncertain	Define habitat requirements and evaluate enhancement opportunities
Pinyon mouse	*Peromyscus truei*	LH	Uncertain	Awareness and education
Heather vole	*Phenacomys intermedius*	ET,LH	Fire suppression	Protect areas where species is detected
Raccoon	*Procyon lotor*	HC	Imapcts: garbage redistribution	Educate people to reduce conflicts
Broad-footed mole	*Scapanus latimanus*	LH	Uncertain	Awareness and education
Western gray squirrel	*Sciurus griseus*	LH,HC	Impacts: property damage	Educate people to reduce conflicts
Dusky shrew	*Sorex monticolus*	LH	Uncertain	Manage old forests to sustain dependent species

Common Name	Scientific Name	Criteria[a]	Potential Threats or Impacts	Conservation Ideas
Water shrew	*Sorex palustris*	LH	Grazing	Manage aquatic ecosystems to support associated species
Trowbridge's shrew	*Sorex trowbridgii*	LH	Uncertain	Awareness and education
Vagrant shrew	*Sorex vagrans*	LH	Uncertain	Awareness and education
California ground squirrel	*Spermophilus beecheyi*	HC	Impacts: property damage	Educate people to reduce conflicts
Belding's ground squirrel	*Spermophilus beldingi*	LH	Uncertain	Awareness and education
Nuttall's cottontail	*Sylvilagus nuttallii*	PO,LH	Uncertain	Protect foraging areas when discovered
Yellow-pine chipmunk	*Tamias flaviventris*	LH	Uncertain	Awareness and education
Least chipmunk	*Tamias minimus*	LH	Uncertain	Awareness and education
Long-eared chipmunk	*Tamias quadrimaculatus*	LH,EN	Uncertain	Awareness and education
Lodgepole chipmunk	*Tamias speciosus*	SC,LH	Uncertain	Awareness and education
Douglas squirrel	*Tamiasciurus douglasii*	LH,HC	Forest management practices, Impacts: property damage	Forest management that results in many large conifers
Badger	*Taxidea taxus*	PO,LH	Grazing	Protect denning and feeding areas from disturbance where discovered
Mountain pocket gopher	*Thomomys monticola*	LH	Uncertain	Awareness and education
Black bear	*Ursus americanus*	PO,WA, HV,HC	Interactions with humans	Educate people to reduce conflicts
Grizzly bear	*Ursus arctos*	ET,FT,PO	Uncertain	Awareness and education regarding past occupancy
Sierra Nevada red fox	*Vulpes vulpes necator*	ET,ST,SC, PO,LH,AE	Uncertain	Maintain movement corridors throughout basin; if detected, develop and implement habitat management direction
Western jumping mouse	*Zapus princeps*	LH	Riparian disturbance	Awareness and education
Amphibians				
Long-toed salamander	*Ambystoma macrodactylum*	LH	Grazing, siphoning, water pollution	Restrict siphoning and water pollution and possibly eradicate trout, esp. in breeding season
Western toad	*Bufo boreas*	PO,LH	Grazing, water pollution	Protect some meadow breeding areas from grazing, recreation
Pacific treefrog	*Hyla regilla*	PO,LH	Grazing, Chemical poisons	Awareness and education
Bullfrog	*Rana catesbeiana*	LH,EX	Impacts: predatory on native amphibians, fish, invertebrates	Eradicate populations from all possible locations, prioritizing those areas where they can spread to other locations

Common Name	Scientific Name	Criteria[a]	Potential Threats or Impacts	Conservation Ideas
Mountain yellow-legged frog*	*Rana muscosa*	SC,PO,LH, AE	Trout, chemical poisons, grazing	Eradication of trout from some high-elevation lakes; reintroduction
Northern leopard frog	*Rana pipiens*	ET,SC,PO, LH,EX,AE	Trout, chemical poisons, grazing	Eradication of trout from some high-elevation lakes; reintroduction
Reptiles				
Sagebrush lizard	*Sceloporus graciosus*	LH	Uncertain	Awareness and education
W. aquatic garter snake	*Thamnophis couchii*	LH	Grazing	Manage aquatic ecosystems to support associated species
W. terrestrial garter snake	*Thamnophis elegans*	PO	Amphibian decline, habitat loss, behavioral modifications from human presence	Develop management considerations for locations where species occurs
Fish				
Goldfish	*Carassius auratus*	EX	Unknown	Awareness and education
Carp	*Cyprinus carpio*	EX	Unknown	Awareness and education
Mosquito fish	*Gambusia affinis*	EX	Impacts: predatory on native amphibians, fish, invertebrates	Awareness and education
Lahontan Lake tui chub	*Gila bicolor pectinifer*	SC,AE	Predation from introduced fish	Eradication of trout from some areas
Brown bullhead	*Ictalurus nebulosis*	EX	Unknown	Awareness and education
Bluegill	*Lepomis macrochirus*	EX	Unknown	Awareness and education
Smallmouth bass	*Micropterus dolomieui*	EX,HV	Impacts: predatory on native amphibians, fish, invertebrates	Awareness and education
Largemouth bass	*Micropterus salmoides*	EX,HV	Impacts: predatory on native amphibians, fish, invertebrates	Awareness and education
Golden shiner	*Notemigonus crysoleucas*	EX	Unknown	Awareness and education
Golden trout	*Oncorhynchus aquabonita*	EX,HV	Impacts: predatory on native amphibians, fish, invertebrates	Awareness and education
Lahontan cutthroat trout*	*Oncorhynchus clarkii henshawi*	ET,FE,PO	Grazing, introduced fish predation	Protection, reintroduction, and habitat restoration
Rainbow trout	*Oncorhynchus mykiss*	EX,HV	Impacts: predatory on native amphibians, fish, invertebrates	Awareness and education
Kokanee salmon	*Oncorhynchus nerka kennerlyi*	EX,WA, HV	Beaver activity in Taylor Creek, Impacts: predatory on native amphibians, fish, invertebrates	Awareness and education
White crappie	*Pomoxis annularis*	EX	Unknown	Awareness and education

Common Name	Scientific Name	Criteria[a]	Potential Threats or Impacts	Conservation Ideas
Black crappie	*Pomoxis nigromaculatus*	EX	Unknown	Awareness and education
Mountain whitefish	*Prosopium williamsoni*	PO	Unknown	Develop conservation measures
German brown trout	*Salmo trutta*	EX,HV	Impacts: predatory on native amphibians, fish, invertebrates	Awareness and education
Brook trout	*Salvelinus fontinalis*	EX,HV	Impacts: predatory on native amphibians, fish, invertebrates	Awareness and education
Mackinaw (lake) trout	*Salvelinus namaycush*	EX,HV	Impacts: predatory on native amphibians, fish, invertebrates	Awareness and education
Invertebrates				
Aquatic macroinvertebrate	*Candona tahoensis*	EN	Uncertain	Awareness and education
Lake Tahoe benthic stonefly	*Capnia lacustra*	SC,PO,EN	Loss of deep-water plant beds (decreasing lake clarity, jigging)	Develop a conservation strategy for deep-water plant beds
Aquatic macroinvertebrate	*Dendrocoelopsis hymanae*	EN	Uncertain	Awareness and education
Mono checkerspot	*Euphadryas deitha monoensis*	SC	Fire suppression, insecticides, grazing	Develop management considerations if occurrence is documented
Lepidoptera	Moths and butterflies	WA	Fire suppression, insecticides, grazing	Awareness and education
Opossum shrimp	*Mysis relicta*	EX	Impacts: predatory on native invertebrates	Awareness and education
Crayfish	*Pacifastacus leniusculus*	EX,HV	Impacts: predatory on native amphibians, fish, invertebrates	Awareness and education
Aquatic macroinvertebrate	*Phagocata tahoena*	EN	Uncertain	Awareness and education
Aquatic macroinvertebrate	*Rhyacodrilus brevidentus*	EN	Uncertain	Awareness and education
Carson Valley silverspot butterfly	*Speyeria nokomis*	SC	Fire suppression, insecticides, grazing	Develop management considerations if occurrence is documented
Aquatic macroinvertebrate	*Spirosperma beetoni*	EN	Uncertain	Awareness and education
Aquatic macroinvertebrate	*Stygobromus lacicolus*	EN	Uncertain	Awareness and education
Aquatic macroinvertebrate	*Stygobromus tahoensis*	EN	Uncertain	Awareness and education
Aquatic macroinvertebrate	*Utacapnia tahoensis*	EN	Uncertain	Awareness and education
Aquatic macroinvertebrate	*Varichaetadrilus minutus*	EN	Uncertain	Awareness and education
Fungi and Lichens				
Coccora	*Amanita calyptrata*	HV	Uncertain	Awareness and education
Honey mushroom	*Armillariella mellea*	HV	Uncertain	Awareness and education

Common Name	Scientific Name	Criteria[a]	Potential Threats or Impacts	Conservation Ideas
King bolete	*Boletus edulis*	HV	Uncertain	Awareness and education
Bryoria	*Bryoria* spp.	PO	Air pollution	Awareness and education
Giant puffball	*Calvatia gigantea*	HV	Uncertain	Awareness and education
Sierra puffball	*Calvatia sculpta*	HV	Uncertain	Awareness and education
Chantrelle	*Cantharellus cibarius*	HV	Uncertain	Awareness and education
Shaggy mane	*Coprinus comatus*	HV	Uncertain	Awareness and education
Lichen	*Dermatocarpon moulinsii*	RA	Air pollution	Awareness and education
Lichen	*Dimelaena oreina*	RA	Air pollution	Awareness and education
Lichen	*Hypogymnia metaphysodes*	RA	Air pollution	Awareness and education
Delicious milk cap	*Lactarius deliciosus*	HV	Uncertain	Awareness and education
Morels	*Morchella* spp.	HV	Uncertain	Awareness and education
Oyster mushroom	*Pleurotus ostreatus*	HV	Uncertain	Awareness and education
Chicken of the woods	*Polyporus sulphureus*	HV	Uncertain	Awareness and education
Yellow coral mushroom	*Ramaria rasilispora*	HV	Uncertain	Awareness and education
Lichen	*Rhizoplaca glaucophana*	RA	Air pollution	Awareness and education
Shrimp russula	*Russula xerampelina*	HV	Uncertain	Awareness and education
Cauliflower mushroom	*Sparassis crispa*	HV	Uncertain	Awareness and education
Lichen	*Thisoplaca marginalis*	RA	Air pollution	Awareness and education
Lichen	*Umblicaria torrefacta*	RA	Air pollution	Awareness and education
Lichen	*Waynea stoechadiana*	RA	Air pollution	Awareness and education

Notes:
[a] In general, criteria were ranked as follows, from greatest concern level to most modest concern level: Federally endangered (FE), Federally threatened (FT), State endangered (SE), State threatened (ST), Federal or State species of special concern (SC), population decline (PO), rarity (RA), Truckee River basin endemic (EN), exotic (EX), vulnerable due to life-history characteristics (LH), Sierra Nevada endemic (EN), agency emphasis (AE), human conflict (HC), Watchable (WA), domestic exotics (EXD), and harvest (HV).

APPENDIX R

RECOMMENDED MONITORING FOR FOCAL SPECIES

APPENDIX R

RECOMMENDED MONITORING FOR FOCAL SPECIES

Patricia N. Manley and Matthew D. Schlesinger

Table R-1—Recommended monitoring for focal species. Species are sorted by taxonomic group along with their associated criteria.[a] Types of monitoring data include presence (pres), frequency of occurrence (freq), relative abundance (relab), population size (popsize), territory density (terr), reproductive success (repro), and population demography (demog). * = species identified by agency representatives as their top priority for additional information. T = target level of monitoring; the recommended level. NT = non-target level of monitoring; desired but not essential data.

Common Name	Scientific Name	Criteria	Pres	Freq	Relab	Popsize	Terr	Repro	Demog	Comments
Vascular plants										
White fir	*Abies concolor*	HV		T						
California red fir	*Abies magnifica* var. *magnifica*	HV		T						
Mountain bentgrass*	*Agrostis humilis*	RA	T	NT						Not yet documented in the basin; potential relict population
Galena Creek rockcress*	*Arabis rigidissima* var. *demota*	SC,RA,EN,AE		NT		T				Two known occurrences in the basin
Twin arnica	*Arnica soroia*	RA	T	NT						One documentation; needs to be confirmed
Green spleenwort	*Asplenium trichomanes-ramosum*	RA		T						
Anderson's aster	*Aster alpigenus* var. *andersonii*	AE		T						
Austin's milkvetch*	*Astragalus austiniae*	EN		T						
Balloon pod milkvetch	*Astragalus whitneyi* var. *lenophyllus*	EN		T						
Trianglelobe moonwort	*Botrychium ascendens*	RA,AE	T							Potentially documented in the basin; difficult to distinguish Botrychium species
Cheatgrass	*Bromus tectorum*	EX		T						Common in the basin
Incense cedar	*Calocedrus decurrens*	HV			T					Species is at the edge of its range in the basin
Plumeless thistle	*Carduus acanthoides*	EX	T							Not yet documented in the basin
Musk thistle	*Carduus nutans*	EX		T	NT	NT				
Davy's sedge	*Carex davyi*	EN		T						
Mud sedge	*Carex limosa*	RA		T						One documentation; needs to be confirmed; occurs in sphagnum bogs

Common Name	Scientific Name	Criteria	Pres	Freq	Relab	Popsize	Terr	Repro	Demog	Comments
Mariposa sedge*	*Carex mariposana*	AE		T						Documented last year
Diffuse knapweed	*Centaurea diffusa*	EX	T	NT						
Spotted knapweed	*Centaurea maculosa*	EX	T	NT						One documentation; needs to be confirmed; poisonous
Bullthistle*	*Cirsium vulgare*	EX		T	NT					
Sierra clarkia	*Clarkia virgata*	EN	T	NT						Not yet documented in the basin; may occur only at lower elevations
Scotch broom	*Cytisus scoparius*	EX	T	NT						One documentation; needs to be confirmed; easily confused with spanish broom; both would be of concern
Lake Tahoe draba*	*Draba asterophora* var. *asterophora*	RA,EN,AE		NT		T				Five populations known to occur in the basin; high elevation, > 8600 ft
Cup Lake draba*	*Draba asterophora* var. *macrocarpa*	SC,RA,EN,AE		NT		T				One known occurrence in the basin
Subalpine fireweed*	*Epilobium howellii*	RA,EN,AE	T	NT						Not yet documented in the basin
Oregon fireweed	*Epilobium oreganum*	SC,AE	T	NT						Not yet documented in the basin
Marsh horsetail	*Equisetum palustre*	RA		T						
Starved fleabane	*Erigeron miser*	RA,EN,AE	T	NT						Not yet documented in the basin; occurs at high elevations; could be present in Desolation Wilderness
Sierra fleabane	*Erigeron petrophilus* var. *sierrensis*	EN	T	NT						Not yet documented in the basin
Brown-margined buckwheat	*Eriogonum ovalifolium* var. *eximium*	HV	T	NT						
Buckwheat	*Eriogonum ovalifolium* var. *vineum*	RA		T						
Torrey buckwheat*	*Eriogonum umbellatum* var. *torreyanum*	SC,RA,EN,HV, AE	T	NT						
Klamathweed	*Hypericum perforatum*	EX	T	NT						One documentation; needs to be confirmed
Plumas mousetail	*Ivesia sericoleuca*	SC,EN,AE	T	NT						Not yet documented in the basin, occurs in open, low elevation sage meadows
Webber's ivesia	*Ivesia webberi*	SC,RA,AE	T	NT						
Tall whitetop*	*Lepidium latifolium*	EX				T				
Long-petaled lewisia*	*Lewisia longipetala*	SC,RA,EN,HV, AE		NT		T				Two known occurrences in the basin
Dalmation toadflax	*Linaria genistifolia* ssp. *dalmatica*	EX	T	NT						
Eurasian watermilfoil*	*Myriophyllum spicatum*	EX,HC			T					
Scotch thistle	*Onopordum acanthium* ssp. *acanthium*	EX	T	NT						

Common Name	Scientific Name	Criteria	Pres	Freq	Relab	Popsize	Terr	Repro	Demog	Comments
Close-throated beardtongue	*Penstemon personatus*	RA,EN,AE	T	NT						Not yet documented in the basin, low probability of occurrence; likely to show up in recent burns
Bacigalupi's perideridia	*Perideridia personatus*	EN	T							
Whitebark pine	*Pinus albicaulis*	PO			T					
Lodgepole pine	*Pinus contorta* ssp. *murrayana*	HV		T						
Jeffrey pine	*Pinus jeffrreyi*	HV		T						
Sugar pine	*Pinus lambertiana*	HV			T					Could also monitor the prevalence of the blister rust
Western white pine	*Pinus monticola*	HV			T					Species is at the edge of its range in the basin
Ponderosa pine	*Pinus ponderosa*	HV		T						
Ribbonleaf pondweed	*Potamogeton epihydrus nuttallii*	RA	T	NT						Not yet documented in the basin
Tahoe yellow cress*	*Rorippa subumbellata*	SE,SC,RA,EN,AE				T		NT	NT	California State Lands Commission is monitoring this species in the basin and has a monitoring plan
American scheuchzeria	*Scheuchzeria palustris americana*	RA,AE	T	NT						Not yet documented in the basin; occurs in fens and sphagnum bogs
Water bulrush*	*Scirpus subterminalis*	RA	T	NT						One documentation; needs to be confirmed
Marsh skullcap	*Scutellaria galericulata*	RA,HV		T						
Smooth goldenrod	*Solidago gigantea*	RA,HV	T	NT						One documentation; needs to be confirmed
Lake Tahoe serpentweed	*Tonestus eximius*	EN		T						
Grey-leaved violet	*Viola pinetorum grisea*	RA,AE	T	NT						
Wooly violet	*Viola tomentosa*	RA,EN	T	NT						Not yet documented in the basin
Nonvascular plants										
Moss	*Andreaea nivalis*	RA	T							
Moss	*Bruchia bolanderi*	RA	T							
Moss	*Campylium stellatum*	RA	T							
Moss	*Distichium inclinatum*	RA	T							
Moss	*Grimma mixleyi*	RA	T							
Moss	*Grimmia hamulosa*	RA,EN	T							
Moss	*Hydrogrimmia mollis*	RA	T							
Moss	*Lescuraea pallida*	RA	T							
Moss	*Mnium arizonicum*	RA	T							
Moss	*Myurella julacea*	RA	T							
Moss	*Orthotrichum euryphyllum*	RA	T							
Moss	*Orthotrichum spjutii*	RA,EN	T							

Common Name	Scientific Name	Criteria	Pres	Freq	Relab	Popsize	Terr	Repro	Demog	Comments
Moss	*Polytrichum sexangulare*	RA	T							
Moss	*Racomitrium hispanicum*	RA	T							
Moss	*Tayloria serrata*	RA	T							
Moss	*Tortula californica*	RA	T							
Birds										
Cooper's Hawk	*Accipiter cooperii*	SC		T	NT					
Northern Goshawk*	*Accipiter gentilis*	SC,LH,AE				T	NT	NT		
Sharp-shinned Hawk	*Accipiter striatus*	SC		T	NT					
Red-winged Blackbird	*Agelaius phoeniceus*	LH			T					
Wood Duck	*Aix sponsa*	PO,LH			T	NT				
Northern Pintail	*Anas acuta*	LH			T					
Northern Shoveler	*Anas clypeata*	PO			T	NT				
Mallard	*Anas platyrhynchos*	LH,WA			T					
American Pipit	*Anthus rubescens*	LH			T					
Western Scrub Jay	*Aphelocoma coerulescens*	PO			T	NT				
Golden Eagle	*Aquila chrysaetos*	SC,AE				T		NT		
Great Blue Heron	*Ardea herodias*	LH			T					
Greater Scaup	*Aythya marila*	PO			T	NT				
Canvasback	*Aythya valisineria*	LH			T					
Canada Goose	*Branta canadensis*	LH,WA,HC			T	NT				
Common Goldeneye	*Bucephala clangula*	LH			T					
Barrow's Goldeneye	*Bucephala islandica*	SC,PO			T	NT				
California Quail	*Callipepla californica*	EX		T	NT					Low to no impact exotic
Lesser Goldfinch	*Carduelis psaltria*	PO			T	NT				
Cassin's Finch	*Carpodacus cassinii*	LH			T					
House Finch	*Carpodacus mexicanus*	PO			T	NT				
Purple Finch	*Carpodacus purpureus*	LH			T					
Swainson's Thrush	*Catharus ustulatus*	PO			T	NT		NT		
Canyon Wren	*Catherpes mexicanus*	ET,LH	T							
Brown Creeper	*Certhia americana*	LH			T					
Belted Kingfisher	*Ceryle alcyon*	PO,LH			T	NT				
Northern Harrier	*Circus cyaneus*	SC	T	NT						
Marsh Wren	*Cistothorus palustris*	LH			T					
Evening Grosbeak	*Coccothraustes vespertinus*	LH			T					
Band-tailed Pigeon	*Columba fasciata*	PO			T	NT				
Rock Dove	*Columba livia*	LH,EX,HC			T					
Olive-sided Flycatcher	*Contopus cooperi*	PO			T	NT				

Common Name	Scientific Name	Criteria	Pres	Freq	Relab	Popsize	Terr	Repro	Demog	Comments
Western Wood-pewee	*Contopus sordidulus*	PO			T	NT				
American Crow	*Corvus brachyrhynchos*	LH			T					
Steller's Jay	*Cyanocitta stelleri*	PO			T	NT				
Tundra Swan	*Cygnus columbianus*	LH			T					
Blue Grouse	*Dendragapus obscurus*	HV		T						
Hermit Warbler	*Dendroica occidentalis*	LH			T					
Yellow Warbler	*Dendroica petechia*	SC			T			NT		Target for cowbird nest parasitism
Pileated Woodpecker*	*Dryocopus pileatus*	LH			T					
Hammond's Flycatcher	*Empidonax hammondii*	LH			T					
Willow Flycatcher*	*Empidonax traillii*	SE,PO,LH,AE		T	NT					
Horned Lark	*Eremophila alpestris*	LH			T					
Peregrine Falcon	*Falco peregrinus*	ET,SE,PO,WA, AE	T							
Common Snipe	*Gallinago gallinago*	PO			T	NT				
Common Loon	*Gavia immer*	SC		T	NT					
Bald Eagle*	*Haliaeetus leucocephalus*	FT,SE,WA,AE				T		NT		
California Gull	*Larus californicus*	SC,LH,HC			T	NT				
Ring-billed Gull	*Larus delawarensis*	LH,HC			T					
Gray-crowned Rosy Finch	*Leucosticte arctoa*	LH			T					
Hooded Merganser	*Lophodytes cucullatus*	LH			T					
Red Crossbill	*Loxia curvirostra*	LH			T					
Lewis's Woodpecker	*Melanerpes lewis*	ET,PO	T							
Wild Turkey	*Meleagris gallopavo*	EX		T	NT					Low to no impact exotic
Lincoln's Sparrow	*Melospiza lincolnii*	LH			T					
Common Merganser	*Mergus merganser*	LH			T					
Brown-headed Cowbird	*Molothrus ater*	PO,EX			T					Other focal species that are targets of parasitism = WIFL, YEWA, AMRO
Black-crowned Night-heron	*Nycticorax nycticorax*	LH			T					
MacGillivray's Warbler	*Oporornis tolmiei*	LH			T			NT		
Mountain Quail	*Oreortyx pictus*	HV		T						
Osprey*	*Pandion haliaetus*	SC,LH,WA,AE				T	NT	NT		
House Sparrow	*Passer domesticus*	LH,EX			T	NT				
Savannah Sparrow	*Passerculus sandwichensis*	ET,LH	T							
American White Pelican	*Pelecanus erythrorhynchos*	SC,PO,LH	T	NT						
Black-billed Magpie	*Pica pica*	LH			T					
White-headed Woodpecker	*Picoides albolarvatus*	LH			T					
Black-backed Woodpecker	*Picoides arcticus*	LH			T					
Pine Grosbeak	*Pinicola enucleator*	LH			T					

Common Name	Scientific Name	Criteria	Pres	Freq	Relab	Popsize	Terr	Repro	Demog	Comments
Green-tailed Towhee	*Pipilo chlorurus*	LH			T					
Pied-billed Grebe	*Podilymbus podiceps*	PO			T	NT				
Bank Swallow	*Riparia riparia*	ST,LH		T						
Red-breasted Nuthatch	*Sitta canadensis*	LH			T					
Pygmy Nuthatch	*Sitta pygmaea*	LH			T					
Red-breasted Sapsucker	*Sphyrapicus ruber*	PO			T	NT				
Williamson's Sapsucker	*Sphyrapicus thyroideus*	LH			T					
Chipping Sparrow	*Spizella passerina*	PO			T	NT				
Forster's Tern	*Sterna forsteri*	PO			T	NT				
Spotted Owl*	*Strix occidentalis*	SC,LH,AE				T	NT	NT		
European Starling	*Sturnus vulgaris*	EX			T	NT				
Winter Wren	*Troglodytes troglodytes*	LH			T					
American Robin	*Turdus migratorius*	PO			T	NT		NT		Potential target for Brown-headed Cowbird nest parasitism
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	LH			T					
White-crowned Sparrow	*Zonotrichia leucophrys*	PO			T	NT				
Mammals										
Pallid bat	*Antrozous pallidus*	SC,AE		T	NT					
Mountain beaver	*Aplodontia rufa*	SC		T	NT					
Cow	*Bos* sp.	EXD			T					
Domestic dog	*Canis familiaris*	EXD			T					
Coyote	*Canis latrans*	HC,WA			T	NT				
Beaver	*Castor canadensis*	PO,EX,HC			T	NT				Monitor stream channel changes resulting from beaver activity
Horse	*Equus* sp.	EXD			T					
Mule	*Equus* sp.	EXD			T					
Domestic cat	*Felis domesticus*	EXD			T					
Northern flying squirrel*	*Glaucomys sabrinus*	LH			T		NT			
Wolverine	*Gulo gulo*	ET,ST,SC,PO,LH,AE	T							
Llama	*Lama glama*	EXD			T					
Sierra Nevada snowshoe hare	*Lepus americanus tahoensis*	SC,LH		T	NT					
White-tailed hare	*Lepus townsendii*	ET,SC,PO,LH	T							
River otter	*Lutra canadensis*	PO,LH	T	NT						
Yellow-bellied marmot	*Marmota flaviventris*	LH			T					
Marten*	*Martes americana*	LH,AE		T	NT		NT			
Fisher	*Martes pennanti*	SC,PO,LH,AE	T	NT						
Long-tailed vole	*Microtus longicaudus*	LH			T					

Common Name	Scientific Name	Criteria	Pres	Freq	Relab	Popsize	Terr	Repro	Demog	Comments
Mink	*Mustela vison*	PO,LH		T	NT					
Long-eared myotis	*Myotis evotis*	SC		T	NT					
Fringed myotis	*Myotis thysanodes*	SC,PO		T	NT					
Yuma myotis	*Myotis yumanensis*	SC		T	NT					
Desert woodrat	*Neotoma lepida*	LH			T					
Pika	*Ochotona princeps*	LH			T					
Mule deer	*Odocoileus hemionus*	WA,HV,AE			T					
Muskrat	*Ondatra zibethicus*	PO,LH		T	NT					
Mountain sheep	*Ovis canadensis californiana*	ET,FE,ST,PO,LH,WA,AE	T							
Brush mouse	*Peromyscus boylii*	LH			T					
Canyon mouse	*Peromyscus crinitus*	ET,LH	T							
Pinyon mouse	*Peromyscus truei*	LH			T					
Heather vole	*Phenacomys intermedius*	ET,LH	T							
Raccoon	*Procyon lotor*	HC			T					
Broad-footed mole	*Scapanus latimanus*	LH			T					
Western gray squirrel	*Sciurus griseus*	LH,HC			T					
Dusky shrew	*Sorex monticolus*	LH		T						
Water shrew	*Sorex palustris*	LH		T						
Trowbridge's shrew	*Sorex trowbridgii*	LH		T	NT					
Vagrant shrew	*Sorex vagrans*	LH		T	NT					
California ground squirrel	*Spermophilus beecheyi*	HC			T					
Belding's ground squirrel	*Spermophilus beldingi*	LH			T					
Nuttall's cottontail	*Sylvilagus nuttallii*	PO,LH		T	NT					
Yellow-pine chipmunk	*Tamias flaviventris*	LH			T					
Least chipmunk	*Tamias minimus*	LH			T					
Long-eared chipmunk	*Tamias quadrimaculatus*	LH,EN			T					
Lodgepole chipmunk	*Tamias speciosus*	SC,LH			T	NT				
Douglas squirrel	*Tamiasciurus douglasii*	LH,HC			T					
Badger	*Taxidea taxus*	PO,LH	T	NT						
Mountain pocket gopher	*Thomomys monticola*	LH			T					
Black bear	*Ursus americanus*	PO,WA,HV,HC			T	NT		NT	NT	
Grizzly bear	*Ursus arctos*	ET,FT,PO	T							
Sierra Nevada red fox	*Vulpes vulpes necator*	ET,ST,SC,PO,LH,AE	T							
Western jumping mouse	*Zapus princeps*	LH			T					
Amphibians										

Common Name	Scientific Name	Criteria	Pres	Freq	Relab	Popsize	Terr	Repro	Demog	Comments
Long-toed salamander	*Ambystoma macrodactylum*	LH			T	NT			NT	Demographic data = relative number of individuals in each life stage
Western toad	*Bufo boreas*	PO,LH			T	NT			NT	Demographic data = relative number of individuals in each life stage
Pacific treefrog	*Hyla regilla*	PO,LH			T	NT			NT	Demographic data = relative number of individuals in each life stage
Bullfrog	*Rana catesbeiana*	LH,EX			T	NT			NT	Demographic data = relative number of individuals in each life stage
Mountain yellow-legged frog*	*Rana muscosa*	SC,PO,LH,AE			T	NT			NT	Demographic data = relative number of individuals in each life stage
Northern leopard frog	*Rana pipiens*	ET,SC,PO,LH,EX?,AE	T							
Reptiles										
Sagebrush lizard	*Sceloporus graciosus*	LH		T	NT					
W. aquatic garter snake	*Thamnophis couchii*	LH			T					
W. terrestrial garter snake	*Thamnophis elegans*	PO			T				NT	Demographic data = relative number of individuals in each age class
Fish:										
Goldfish	*Carassius auratus*	EX		T	NT					
Carp	*Cyprinus carpio*	EX		T	NT					
Mosquito fish	*Gambusia affinis*	EX			T					High impact exotic
Lahontan Lake tui chub	*Gila bicolor pectinifer*	SC,AE			T	NT			T	Demographic data = relative number of individuals in each age class
Brown bullhead	*Ictalurus nebulosis*	EX		T	NT					
Bluegill	*Lepomis macrochirus*	EX		T	NT					
Smallmouth bass	*Micropterus dolomieui*	EX,HV			T					
Largemouth bass	*Micropterus salmoides*	EX,HV		T	NT					
Golden shiner	*Notemigonus crysoleucas*	EX		T	NT					
Golden trout	*Oncorhynchus aquabonita*	EX,HV		T	NT					Monitoring should consist of frequency in Lake Tahoe, and relative abundance everywhere else
Lahontan cutthroat trout*	*Oncorhynchus clarkii henshawi*	ET,FE,PO			T	NT			T	Demographic data = relative number of individuals in each age class
Rainbow trout	*Oncorhynchus mykiss*	EX,HV			T					Monitoring should consist of frequency in Lake Tahoe, and relative abundance everywhere else
Kokanee salmon	*Oncorhynchus nerka kennerlyi*	EX,WA,HV			T					
White crappie	*Pomoxis annularis*	EX		T	NT					

Common Name	Scientific Name	Criteria	Pres	Freq	Relab	Popsize	Terr	Repro	Demog	Comments
Black crappie	*Pomoxis nigromaculatus*	EX		T	NT					
Mountain whitefish	*Prosopium williamsoni*	PO		T	NT					
German brown trout	*Salmo trutta*	EX,HV			T					
Brook trout	*Salvelinus fontinalis*	EX,HV			T					Monitoring should consist of frequency in Lake Tahoe, and relative abundance everywhere else
Mackinaw (lake) trout	*Salvelinus namaycush*	EX,HV		T	NT					
Invertebrates										
Aquatic macroinvertebrate	*Candona tahoensis*	EN		T						
Aquatic macroinvertebrate	*Capnia lacustra*	SC,PO,EN		T		NT				
Aquatic macroinvertebrate	*Dendrocoelopsis hymanae*	EN		T						
Mono checkerspot	*Euphadryas deitha monoensis*	SC		T	NT					
Lepidoptera	*Moths and butterflies*	WA		T	NT					
Opossum shrimp	*Mysis relicta*	EX			T					
Crayfish	*Pacifastacus leniusculus*	EX,HV			T					
Aquatic macroinvertebrate	*Phagocata tahoena*	EN		T						
Aquatic macroinvertebrate	*Rhyacodrilus brevidentus*	EN		T						
Carson Valley silverspot butterfly	*Speyeria nokomis*	SC		T	NT					
Aquatic macroinvertebrate	*Spirosperma beetoni*	EN		T						
Aquatic macroinvertebrate	*Stygobromus lacicolus*	EN		T						
Aquatic macroinvertebrate	*Stygobromus tahoensis*	EN		T						
Aquatic macroinvertebrate	*Utacapnia tahoensis*	EN		T						
Aquatic macroinvertebrate	*Varichaetadrilus minutus*	EN		T						
Fungi and lichens										
Coccora	*Amanita calyptrata*	HV		T						
Honey mushroom	*Armillariella mellea*	HV		T						
King bolete	*Boletus edulis*	HV		T						
Lichen	*Bryoria spp.*	PO		T		NT				
Giant puffball	*Calvatia gigantea*	HV		T						
Sierra puffball	*Calvatia sculpta*	HV		T						
Chantrelle	*Cantharellus cibarius*	HV		T						
Shaggy mane	*Coprinus comatus*	HV		T						
Lichen	*Dermatocarpon moulinsii*	RA	T							
Lichen	*Dimelaena oreina*	RA	T							
Lichen	*Hypogymnia metaphysodes*	RA	T							
Delicious milk cap	*Lactarius deliciosus*	HV		T						

Common Name	Scientific Name	Criteria	Pres	Freq	Relab	Popsize	Terr	Repro	Demog	Comments
Morels	*Morchella spp.*	HV		T						
Oyster mushroom	*Pleurotus ostreatus*	HV		T						
Chicken of the woods	*Polyporus sulphureus*	HV		T						
Yellow coral mushroom	*Ramaria rasilispora*	HV		T						
Lichen	*Rhizoplaca glaucophana*	RA	T							
Shrimp russula	*Russula xerampelina*	HV		T						
Cauliflower mushroom	*Sparassis crispa*	HV		T						
Lichen	*Thisoplaca marginalis*	RA	T							
Lichen	*Umblicaria torrefacta*	RA	T							
Lichen	*Waynea stoechadiana*	RA	T							

[a] In general, criteria were ranked as follows, from greatest concern level to most modest concern level: Federally endangered (FE), Federally threatened (FT), State endangered (SE), State threatened (ST), Federal or State species of special concern (SC), population decline (PO), rarity (RA), Truckee River basin endemic (EN), exotic (EX), vulnerable due to life-history characteristics (LH), Sierra Nevada endemic (EN), agency emphasis (AE), human conflict (HC), Watchable (WA), domestic exotics (EXD), and harvest (HV).

APPENDIX S

DRAFT LIST OF KEY INDICATORS IDENTIFIED BY THE SOCIOECONOMIC AND INSTITUTIONAL WORKING GROUP

APPENDIX S

DRAFT LIST OF KEY INDICATORS IDENTIFIED BY THE SOCIOECONOMIC AND INSTITUTIONAL WORKING GROUP

Mark Nechodom, Rowan Rowntree, and Jamie Goldstein

Demographics

Visitor Profile Information
- Origin (residence zip code)
- Mode of arrival (e.g., car, bus, other)
- Destinations
- Mean days length of stay
- Per capita expenditures for:
  - room/board
  - recreation
  - gaming
- Average household income
- Ethnicity

Seasonal and/or 2nd Home Residents
- Location of residence
- Modes of transportation
- Patterns of day use

Full-time Residents
- Total population by census tract and block
- Age (using typical census data)
- Average household income
- Ethnicity

Social Indicators
- Educational achievement indicators
- Library use and circulation

Political and Social Participation
- Voter eligibility, registration, and participation
- Awareness indicators
- Non-elected participation indicators
- Voluntarism

Economic Activities

Recreation
- Better measurement of RVDs
- More accurate measurements of people at one time
- Lakefront access

New and Emerging Economic Activities
- Light manufacturing trends
- Non-recreation services (e.g., "lone-eagle" phenomena, financial services, remote telecommuter activity, semi-retired consulting)

Labor and Employment
- Job creation and loss by economic sector
- Unemployment by season
- Per capita income by economic sector (correlated to census tract data)
- Cost of living indices
  - percent of income for housing
  - percent of income for recreation
  - percent of income for subsistence
- Commute distances and modes

Housing
- Affordability
- Median home prices
- Mortgage risk indicators
- Open space and scenic affectors (location)
- Seasonal housing
- Rental use
- Owner-occupied

- Second home

Transportation

- VMTs by labor force sector and by visitor profile
- Average daily traffic volumes in key corridors
- Level of Service rating in key corridors
- Peak hourly volumes at several points of constricted flow
- Parking availability (visitor and resident perceptions)
- Public transit ridership
- Bike trail usage

Redevelopment and Community Reinvestment

- Public investment in local and regional infrastructure (spatially displayed)
- Private sector redevelopment contributions
- Community banks
- Small businesses
- Corporate contributions
- Visitor-focused redevelopment
- Community-focused redevelopment
- Recreation-focused redevelopment
- TOT distributions to redevelopment project

Social, Economic and Institutional Working Group Members

Bill Chernock
Travel Systems Limited

Kathleen Farrell
Tahoe Douglas Chamber of Commerce

Cindy Gustafson
Tahoe City Public Utility District

Bob Harris
Retired Supervisor, US Forest Service, Lake Tahoe Basin Management Unit

Amy Horne
Sierra Business Council

Sue Rea Irelan
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Ray Lacey
California Tahoe Conservancy

Ron McIntyre
North Lake Tahoe Resort Association

Don Morrison
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