

Spatial Patterns of Rare Species in Yosemite Forest Dynamics Plot as a Result of Seed Dispersal

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Abstract

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An understanding of the mechanisms of seed dispersal at a site gives information on its present and potential spatial patterns and is often a reflection of alpha diversity. In this paper, I examine the potential mechanisms of seed dispersal at the Yosemite Forest Dynamics Plot (YFDP), located in Yosemite National Park. I compare the alpha diversity of YFDP (0.98) to that of the Barro Colorado Island Plot in Panama (3.96). I state that higher alpha diversity is related to the larger number of dispersers present in the area.

I determine the rare species of the plot, as these have the most unique spatial patterns. A rare species is defined as having an importance value index less than one percent and a density less than 0.1. These include: *Abies magnifica*, *Pseudotsuga menziesii*, *Pinus ponderosa*, *Rhamnus californica* and *Salix scouleriana*.

I analyze the spatial patterns and seed dispersal mechanisms of the rare species to determine correlation. Most of the species considered rare use abiotic vectors as their main mechanism of dispersal. Many animal species are present in YFDP, and are responsible for many of the spatial patterns seen, especially those of *Pinus ponderosa*, *Abies magnifica* and *Rhamnus californica*.

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1. INTRODUCTION

Plants are sessile organisms that rely on seed dispersal as one of their only forms of movement in attempts to increase the fitness of their offspring (Nathan and Muller-Landau 2000). An increase in distance between parent and offspring reduces the chance of predation by density-responsive predators and gives the offspring access to resources that they need not share with their parent plant (Janzen 1970). The mechanisms of seed dispersal vary from abiotic to biotic vectors and are often a combination of both (Clark et al. 2003). The mechanisms by which trees disperse seeds are influenced by the alpha diversity of the area, and reflect the spatial patterns of a forest (Fuentes 2000; Russo et al. 2006).

The alpha diversity of a forest is often correlated to the types of seed dispersal mechanisms available in that forest (Howe and Smallwood 1982). Alpha diversity is relative to location. Ecosystems at low latitudes often display a greater alpha diversity than those at higher latitudes (Pianka 1966; Rohde 1992; Wright 2002). Tropical forests are most concentrated at low latitudes, and have a vast array of angiosperm species that show a great diversity in morphology and strategy in dispersing their seeds (Prance 1977; Muller-Landau and Hardesty 2005; Muller-Landau et al. 2006). The high alpha diversity at low latitudes also equates to a higher diversity of biotic vectors that have co-evolved with many of the flora species to enhance dispersal rates (Howe and Smallwood 1982). Temperate forests that are dominated by gymnosperms most commonly rely on abiotic factors, such as wind, for dispersal (Lanner 1982). Biotic seed dispersal in these temperate forests is limited, due to the presence of fewer biotic vectors than found in tropical forests (Howe and Smallwood 1982).

The mechanisms of seed dispersal also contribute to the spatial patterns of a forest. Larger animals eat larger fruits and are capable of traveling longer distances (Janson 1980; Kelt and Van Vuren 2001). Trees dispersed by large animals are spatially spread out greater distances from their parent plant (Seidler and Plotkin 2006). Seeds dispersed by animals are also commonly aggregated near roosting and nesting sites (Stebbins 1971). The distance of wind dispersed seeds depends greatly on the mass of the seed, and small, lighter seeds travel furthest (Stebbins 1971). Location of offspring is also relevant to the direction of wind (Greene and Johnson 1989). Wind and gravity create spatial patterns where the highest densities of offspring are closest to the parent plant (Janzen 1970, Connell 1971).

Spatial patterns are often modeled to predict future trends. There have been many attempts to model seed dispersal in order to predict spatial patterns (Chave et al. 2002; Wright 2002), but this task proves difficult when many field components are not depicted. Dispersal models often only consider one vector of dispersal and fail to recognize the potential of multiple vectors (Clark et al. 2003). Many factors affect the success of seed dispersal, including: the vegetation cover, soil resources and microclimate of the site (Wright 2002), and are often not included in models. Models are most effective when variables are measurable (Russo et al. 2006). Factors affecting wind dispersal, including: height of release, wind velocity, and seed mass are quantifiable (Greene and Johnson 1996). Factors affecting animal dispersal include more variable components that are harder to quantify, such as food availability, distribution of resources, weather and social dynamics (Nathan and Muller-Landau 2000; Russo et al. 2006). Long distance and rare dispersal events are difficult to model, since data on such events is hard to collect (Clark et al. 1998; Ouborg et al. 1999).

My objective of this study is to examine the data collected at Yosemite Forest Dynamic Plot (YFDP) to (1) determine how alpha diversity affects seed dispersal methods, (2) distinguish which species are rare, and (3) hypothesize how seed dispersal mechanisms contribute to the spatial patterns present at YFDP. I hypothesize the following: (a) the dominance of a few species will equate to a low alpha diversity at YFDP (b) species determined to be rare will exhibit the most unique spatial patterns when compared to the more dominant species that will have a more even distribution, and (c) a biotic vector of either a bird or mammal contributed to many of the spatial patterns present in YFDP.

2. METHODS

2.1. Study Site

The data originated from the Yosemite Forest Dynamics Plot (Figure 1), which is a 25.6 ha plot located near Crane Flat in Yosemite National Park (latitude 37.7° N, longitude 119.7° W). The elevation of YFDP varies from 1774 m in the north portion of the plot to 1911 m in the south (Figure 2). YFDP has a Mediterranean climate, consisting of cool, moist winters and hot, dry summers (Graber and White 1980). At the elevation of YFDP, most precipitation falls between November and April as snow (Graber and White 1980). Average temperatures at 1560 m in elevation range from 2°C in January to 18°C in July (Scholl and Taylor 2010). Soils at YFDP consist of the Craneflat Series of sandy-skeletal, isotic, frigid Humic Dystrochrepts that formed from granitoid rock (Soil Survey 2006).

YFDP was surveyed in 2009/2010 using total stations to establish a grid system with 400 m² squares. A number (1-40) and letter (A-P) were assigned to all points in the grid. All live trees and snags with DBH greater than one centimeter were tagged and mapped. There are 34468 live trees and 2717 snags in the plot consisting of the tree species: *Abies concolor* (ABCO), *Abies magnifica* (ABMA), *Cornus nuttallii* (CONU), *Calocedrus decurens* (CADE), *Pinus lambertiana* (PILA), *Pinus ponderosa* (PIPO), *Prunus emarginata* (PRUNUS), *Pseudotsuga menziesii* (PSME), *Quercus kelloggii* (QUKE), *Rhamnus californica* (RHCA), and *Salix scouleriana* (SALIX) (Table 1). *Salix* and *Prunus* individuals were consolidated at genus level.

TABLE 1. Quantity and basal area of tree species present at YFDP.

	Stems		Basal Area (m ²)	
	Alive	Snags	Alive	Snags
ABCO	24494	1994	749.8311	231.0055
AMBA	11	0	1.5641	0
CADE	1591	48	122.4198	11.1516
CONU	2370	1	6.6010	0.0113
PILA	4745	542	735.3544	242.4618
PIPO	2	0	0.3100	0
PRUNUS	128	0	0.0508	0
PSME	6	1	0.8986	1.2272
QUKE	1109	131	28.7906	4.0156
RHCA	1	0	0.0001	0
SASC	11	0	0.0038	0
Total:	34468	2717	1645.8243	489.873



FIGURE 1. Map of Yosemite Forest Dynamics Plot in Yosemite National Park, CA.

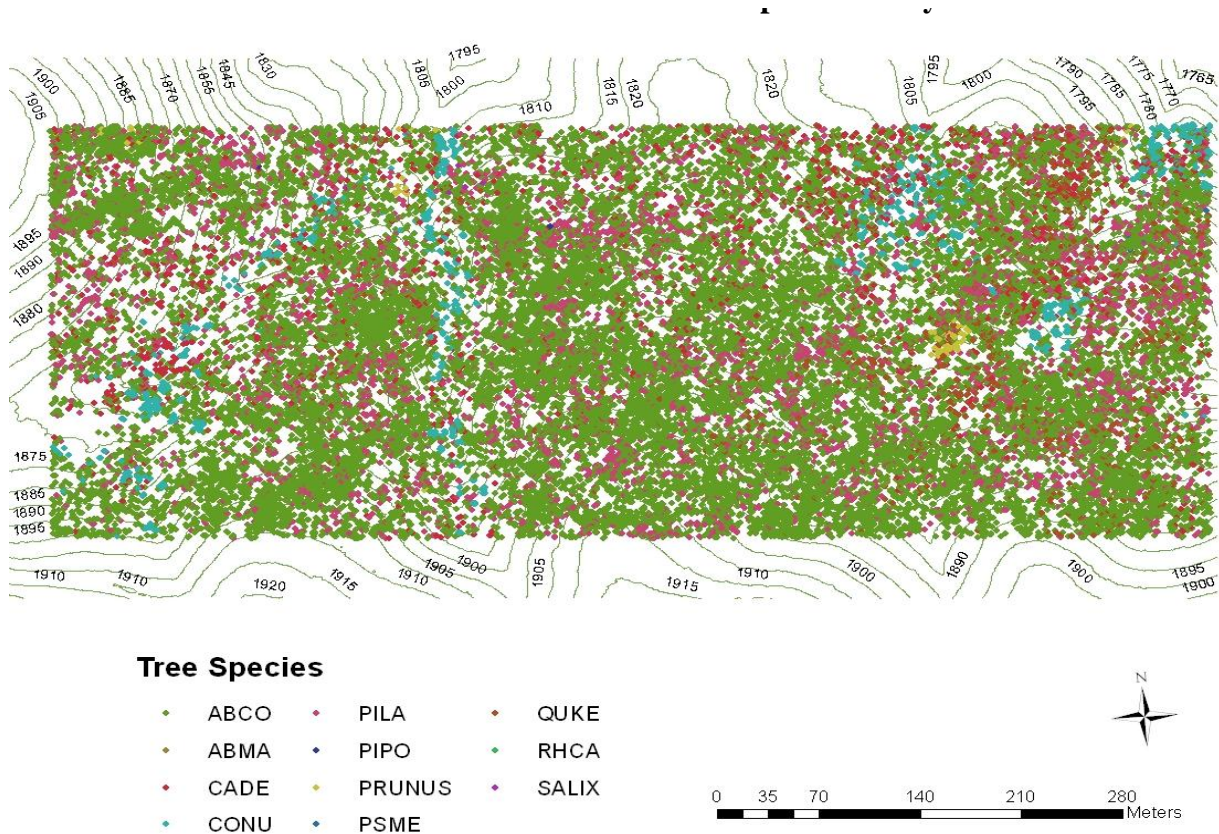


FIGURE 2. Tree species and their corresponding elevation in YFDP.

2.2 Alpha Diversity

I compared the alpha diversity of a temperate and tropical forest. I used YFDP as the temperate forest and the Barro Colorado Island Plot (BCI; 9.15° N, 79.51° W) in Panama as the tropical forest. BCI is a 50 ha plot with 208341 live trees with DBH greater than 1 cm. Average rainfall is 260 cm/yr, falling over the wet (May to November) and dry seasons (December to April) (Leigh Jr and de Alba 1992).

The Alpha diversity of these forests was determined by the Shannon-Wiener Index (Shannon 1948):

$$H' = \sum_{i=1}^S (p_i \ln p_i) \quad [1]$$

where H' is the measure of diversity, S is the number of species and p_i is the relative abundance of each species. The evenness (E) of the species (Shannon 1948), which is on a scale from zero to one, is determined by:

$$E = H' / H_{\max} \quad [2]$$

$$H_{\max} = \ln S \quad [3]$$

where H_{\max} is the highest number of H' possible given the number of species. This information will be correlated to mechanisms of dispersal, and the effects they may have on spatial patterns.

2.3 Rare Species Index

I determined the rare species of the plot, as these presented the most unique spatial patterns. I classified as rare those with a density less than 0.1 and an importance value index less than 1 percent using the importance value index (Curtis and McIntosh 1950):

$$\text{Importance} = \text{relative density} + \text{relative dominance} + \text{relative frequency} \quad [4]$$

I also used the density as a parameter of rarity, because the importance value index takes into consideration the basal area of the species. Species that are characterized by small diameter at breast height are thus compared to species that have large diameters at breast height. Relying solely on the importance value index gives an inaccurate depiction of the rare species.

2.4 Seed Dispersal

I tested the relevance of a model to describe spatial patterns. I used the Cremer model (1971):

$$D = V * H / V_f \quad [5]$$

where D is the dispersal distance in meters, V is the wind velocity in meters per second, H is the height of the presumed parent tree in meters, and V_f is the falling seed velocity of the species in meters per second, to determine potential patterns of wind dispersal. This model simplifies the wind data, since the downwind, crosswind, and velocities at different heights are not taken into consideration (Greene and Johnson 1989). I used wind data from the weather station on Crane Flat that is at latitude 37.75° N and longitude 119.82° W. Crane Flat is located south of YFDP at an elevation 2022 m above sea level, making it 111 m higher than YFDP (Weather conditions 2011). *Pinus ponderosa*, *Abies magnifica* and *Pseudotsuga menziesii* disperse their seeds in the fall (Table 2), so the data for the first day of September, October, November and December were used over three years (2008, 2009, 2010). *Salix scouleriana* disperse their seeds from May to June (Table 3), so the wind data for the first day of these two months were used for four years (2008, 2009, 2010, 2011). Two measurements were considered. The first was the average wind gust measured over the time period. The second measurement was maximum wind gust of the time period, and represented a rare dispersal event caused by a rare wind event. Data from LIDAR was used for the height (H) of the tree (Figure 3).

TABLE 2. Wind gust data at Crane Flat (m/s)

	2010	2009	2008
1-September	6.3	6.8	13.5
1-October	7.2	8.1	9.5
1-November	8.1	4.1	23.4
1-Decemeber	6.3	6.8	5.0
Average:	8.7		
Maximum:	23.4		

TABLE 3. Wind gust data for Crane Flat (m/s)

	2011	2010	2009	2008
1-May	7	6	8	8.4
1-June	8	6.7	8	13.4
Average:	8.1			
Maximum:	13.4			

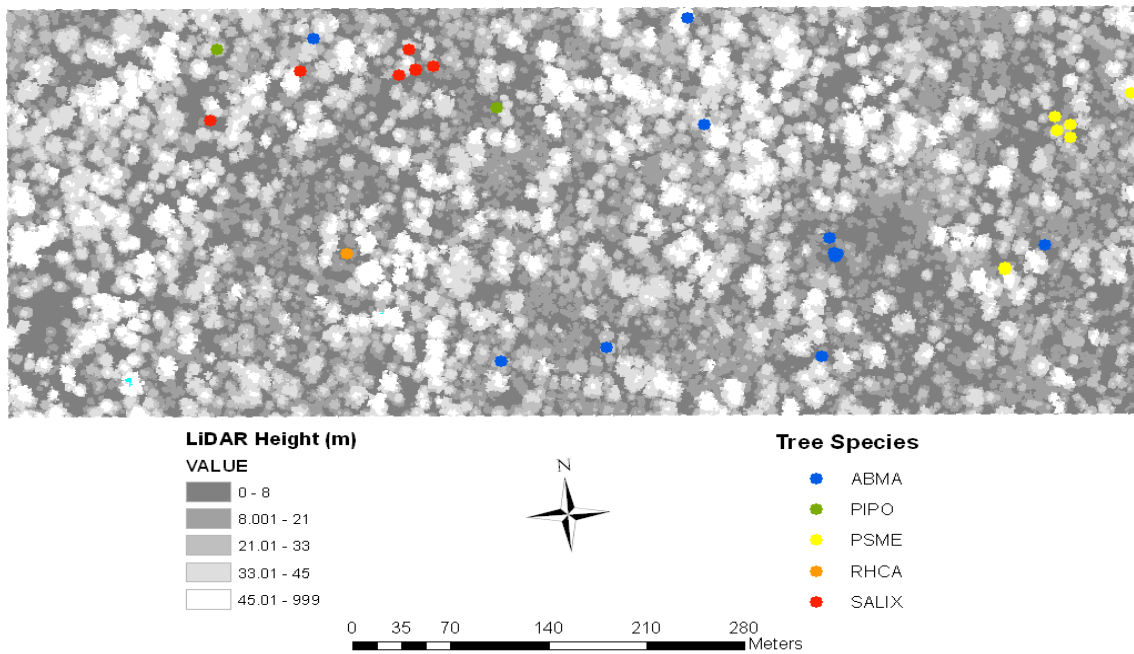


FIGURE 3. LiDAR data on heights of the rare species in YFDP.

I assumed the potential parent tree of an individual to be the nearest tree whose age, inferred by DBH, is of seed bearing capabilities. The difference in diameters of the parent tree and offspring need also be correlated to the abilities of the parent tree to produce the offspring. A potential parent tree may be located outside the perimeter of YFDP, so distance to nearest edge was considered. Coarse woody debris (CWD) was inventoried for YFDP, and was considered as potential parent trees. ArcGIS was used to measure distances between trees, and horizontal and transect distances were used to measure distances to the plot boundaries.

Seed characteristics vary between individual trees of the same species dependant upon most notably site conditions (Sharpe and Fields 1982). I assumed that seed characteristics at YFDP matched those available for the species. All data used is averaged (Table 4).

TABLE 4. Seed characteristics of rare species in YFDP.

Species	Weight (mg)	Decent Velocity (m/s)	Reproductive Age(Years)
ABMA	70.87	1.92	35 to 45
PIPO	46.82	1.30	7
PSME	20.47	1.31	10
RHCA	93.00	N/A	2 to 3
SASC	0.07	0.39	10

*All sources cited in text below.

2.41 *Pseudotsuga menseizii*

Pseudotsuga menziesii have seeds with a single wing and are primarily dispersed by wind and gravity (Siggins 1933). *Pseudotsuga menziesii* reach a minimum seed bearing age of fifteen years old, and disperse their seed from September to early winter depending on the surrounding environmental conditions (Allen 1942). Allen concluded that trees at 15 years in age have an average DBH of 10.30 cm. Dick (1955) found that the majority of *Pseudotsuga menziesii* seeds fall within 100 m of the parent tree, but noted reports that indicate dispersal from 1000 m to 2000 m away from the parent tree in the state of Washington. The amount of seed that is produced is variable, but Hermann and Lavender (1990) indicate that average amounts are 2.2 kg/ha, of which less than half are viable. They also indicate that the average *Pseudotsuga menziesii* seed in California has a weight of 19.61 mg. Vander Wall et al. (2006) collected 140 seeds of *Pseudotsuga menziesii* along Hwy 89, between Graeagle and Quincy, in northern California. They found average seed weight to be 24.80 mg, descent velocity to be 1.28 m/s, wing area to be 52 mm² and wind loading 0.52 mg/mm². A study done by Siggins (1933), in which he dropped seeds from designated heights, found that the *Pseudotsuga menziesii* seeds from California fell at a velocity of 1.34 m/s, and had an average mass of 17.00 mg. In the Sierra Nevada, *Pseudotsuga menziesii* have an elevation range of 610 m to 1830 m (Herman and Lavender 1990). Mean elevation of the species in Yosemite National Park is 1564 m (Lutz et al. 2010).

2.42 *Abies Magnifica*

Abies magnifica are most frequently dispersed by wind, which occurs from September to October (Gordon 1970). The seed bearing age of *Abies magnifica* in California is 35 to 45 years old, and the average weight is 70.87 mg (Schopmeyer 1974). At 30 years old, *Abies magnificfa* are noted to have a DBH of 30 cm in the Sierra region (Hill 1920). Cones are concentrated in the uppermost portion of the crown (Laacke 1990). The seeds generally fall within a radius equal to 1.5 to 2 times the height of the parent tree (Furniss and Carolin 1977). Siggins (1933) noted *Abies magnifica* to fall at an average velocity of 1.92 m/s. Elevation of *Abies magnifica* ranges from 2130 m to 2740 m in the Sierra Nevada (Laacke 1990). Mean elevation of *Abies magnifica* in Yosemite National Park is 2426 meters (Lutz et al. 2010).

2.43 *Pinus ponderosa*

Pinus ponderosa begin to bear seed when they are seven years old, and seeds are dispersed from September to November (Oliver and Ryker 1990; Krugman and Jenkinson 2008). Krugman and Jenkinson (2008) indicate the average weight of a seed to be 37.74 mg and they recorded seed bearing age to be 6 to 20 years old. Vander Wall (2008) found that of the California *Pinus ponderosa* trees he used in his study, seeds had an average weight of 55.9 mg, wing mass of 9.6 mg, wing loading of 0.029 g/cm², and descent velocity of 1.07 m/s. Siggins found average velocity to be 1.52 m/s. Seedlings are able to grow an average of 22cm per 10 years (Oliver and Ryker 1990). Vankat (1970) reported *Pinus ponderosa* stands to have basal areas ranging from 26 to 172 m² ha⁻¹. The average basal area being 46.49 m²ha⁻¹. The elevation range of *Pinus ponderosa* in the Sierra Nevada is 1200 m - 2100 m (Rundel et al. 1977). Mean elevation in Yosemite National Park is 1680 m (Lutz et al. 2010)

2.44 *Rhamnus californica*

The fruit of *Rhamnus californica* is a berrylike drupe that is 7-9 mm in diameter and contains two nutlike seeds (Hubbard 1974). Many animals consume *Rhamnus californica* berries, including many birds (especially band-tailed pigeons), black bears and woodrats (Dayton 1931; Conrad 1987). *Rhamnus californica* has a long lifespan of 100 to 200 years (Keeley 1981). Seed production occurs at 2 to 3 years in age (Everett 1957), and seeds are dispersed in the fall

(Keeley 1987). Seed weight is 93 mg (Keeley 1991). *Rhamnus californica* is present in California at elevations less than 2300 m (Sawyer 1993).

2.45 *Salix scouleriana*

Salix scouleriana disperse their seed by wind miles away from the parent tree between May and June (Sasada et al 2008). Seeds have an average weight of .07 mg (Anderson 2001). The seeds have plumage that increase the time they are airborne (Hickman 2003). This species starts producing seed around ten years of age (Anderson 2001). Seed decent velocity of *Populus tremuloides* will be used, since there has been no study on the decent velocity of *Salix scouleriana*. Both trees are in the family Salicaceae. *Populus tremuloides* has a seed weight of 0.13 mg, making it .06 mg bigger than *Salix scouleriana* (Perala 1990). The decent velocity of *Populus tremuloides* is 0.39 m/s (Leadem et al. 1997). *Salix scouleriana* commonly reproduce vegetatively (Voires 1981, Argus 1986). General elevation of *Salix scouleriana* ranges from sea level to 3000 m (Densmore and Zasada 1983).

2.46 Animal Dispersal

While no data was collected on animals present at YFDP, many species of animals are presumed present on the site and are listed in Appendix B. I assumed that general characteristics of animal seed dispersal at YFDP matched those available at other sites. The results will be incorporate into the discussion of the spatial patterns of the rare species.

3. RESULTS

3.1 Alpha Diversity

The alpha diversity of YFDP is 0.98. Species evenness is 0.09. Alpha diversity data for YFDP is shown in Table 5. The alpha diversity of BCI is 3.96. Species evenness is 0.32. Data for the alpha diversity of BCI is shown in Appendix A.

TABLE 5. Alpha Diversity of YFDP

	Number	p_i	$\ln(p_i)$	$\ln(p_i)*p_i$
ABCO	24494	0.71063	-0.34160	-0.24275
AMBA	11	0.00032	-8.04989	-0.00257
CADE	1591	0.04616	-3.07567	-0.14197
CONU	2370	0.06876	-2.67714	-0.18408
PILA	4745	0.13766	-1.98294	-0.27298
PIPO	2	0.00006	-9.75464	-0.00057
PREM/PRVI	128	0.00371	-5.59576	-0.02078
PSME	6	0.00017	-8.65603	-0.00151
QUKE	1109	0.03217	-3.43657	-0.11057
RHCA	1	0.00003	-10.44779	-0.00030
SASC	11	0.00032	-8.04989	-0.00257
Total:	34468.0		$H' =$	0.98065

3.2 Rare Species Index

The species determined rare at YFDP, which have a density less than 0.1 and importance value index of less than 1 percent, are: *Abies magnifica*, *Pinus ponderosa*, *Pseudotsuga menziesii*, *Rhamnus californica*, and *Salix scouleriana* (Table 6).

TABLE 6: Importance Value Index

	Number	Relative Density	Relative Frequency	Relative Dominance	Importance
ABCO	24494	65.826	65.830	34.910670	166.567
AMBA	11	0.030	0.030	0.072822	0.132
CADE	1591	4.276	4.276	5.699625	14.251
CONU	2370	6.369	6.369	0.307329	13.046
PILA	4745	12.752	12.752	34.236661	59.741
PIPO	2	0.005	0.005	0.014434	0.025
PREM/PRVI	128	0.344	0.344	0.002365	0.690
PSME	6	0.016	0.016	0.041835	0.074
QUKE	1109	2.980	2.980	1.340432	7.301
RHCA	1	0.003	0.003	0.000004	0.005
SASC	11	0.030	0.030	0.000177	0.059
Total:	34468				

Note: Relative density and relative frequency are equal because only one plot was analyzed. Relative dominance was calculated from dominance, which is the total basal area of a species divided by the area of YFDP (25.6 ha).

3.3 Seed Dispersal

TABLE 7. Potential Distances of Seed Dispersal Using the Cremer Model.

Species	Tag	Height*	Seed Velocity	Distance Average [¥]	Distance Maximum ^H
PSME	38-0698	5	1.31	33	89
PSME	38-0763	10	1.31	66	179
PSME	38-0735	39	1.31	259	697
PSME	36-0367	16**	1.31	73	196
ABMA	18-0073	24	1.92	109	293
ABMA	22-0143	26	1.92	118	317
ABMA	25-0616	27	1.92	122	329
ABMA	25-0783	50	1.92	227	609
ABMA	37-0553	19	1.92	86	232
PIPO	18-0888	3	1.3	20	54
SALIX	07-0447	6	0.39	125	206
SALIX	11-1061	6	0.39	134	360
SALIX	11-1062	3	0.39	67	180
SALIX	14-0646	3	0.39	67	180
SALIX	14-0648	4	0.39	89	240
SALIX	15-0647	4	0.39	89	240
SALIX	15-0648	4	0.39	89	240
SALIX	15-0665	26	0.39	580	1560
SALIX	15-0692	2	0.39	45	120

* Height of tree using the LiDAR data.

** 36-0367 is a snag, height was measure using a laser and is used in equation

¥ Distance inputing average wind gust (Table 3 and Table 4) into Cremer equation.

H Distance inputinn maximum wind gust (Table 3 and Table 4) into Cremer equation.

3.31 *Pseudotsuga menziesii*

There are seven *Pseudotsuga menziesii* individuals present in the plot (Figure 4). All are located in the eastern portion of YFDP between the elevations of 1805 m and 1850 m.

The seed dispersal distance of potential parent trees using the Cremer model is listed in Table 7. Potential seed bearing trees are those with DBH above 10 cm and include: 38-0698, 38-0763, 38-0735, 36-0367 and potential trees outside the perimeter of YFDP.

Distances between these individuals and the four boundaries of the plot are listed in Table 8. Potential parent trees are listed on the horizontal axis of the table and offspring are located on the vertical axis of the table. The parent tree for 40-0590, 38-0367 and 38-0735 is presumed to be outside the east perimeter of YFDP. The parent tree for 36-0373 is presumed to be 36-0367. The parent tree of 36-0763 is presumed to be 38-0735. The parent tree for 38-0797 is presumed to be 38-0735. The parent tree for 38-0698 is presumed to be 38-0698.

Of the rare species determined, only *Pseudotsuga menziesii* was identified in the CWD inventoried (Figure 5).

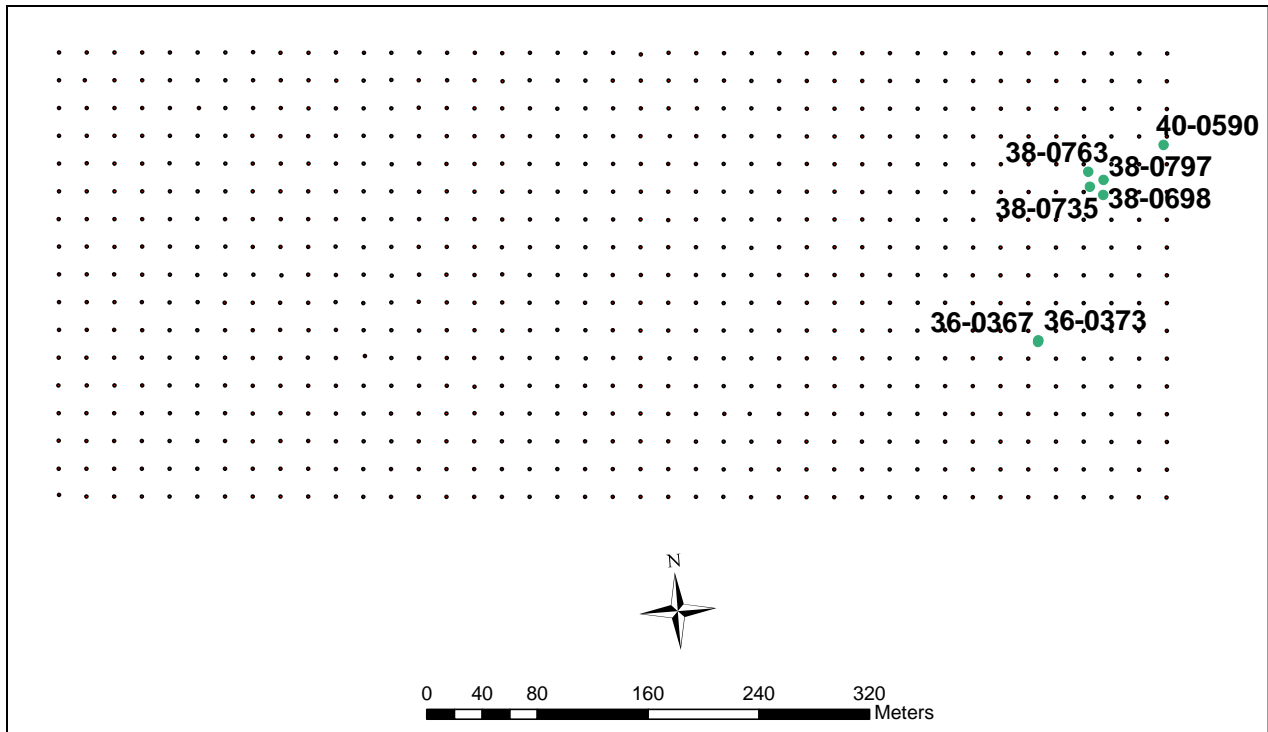


FIGURE 4. Location of *Pseudotsuga menziesii* in YFDP.

TABLE 8. Distances (in m) between potential parent *Pseudotsuga menziesii* trees and offspring.

		38-0698*	38-0763*	38-0735*	36-0367*	North [¥]	South [¥]	East [¥]	West [¥]
	DBH	10	30	102	125	-	-	-	-
40-0590	7	57	58	61	168	65	255	2	798
36-0373	5	115	128	117	1	206	113	93	707
38-0763	30	20	0	11	128	84	236	43	743
38-0797	8	11	13	11	126	91	229	46	754
38-0698	10	0	20	11	116	101	219	46	754
36-0367	125	-	-	-	-	207	113	94	706
38-0735	102	-	-	-	-	101	219	46	754

* Denotes potential parent tree

¥ Denotes potential parent tree on directional perimeter of plot

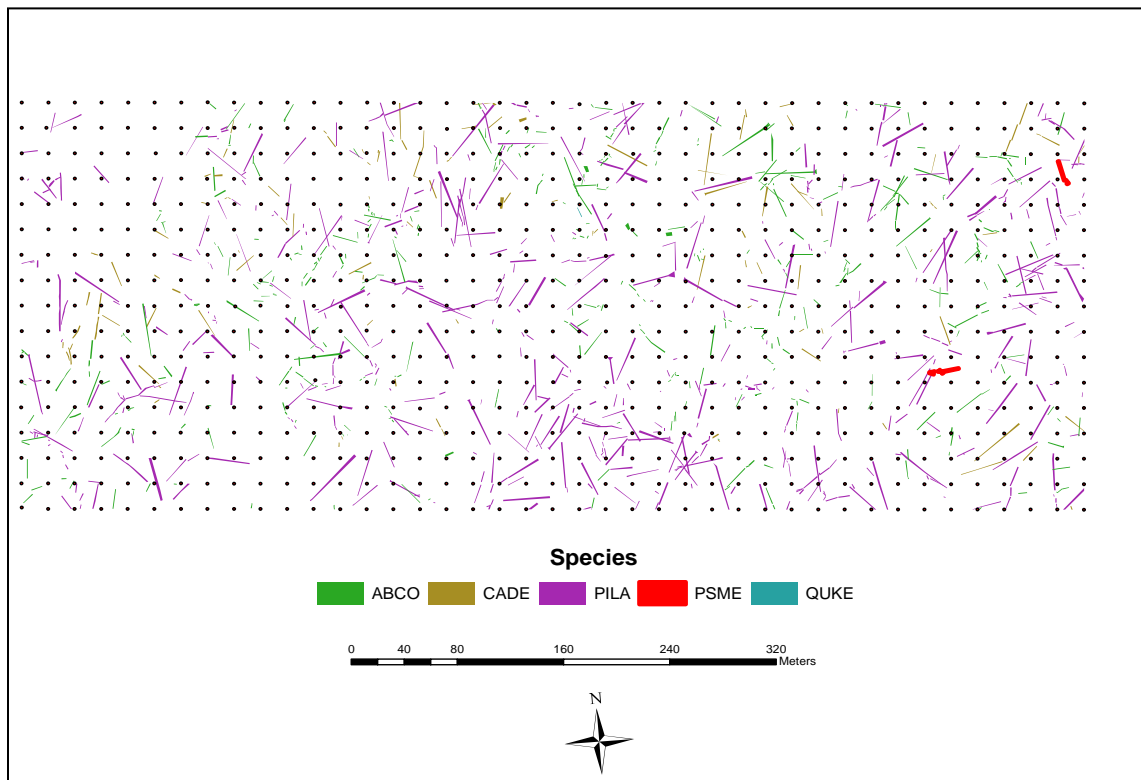


FIGURE 5. CWD of species in YFDP.

3.32 *Abies magnifica*

There are eleven *Abies magnifica* individuals present at YFDP (Figure 6). The *Abies magnifica* are spatially spread out, but the majority of the trees are present in the southeastern portion of YFDP. All are located between the elevations of 1818 m and 1900 m.

The seed dispersal distance of potential parent trees using the Cremer model is listed in Table 7. Potential seed bearing trees are those with DBH above 30 cm and include: 18-0073, 22-0134, 25-0616, 25-0783, 37-0553 and potential trees outside the perimeter of YFDP.

Distances between these individuals and the four boundaries of the plot are listed in Table 9. Potential parent trees are listed on the horizontal axis of the table and offspring are located on the vertical axis of the table. The parent tree for 11-1139 and 25-0783 is presumed to reside beyond the north perimeter of YFDP. The parent tree of 18-0073, 29-0206, 30-0354, 30-0365, 30-0355, 30-0353 and 22-0134 is presumed to reside beyond the south perimeter of YFDP. The parent tree for 25-0616 is presumed to be 25-0783. The parent tree of 37-0553 is presumed to reside beyond the east perimeter of the plot.

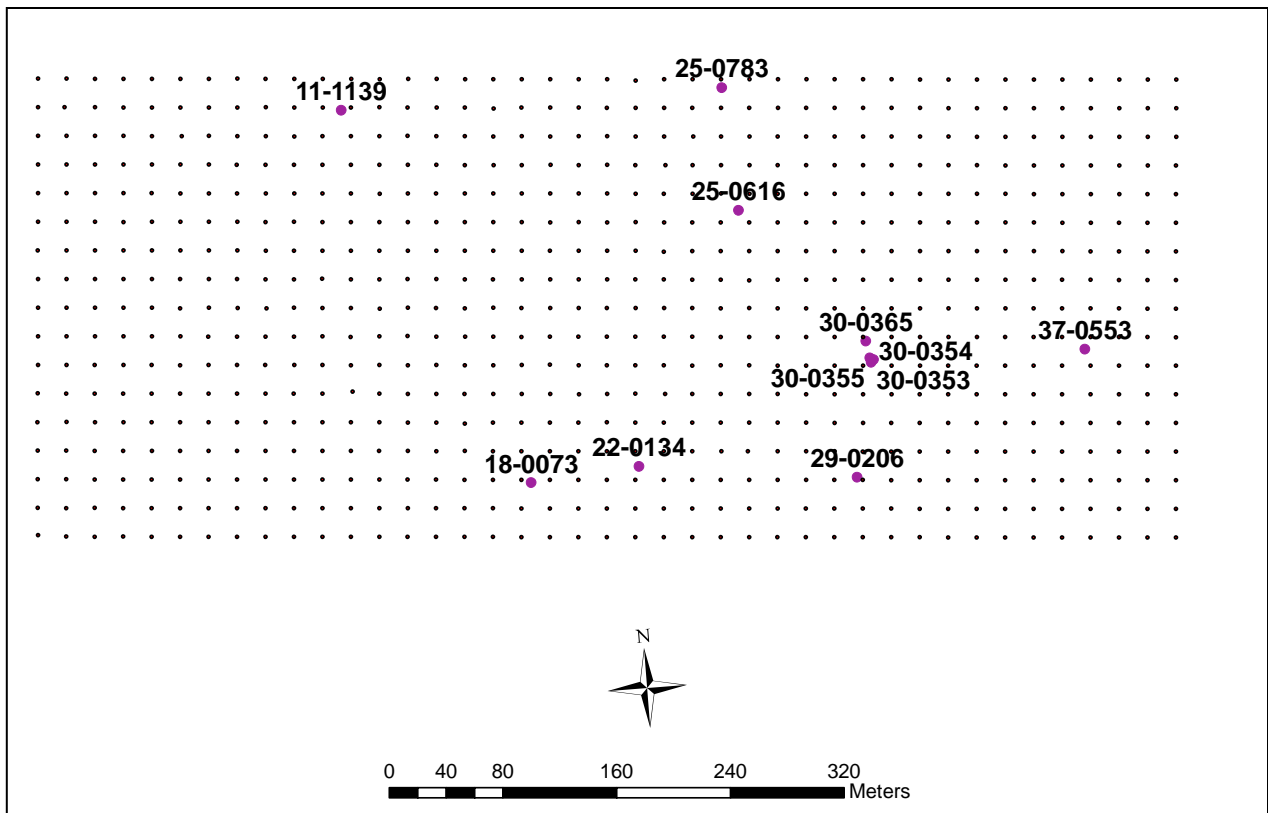


FIGURE 6. Location of *Abies magnifica* in YFDP

TABLE 9. Distances (in m) between potential parent *Abies magnifica* trees and offspring.

	18-0073*	22-0134*	25-0616*	25-0783*	37-0553*	North [¥]	South [¥]	East [¥]	West [¥]	
DBH	40	57.6	40.8	109.8	34.7					
11-1139	3.5	292	325	288	268	549	39	281	607	193
18-0073	39.9	0	77	240	307	400	282	38	454	347
22-0134	57.6	77	0	192	271	324	271	49	378	422
25-0616	40.8	240	192	0	87	262	91	229	307	493
37-0553	34.7	400	324	262	314	0	183	137	64	736
29-0206	4.8	229	153	204	288	183	278	42	224	576
30-0353	4.1	253	179	141	219	150	198	122	214	586
30-0354	3.8	256	181	141	218	149	196	124	213	587
30-0355	3.3	254	179	138	216	151	195	125	215	585
30-0365	1.7	255	182	128	204	154	182	138	218	582
25-0783							5	315	320	480

* Denotes potential parent tree

¥ Denotes potential parent tree on directional perimeter of plot

3.3 *Pinus Ponderosa*

There are two *Pinus ponderosa* in the plot (Figure 7). Both are present in the northwestern portion of YFDP between the elevations of 1840 m and 1850 m.

The seed dispersal distance of potential parent trees using the Cremer model is listed in Table 7. The potential seed bearing trees include: 18-0888 and potential trees outside the perimeter of YFDP.

Distances between these individuals and the four boundaries of the plot are listed in Table 10. Potential parent trees are listed on the horizontal axis of the table and offspring are located on the vertical axis of the table. The parent tree of both 08-0841 and 18-0888 is presumed to be located beyond the north perimeter of the plot.

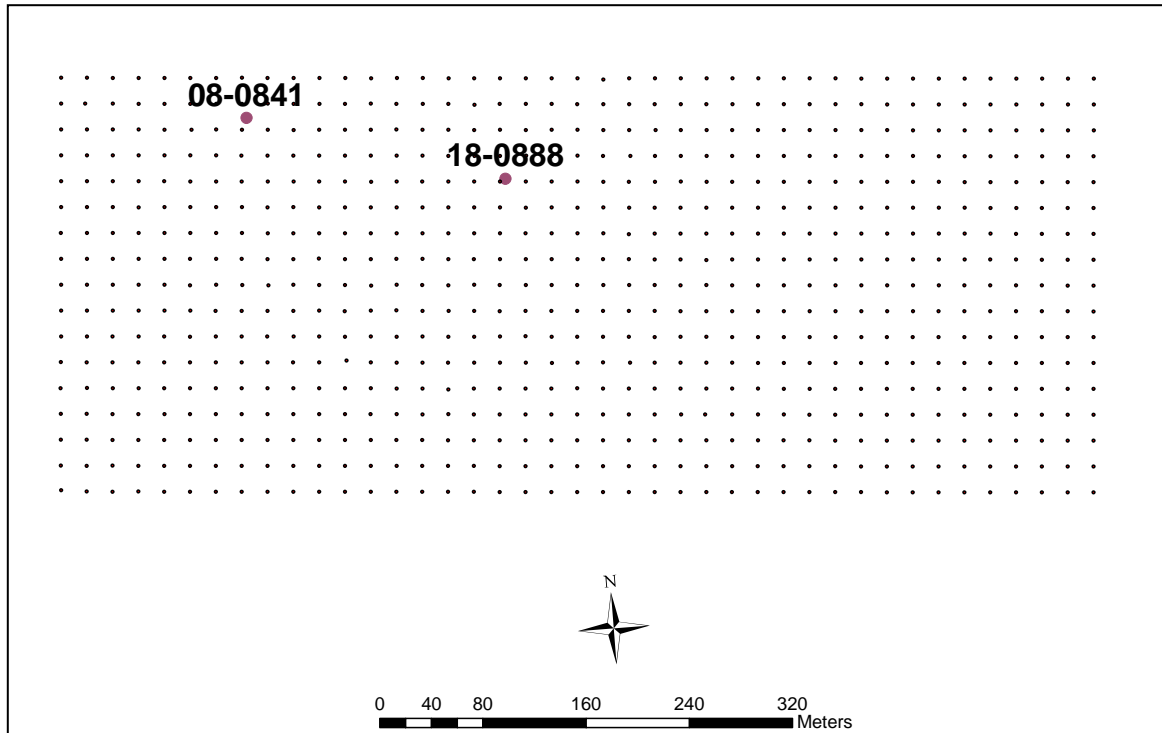


FIGURE 7. Locations of *Pinus Ponderosa* in YFDP.

TABLE 10. Distances (in m) between potential parent *Pinus ponderosa* trees and offspring.

	DBH	18-0888*	North [¥]	South [¥]	East [¥]	West [¥]
08-0841	1.9	206	30	350	657	143
18-0888	62.8		48	272	456	344

* Denotes potential parent tree

¥ Denotes potential parent tree on directional perimeter of plot

3.34 *Rhamnus californica*

There is one individual of *Rhamnus californica* in the plot (Figure 9). The tree is located at an elevation of approximately 1866 m. The distances between this tree and the plot boundaries are shown in Table 11. The parent tree of 12-0398 is presumed to reside beyond the south perimeter of YFDP. The Cremer model is not applicable in this situation, because *Rhamnus californica* is dispersed by animals.

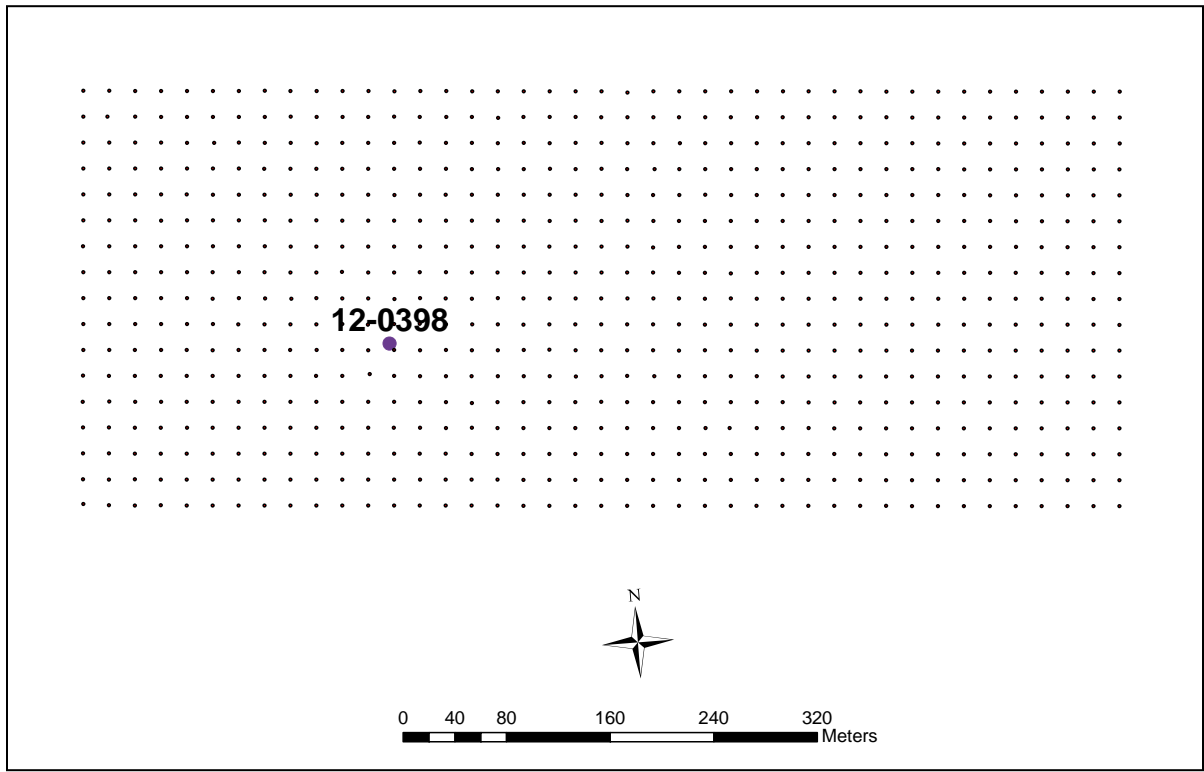


FIGURE 8. Location of *Rhamnus californica* in YFDP.

TABLE 11. Distances of *Rhamnus californica*.

	DBH	North [¥]	South [¥]	East [¥]	West [¥]
12-0398	1.1	195	125	564	236

¥ Denotes potential parent tree on directional perimeter of plot

3.23 *Salix scouleriana*

There are eleven *Salix scouleriana* individuals present in the plot (Figure 9). All are present in the northwestern portion of YFDP between the elevations of 1814 m and 1844 m.

The seed dispersal distance of potential parent trees using the Cremer model is listed in Table 7. Potential seed bearing trees include: 07-0447, 11-1061, 11-1062, 14-0646, 14-0648, 14-

0647, 15-0647, 15-0646, 15-0648, 15-0665, 15-0692 and potential trees outside the perimeter of YFDP.

Distances between these individuals and the four boundaries of the plot are listed in Table 12. Potential parent trees are listed on the horizontal axis of the table and offspring are located on the vertical axis of the table. The parent tree of 07-0447 is presumed to be either 11-1061 or 11-1062. The parent tree of 11-1061 and 11-1062 is presumed to reside beyond the north perimeter of YFDP. The parent tree of 14-0646, 14-0647, 14-0648, 15-0665 and 15-0692 is presumed to be either 15-0646, 15-0647 or 15-0648. The parent tree of 15-0646, 15-0647 and 15-0648 is presumed to be either 14-0648, 14-0647, 14-0646 or 15-0648.

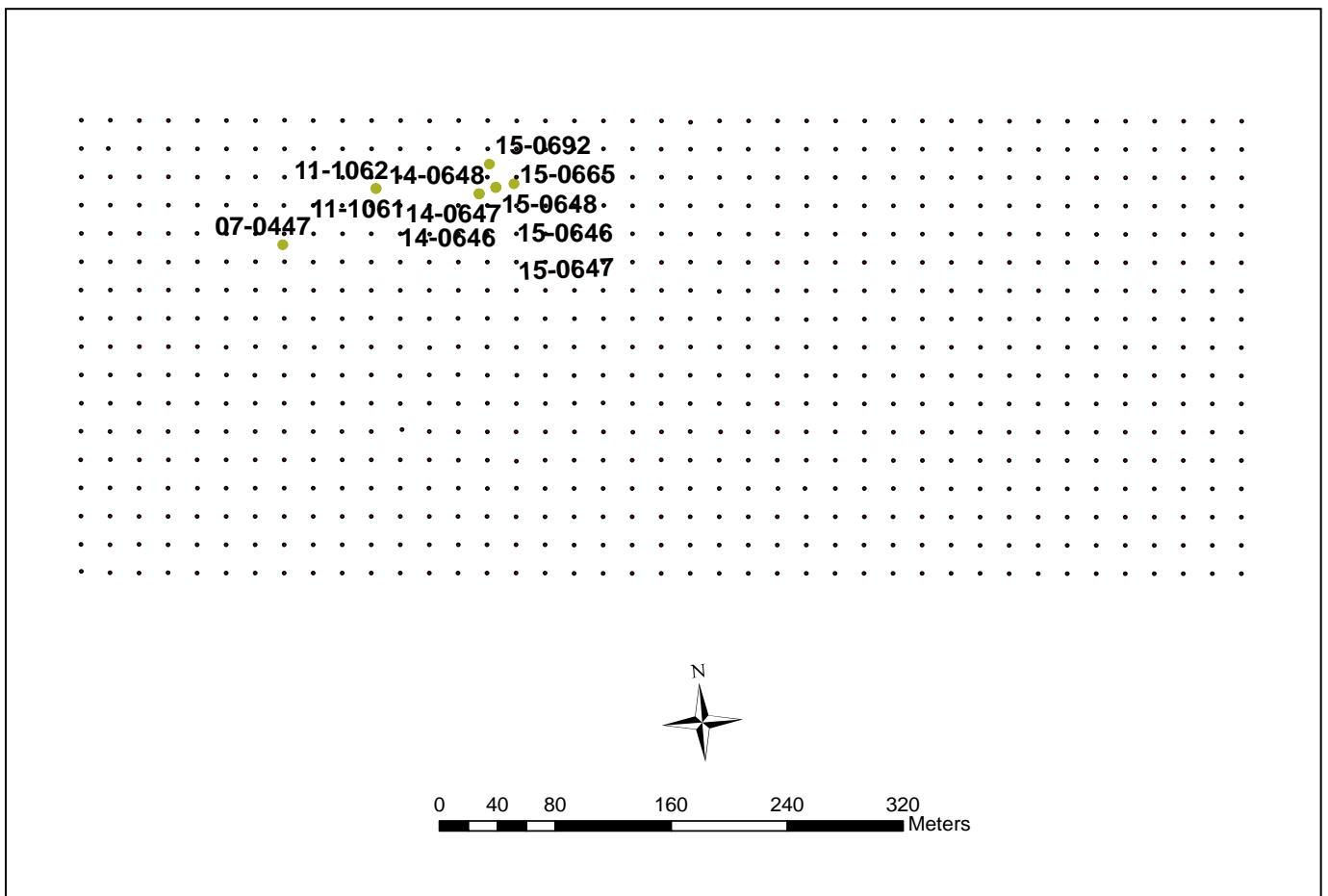


FIGURE 9. Locations of *Salix scouleriana* in YFDP

TABLE 12. Distances (in m) between potential parent *Salix scouleriana* trees and offspring.

		11-1061*	14-0646* 14-0647*	15-0646* 15-0648*	15-0647*	15-0648*	15-0665*	15-0692*	North‡	South‡	East‡	West‡
DBH	1.6	1.7	3	23	25	1	15	1.1				
07-0447	0	76	140	140	152	153	165	153	88	232	159	641
11-1061	76	0	71	71	83	83	95	80	48	272	203	597
11-1062	76	0	71	71	83	83	95	80	48	272	203	597
14-0646	140	71	0	0	12	12	25	22	51	269	274	526
14-0647	140	71	0	0	12	12	25	22	51	269	274	526
14-0648	140	71	0	0	12	12	25	22	51	269	274	526
15-0646	152	83	12	12	0	0	13	17	46	274	286	514
15-0647	152	83	12	12	0	0	13	17	46	274	286	514
15-0648	153	83	12	12	0	0	13	17	46	274	286	514
15-0665	165	95	25	25	13	13	0	22	43	277	298	502
15-0692	153	80	22	22	17	17	22	0	50	270	281	519

* Denotes potential parent tree

‡ Denotes potential parent tree on directional perimeter of plot

3.24 Animal Dispersal

Animals are capable of transferring a seed by direct contact with a seed through consumption and indirect contact with a seed when a seed adheres to the body of the animal. It is from this that all species that reside within the elevation range of YFDP are considered potential dispersers.

Birds are capable of dispersing seeds a greater mean and maximum distance than wind dispersion (Clark et al. 2005). Surrounding conditions, including: proximity to nest sites, other foraging sources within the forest, and breeding grounds have a large effect on the species of seeds birds choose to consume (Wenny and Levey 1998; Clark et al. 2004). Birds often disperse seeds directly by the parent tree as foraging and defecation can occur in the same area (Clark et al. 2005).

A study done by Hutchins and Lanner (1982) on animal dispersal in Whitebark pine forests found that the most common seed consumers at that site were Clark's Nutcracker, Steller's Jay, Pine Grosbeak and chipmunks. The Clark's Nutcracker was the most frequent consumer and many seeds were cached in various locations in the soil. Steller's Jays were also frequent

visitors, but often tore the seeds apart to eat them, making germination unlikely. Catches made by Stellar's Jay were not in the soil. Many of the other bird species also tore apart the seeds such as Mountain Chickadee, and Pine Grosbeak.

The effectiveness of rodents in seed dispersal is debatable. Hutchins and Lanner found that red squirrels were responsible of much of the seed caching in their study, but that squirrels place the seeds too deep to germinate. They also found that chipmunks buried their seeds too deep as well. Bradbrooks (1958) found that caches made by chipmunks averaged 28 cm in depth. However, many have proven that rodents are effective in acting as seed dispersers (Gordon 1943; Tevis 1953; MacClintock 1970). A study conducted by West (1968) concluded a patch of *Pinus ponderosa* seedlings originated from a rodent cache.

4. DISCUSSION

4.1 Alpha Diversity

Alpha diversity at YFDP (0.98) is low compared to BCI (3.96). This is a result of YFDP having only 11 species and BCI having 283 species. This follows the trend of a greater alpha diversity at lower latitudes than at higher latitudes. Tropical forests usually exhibit a greater amount of species diversity (Glenn-Lewin 1977). A hectare of Amazonian forest can contain 20-300 species (Gentry 1988). Species evenness of YFDP is 0.09, indicating that YFDP is not very even. It is heavily dominated by *Abies concolor* and *Pinus lambertiana*. Species evenness of BCI is 0.32, indicating that it is not very even, but more so than YFDP. Table 5 shows that the most dominant species in YFDP, *Abies concolor*, constitutes 71 percent of the total number of live trees. Appendix A show the most dominant species in BCI, *Hybanthus prunifolius*, counts for 14 percent of the total number of live trees. BCI reflects the more even distribution of individuals between the species as well as there being a greater number of species.

The high amount of alpha diversity in tropical forests also reflects the large number of animals present (Howe and Smallwood 1982). Together, the high diversity of flora and fauna in tropical forests contribute to a wide range of seed dispersal techniques (Muller-Landau et al. 2006). Producing a fruit that attracts many animal species increases the chances of it being consumed (Howe and Smallwood 1982).

General fruit characteristics differ between tropical and temperate forests. Fruit in temperate forests are often smaller and have less nutritional value than tropical fruit that have more pulp and larger seeds (Herrera 1981). Sautu et al. (2006) characterized the seed biology of 100 native species of trees in the Panama Canal Watershed, an area of tropical forest in Panama. The study concluded that the average seed weight of the 100 species is 1960 mg. The maximum weight is 58,820 mg and the minimum weight is .1 mg. The average seed weight of the rare species in YFDP is 46.25 mg. The maximum weight is 93 mg, and the minimum weight is 0.07 mg, stating that the seeds are much smaller than in the Panama Canal Watershed.

The vector by which plants disperse their seeds also can influence the success of the seed being dispersed (Wills et al. 1997). There are some advantages to animal dispersal compared to wind dispersal. Birds and mammals often migrate to or are in the area during the time of seed dispersal, whereas strong winds may occur when seeds are not ready for dispersal (Stebbins 1971). Animals tend to move from the parent plant to areas that are similar or where conditions

are adventitious to the animal, increasing the chance of a seeds being deposited on a microsite that is favorable to germination (Howe and Smallwood 182). The direction of wind is more variable and has a higher probability of transferring seeds to unfavorable conditions (Stebbins 1971).

4.2 Rare Species

The definition of rarity has no set standard. The criteria for the importance value index and density parameters in determining rarity were arbitrarily chosen, and as such are biased. The standards chosen for YFDP fit the specific location, but may not apply to other sites. Many of the rare species did display the most unique spatial patterns of the site in that their distribution was less even.

4.3 Seed Dispersal

The Cremer model presented tenuous results given important parameters were not included in the equation, some including: wind velocities from various heights of a tree, percent slope on which the tree is anchored, climate of the site, and potential for multiple vectors. Heights originated from LiDAR data, and were not specific to the tree. This method indicated the tallest tree in the area of the tag number and did not give exact measurements.

Seed morphology is a good indicator of the potential movements of the seed. It is found that small seeds with a smaller wind velocity are best transported by wind (Vander Wall 2003), and that larger seeds are more prone to animal dispersal (Vander Wall 2008). These parameters will be considered in the discussion of the rare species noted in YFDP.

4.32 *Pseudotsuga menziesii*

The *Pseudotsuga menziesii* present in YFDP are located in the upper extent of their elevation range, and extend out of the ranges indicated by Herman and Lavender. The presence of *Pseudotsuga menziesii* is still feasible given it is only 20 m above the indicated ranges.

Results of the Cremer equation are highly variable depending on the data inputs. As indicated in Table 7, 36-0367 is capable of dispersing seeds a distance of 73 m under average wind gust conditions. Tree 36-0373, the presumed offspring of the tree, is within this distance. Tree 38-0735 is capable of dispersing seeds 259 m. The presumed offspring: 38-0763, 38-0797

and 38-0698 are all within this distance. All trees are within 259 m of 38-0735, indicating that it could be the potential parent to all the trees, with the exception of 36-0367 whose DBH is greater than 38-0735. All offspring are within 100 meters of their presumed parent plant and are in accordance to the results of Dick.

Figure 5 shows *Pseudotsuga menziesii* CWD in the plot at close proximity to the standing trees. All diameters of the CWD place them at seed bearing age when they were alive, thus indicating that any of the CWD has the potential to be parent tree to any of the other *Pseudotsuga menziesii* trees. Uncertainty on how long ago the trees were alive and capable of producing seed makes correlations tenuous.

The close proximity of the *Pseudotsuga menziesii* trees to each other and to the plot boundaries makes wind dispersal the most likely vector of dispersal. Trees 38-0797, 38-0797 and 38-0698 are all located 11 m away in a semicircular fashion east of presumed parent tree 38-0735. The symmetry and similar direction in placement are characteristic of wind dispersal (Seidler and Plotkin 2006). *Pseudotsuga menziesii* have a large wing length to seed weight ratio when compared to other species, such as *Pseudotsuga macrocarpa*, making dispersal by wind more effective (Vander Wall et al. 2006). The animals listed in Appendix B could also be responsible for movement of seeds small distances, or for the placement of parent trees 36-0367 and 38-0735.

4.33 *Abies magnifica*

The *Abies magnifica* in the plot are well below their elevation ranges cited by Laacke and Lutz et al. The *Abies magnifica* at the highest elevation point is 230 m below 2130 m, the minimum elevation range. This makes the presence of this species in the plot of rarity. Most likely a rare event or long distance dispersal occurred.

All *Abies magnifica*, except 25-0616, have closest potential parent trees beyond the perimeter of YFDP. Trees are placed in a random spatial pattern, and offspring are not located closest to trees of seed bearing age. The Cremer model gives 25-0783 a dispersal distance of 227 when average wind gust is considered. Tree 25-0616 falls within this range, and it can be inferred that 25-0783 is the parent tree. Using maximum wind gust, 25-0783 is capable of a dispersal distance of 609 m. This distance means that if a wind gust of 23.4 m/s were to have originated from the north, all individuals present could have originated from 25-0783.

However, this is highly unlikely given the spatial patterns of *Abies magnifica* present at YFDP. It is more probable that animals or a combination of animals and wind are responsible for the spatial patterns present. *Abies magnifica* have a large seed weight of 70.87 mg, which is often favorable to animals given the high nutrient content (Vander Wall 2008). The large weight also equates to a fast decent velocity that is unable to transport seeds far distances. The characteristics of seed dispersing animals, described in 3.24, indicates that most of the *Abies magnifica* in YFDP were probably dispersed by birds. Squirrels are unlikely the disperser due to the depth of burial (Hutchins and Lanner 1982).

4.34 *Pinus ponderosa*

Pinus ponderosa are present within the upper limits of their elevation range cited by Rundel et al. At YFDP, the *Pinus ponderosa* at the lowest elevation range is 160 m above the mean elevation cited by Lutz et al.

The closest parent tree of both *Pinus ponderosa* trees is presumed to be beyond the north perimeter of YFDP. The Cremer model gives 18-0888 a dispersal distance of 54 m when maximum wind gusts are considered. This model predicts that 18-0888 is not the parent tree to 08-0841, since the distance between them is greater than 54 m.

The average weight of the *Pinus ponderosa* seed indicated in Table 4 is 46.82 mg, making it 26.35 mg larger than *Pseudotsuga menziesii*. The decent velocity of *Pinus ponderosa* is 1.30 m/s, while the decent velocity of *Pseudotsuga menziesii* is 1.31 m/s. *Pinus ponderosa* have a lower decent velocity compared to their weight. Together the large seed weight and low decent velocity make the species a viable wind disperser and an effective specimen for animal dispersal.

While it is possible that a parent *Pinus ponderosa* resides beyond the perimeter of YFDP, an animal is most likely the cause of the spatial patterns of this species in YFDP. Given the distance between the individuals, it is most likely that a bird distributed the seeds to their locations, given birds disperse seeds greater distances than rodents (Clark et al. 2005). Vander Wall (2008) found that animals gathered 38 percent of the seeds of the *Pinus ponderosa* in the 60 days observation study conducted. He noted the importance of animals in the dispersal patterns of *Pinus ponderosa*.

The Vander Wall study (2008) concluded an inverse relationship between seed size and predation rates. A significant portion of the seedling establishment of *Pinus ponderosa* was due to seed catching rodents. This was a result of the relatively large size of the seed. Rodents have a greater chance of burying the seeds, which increases the chances of germination given the favorable microcondition (Brewer and Rejmanek 1999, Forget 1990, Forget 1992).

4.35 *Rhamnus californica*

There is only one *Rhamnus californica* present in YFDP. The origin of this tree is most likely from outside YFDP, unless it is a relic population. The individual at the site is within the cited elevation ranges made by Sawyer (1993). The fruit of *Rhamnus californica* is a drupe and is dispersed by animals. Given the large distance between the tree and the perimeters of the plot, a bird or bear is most likely the disperser of this tree (Clark et al. 2005).

4.36 *Salix scouleriana*

All trees of this species are within the elevation ranges cited by Densmore and Zasada. Most trees are aggregated by each other, and are in or in close proximity to N11, N14 and N15 and 015. The Cremer model gives the correlation that all of the *Salix* trees have the potential to be the parent plant of the other trees. There is little research on the relation between DBH and age, so the potential parent trees that dispersed seeds were indistinguishable. All trees had the potential to be parent trees through vegetative reproduction.

Analysis of the LiDAR data gave the *Salix* species uncharacteristic heights compared to their DBHs. Through the LiDAR data, tree 15-0665 was associated with the tree height of 26 m. This is highly unlikely, given the DBH of this tree is 1.5 cm.

Seeds of *Salix scouleriana* are small and thus easily taken long distances by wind. Wind is most effective for smaller seeds (Siepielski and Benkman 2007). Animals are most likely not attracted to these seeds given their poor nutrient composition, suggesting that wind is the most likely cause of the spatial patterns.

5. CONCLUSION

Alpha diversity contributes to the seed dispersal potential of a forest. Those with high alpha diversity have a greater number of potential vectors of dispersal than those with lower alpha diversity. This diversity in dispersal vectors often leads to more diverse spatial patterns as each vector is capable of contrasting movement.

With much research on climate change, movement capabilities of plants through seed dispersal are highly desirable and often modeled. While it was proposed by Anderson (1991) that models are a better representation of data, because they are more precise and have better explanatory power when compared to phenomenological description, this may not always be the case. Seed dispersal models are often a generalization of the event, and factors such as climate, soil properties, individual vector characteristics and various wind descriptors are not included. This makes results tenuous. Models need to be calibrated to the specific site at which the data is accumulated, so unique characteristics of the site can be considered. The Cremer model was an inaccurate depiction of YFDP, and results could be molded depending on inputs to fit an array of conclusions.

There are many animals present in YFDP. While they may not be the characteristic disperser of most of the rare species present at YFDP, they are most likely consuming seeds and contributing to the spatial patterns of the area. The Vander Wall (2008) study found that rodents removed 99% of the *Pinus lambertiana* in the Whittell Forest and Wildlife Area in Nevada. As shown in Table 5, *Pinus lambertiana* is the second most dominant species in YFDP, indicating the method of animal dispersal to be more important than historically considered. As apparent from the differences in data from studies at various locations, seed morphology is characteristic of the individual tree and specific location. A basic trend holds that individuals at sites with high animal dispersal potential have greater seed weights than individuals where numbers are not as high (Wilson 1990). The biotic vectors at YFDP need to be considered in further research, and their importance quantified in attempts to understand the co-existence of the tree and animal species. Further research is needed on the specific seed characteristics of the species at YFDP as well as a study on the habits of the animals present.

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APPENDIX A: Alpha Diversity of BCI Species

Species	Number	p_i	$\ln(p_i)$	$\ln(p_i)*p_i$
Abarema macradenia	1	0.000005	-12.2469	-0.0001
Acacia melanoceras	22	0.000106	-9.1559	-0.0010
Acalypha diversifolia	746	0.003581	-5.6322	-0.0202
Acalypha macrostachya	52	0.000250	-8.2957	-0.0021
Adelia macrostachya	142	0.000682	-7.2911	-0.0050
Aegiphila panamensis	44	0.000211	-8.4627	-0.0018
Alchornea costaricensis	227	0.001090	-6.8220	-0.0074
Alchornea latifolia	2	0.000010	-11.5538	-0.0001
Alibertia edulis	370	0.001776	-6.3334	-0.0112
Allophylus psilospermus	103	0.000494	-7.6122	-0.0038
Alseis blackiana	7,754	0.037218	-3.2910	-0.1225
Amaioua corymbosa	22	0.000106	-9.1559	-0.0010
Anacardium excelsum	25	0.000120	-9.0281	-0.0011
Anaxagorea panamensis	794	0.003811	-5.5698	-0.0212
Andira inermis	278	0.001334	-6.6193	-0.0088
Annona acuminata	485	0.002328	-6.0628	-0.0141
Annona spraguei	123	0.000590	-7.4347	-0.0044
Apeiba membranacea	289	0.001387	-6.5805	-0.0091
Apeiba tibourbou	39	0.000187	-8.5834	-0.0016
Aphelandra sinclairiana	8	0.000038	-10.1675	-0.0004
Appunia seibertii	2	0.000010	-11.5538	-0.0001
Ardisia bartlettii	5	0.000024	-10.6375	-0.0003
Ardisia fendleri	103	0.000494	-7.6122	-0.0038
Ardisia guianensis	17	0.000082	-9.4137	-0.0008
Aspidosperma spruceanum	469	0.002251	-6.0963	-0.0137
Astrocaryum standleyanum	165	0.000792	-7.1410	-0.0057
Astronium graveolens	97	0.000466	-7.6722	-0.0036
Attalea butyracea	34	0.000163	-8.7206	-0.0014
Bactris barronis	5	0.000024	-10.6375	-0.0003
Bactris coloniata	2	0.000010	-11.5538	-0.0001
Bactris major	80	0.000384	-7.8649	-0.0030
Beilschmiedia pendula	2,115	0.010152	-4.5901	-0.0466
Borojoa panamensis	1	0.000005	-12.2469	-0.0001
Brosimum alicastrum	892	0.004281	-5.4535	-0.0233
Brosimum guianense	5	0.000024	-10.6375	-0.0003
Calophyllum longifolium	1,427	0.006849	-4.9836	-0.0341
Capparis frondosa	2,749	0.013195	-4.3279	-0.0571
Casearia aculeata	434	0.002083	-6.1739	-0.0129
Casearia arborea	124	0.000595	-7.4266	-0.0044
Casearia commersoniana	24	0.000115	-9.0689	-0.0010
Casearia guianensis	14	0.000067	-9.6079	-0.0006
Casearia sylvestris	131	0.000629	-7.3717	-0.0046
Cassipourea elliptica	1,069	0.005131	-5.2725	-0.0271
Cavanillesia platanifolia	24	0.000115	-9.0689	-0.0010
Cecropia insignis	1,144	0.005491	-5.2046	-0.0286

APPENDIX A (continued)

Species	Number	p_i	$\ln(p_i)$	$\ln(p_i)*p_i$
<i>Cecropia obtusifolia</i>	235	0.001128	-6.7873	-0.0077
<i>Cedrela odorata</i>	10	0.000048	-9.9443	-0.0005
<i>Ceiba pentandra</i>	64	0.000307	-8.0880	-0.0025
<i>Celtis schippii</i>	114	0.000547	-7.5107	-0.0041
<i>Cespedesia spathulata</i>	2	0.000010	-11.5538	-0.0001
<i>Cestrum megalophyllum</i>	54	0.000259	-8.2579	-0.0021
<i>Chamaedorea tepejilote</i>	7	0.000034	-10.3010	-0.0003
<i>Chamguava schippii</i>	449	0.002155	-6.1399	-0.0132
<i>Chimarrhis parviflora</i>	3	0.000014	-11.1483	-0.0002
<i>Chrysochlamys eclipses</i>	391	0.001877	-6.2782	-0.0118
<i>Chrysophyllum argenteum</i>	670	0.003216	-5.7397	-0.0185
<i>Chrysophyllum cainito</i>	147	0.000706	-7.2565	-0.0051
<i>Cinnamomum triplinerve</i>	59	0.000283	-8.1694	-0.0023
<i>Clidemia dentata</i>	18	0.000086	-9.3566	-0.0008
<i>Clidemia octona</i>	12	0.000058	-9.7620	-0.0006
<i>Coccoloba coronata</i>	112	0.000538	-7.5284	-0.0040
<i>Coccoloba manzinellensis</i>	372	0.001786	-6.3280	-0.0113
<i>Cojoba rufescens</i>	2	0.000010	-11.5538	-0.0001
<i>Colubrina glandulosa</i>	1	0.000005	-12.2469	-0.0001
<i>Conostegia bracteata</i>	4	0.000019	-10.8606	-0.0002
<i>Conostegia cinnamomea</i>	98	0.000470	-7.6620	-0.0036
<i>Cordia alliodora</i>	148	0.000710	-7.2497	-0.0052
<i>Cordia bicolor</i>	658	0.003158	-5.7577	-0.0182
<i>Cordia lasiocalyx</i>	1,171	0.005621	-5.1813	-0.0291
<i>Coussarea curvigemma</i>	2,058	0.009878	-4.6174	-0.0456
<i>Coutarea hexandra</i>	3	0.000014	-11.1483	-0.0002
<i>Croton billbergianus</i>	468	0.002246	-6.0985	-0.0137
<i>Cupania cinerea</i>	10	0.000048	-9.9443	-0.0005
<i>Cupania latifolia</i>	46	0.000221	-8.4183	-0.0019
<i>Cupania rufescens</i>	92	0.000442	-7.7251	-0.0034
<i>Cupania seemannii</i>	1,213	0.005822	-5.1461	-0.0300
<i>Dendropanax arboreus</i>	88	0.000422	-7.7696	-0.0033
<i>Desmopsis panamensis</i>	11,327	0.054368	-2.9120	-0.1583
<i>Diospyros artanthifolia</i>	95	0.000456	-7.6931	-0.0035
<i>Dipteryx oleifera</i>	51	0.000245	-8.3151	-0.0020
<i>Drypetes standleyi</i>	2,180	0.010464	-4.5599	-0.0477
<i>Elaeis oleifera</i>	21	0.000101	-9.2024	-0.0009
<i>Enterolobium schomburgkii</i>	13	0.000062	-9.6820	-0.0006
<i>Erythrina costaricensis</i>	89	0.000427	-7.7583	-0.0033
<i>Erythroxylum macrophyllum</i>	242	0.001162	-6.7580	-0.0078
<i>Erythroxylum panamense</i>	110	0.000528	-7.5465	-0.0040
<i>Eugenia coloradoensis</i>	611	0.002933	-5.8318	-0.0171
<i>Eugenia galalonensis</i>	1,751	0.008404	-4.7790	-0.0402
<i>Eugenia nesiotica</i>	482	0.002314	-6.0690	-0.0140
<i>Eugenia oerstediana</i>	1,816	0.008716	-4.7425	-0.0413
<i>Faramea occidentalis</i>	26,038	0.124978	-2.0796	-0.2599
<i>Ficus bullenei</i>	5	0.000024	-10.6375	-0.0003
<i>Ficus costaricana</i>	8	0.000038	-10.1675	-0.0004

APPENDIX A (continued)

Species	Number	p_i	$\ln(p_i)$	$\ln(p_i)*p_i$
Ficus insipida	16	0.000077	-9.4743	-0.0007
Ficus maxima	8	0.000038	-10.1675	-0.0004
Ficus obtusifolia	6	0.000029	-10.4552	-0.0003
Ficus popenoei	3	0.000014	-11.1483	-0.0002
Ficus tonduzii	24	0.000115	-9.0689	-0.0010
Ficus trigonata	5	0.000024	-10.6375	-0.0003
Ficus yoponensis	7	0.000034	-10.3010	-0.0003
Garcinia intermedia	4,602	0.022089	-3.8127	-0.0842
Garcinia madruno	393	0.001886	-6.2731	-0.0118
Genipa americana	66	0.000317	-8.0573	-0.0026
Guapira standleyana	164	0.000787	-7.1471	-0.0056
Guarea 'fuzzy'	823	0.003950	-5.5340	-0.0219
Guarea grandifolia	59	0.000283	-8.1694	-0.0023
Guarea guidonia	1,774	0.008515	-4.7659	-0.0406
Guatteria dumetorum	896	0.004301	-5.4490	-0.0234
Guazuma ulmifolia	64	0.000307	-8.0880	-0.0025
Guettarda foliacea	268	0.001286	-6.6559	-0.0086
Gustavia superba	734	0.003523	-5.6484	-0.0199
Hamelia axillaris	98	0.000470	-7.6620	-0.0036
Hampea appendiculata	140	0.000672	-7.3053	-0.0049
Hasseltia floribunda	484	0.002323	-6.0648	-0.0141
Heisteria acuminata	100	0.000480	-7.6418	-0.0037
Heisteria concinna	927	0.004449	-5.4150	-0.0241
Herrania purpurea	521	0.002501	-5.9912	-0.0150
Hieronyma alchorneoides	85	0.000408	-7.8043	-0.0032
Hirtella americana	25	0.000120	-9.0281	-0.0011
Hirtella triandra	4,566	0.021916	-3.8205	-0.0837
Hura crepitans	103	0.000494	-7.6122	-0.0038
Hybanthus prunifolius	29,846	0.143256	-1.9431	-0.2784
Inga acuminata	424	0.002035	-6.1972	-0.0126
Inga cocleensis	48	0.000230	-8.3757	-0.0019
Inga goldmanii	313	0.001502	-6.5007	-0.0098
Inga laurina	60	0.000288	-8.1526	-0.0023
Inga marginata	400	0.001920	-6.2555	-0.0120
Inga mucuna	2	0.000010	-11.5538	-0.0001
Inga nobilis	615	0.002952	-5.8253	-0.0172
Inga oerstediana	2	0.000010	-11.5538	-0.0001
Inga pezizifera	126	0.000605	-7.4106	-0.0045
Inga punctata	32	0.000154	-8.7812	-0.0013
Inga ruiziana	8	0.000038	-10.1675	-0.0004
Inga sapindoides	205	0.000984	-6.9239	-0.0068
Inga spectabilis	21	0.000101	-9.2024	-0.0009
Inga thibaudiana	178	0.000854	-7.0651	-0.0060
Inga umbellifera	797	0.003825	-5.5661	-0.0213
Jacaranda copaia	280	0.001344	-6.6121	-0.0089
Lacistema aggregatum	1,276	0.006125	-5.0954	-0.0312
Lacmellea panamensis	100	0.000480	-7.6418	-0.0037
Laetia procera	26	0.000125	-8.9888	-0.0011

APPENDIX A (continued)

Species	Number	p_i	$\ln(p_i)$	$\ln(p_i)*p_i$
Laetia thamnia	410	0.001968	-6.2308	-0.0123
Lafoensia puniceifolia	5	0.000024	-10.6375	-0.0003
Licania hypoleuca	127	0.000610	-7.4027	-0.0045
Licania platypus	266	0.001277	-6.6634	-0.0085
Lindackeria laurina	59	0.000283	-8.1694	-0.0023
Lonchocarpus heptaphyllus	659	0.003163	-5.7562	-0.0182
Lozania pittieri	1	0.000005	-12.2469	-0.0001
Luehea seemanii	190	0.000912	-6.9999	-0.0064
Maclura tinctoria	1	0.000005	-12.2469	-0.0001
Macrocnemum roseum	94	0.000451	-7.7036	-0.0035
Malpighia romeroana	38	0.000182	-8.6093	-0.0016
Maquira guianensis	1,396	0.006701	-5.0056	-0.0335
Margaritaria nobilis	2	0.000010	-11.5538	-0.0001
Marila laxiflora	23	0.000110	-9.1114	-0.0010
Maytenus schippii	77	0.000370	-7.9031	-0.0029
Miconia affinis	389	0.001867	-6.2834	-0.0117
Miconia argentea	518	0.002486	-5.9970	-0.0149
Miconia elata	12	0.000058	-9.7620	-0.0006
Miconia hondurensis	58	0.000278	-8.1865	-0.0023
Miconia impetioaris	14	0.000067	-9.6079	-0.0006
Miconia nervosa	262	0.001258	-6.6786	-0.0084
Mosannonna garwoodii	472	0.002266	-6.0900	-0.0138
Mouriri myrtilloides	6,540	0.031391	-3.4612	-0.1087
Myrcia gatunensis	46	0.000221	-8.4183	-0.0019
Myrospermum frutescens	9	0.000043	-10.0497	-0.0004
Nectandra 'fuzzy'	2	0.000010	-11.5538	-0.0001
Nectandra cissiflora	179	0.000859	-7.0595	-0.0061
Nectandra lineata	112	0.000538	-7.5284	-0.0040
Nectandra purpurea	70	0.000336	-7.9984	-0.0027
Neea amplifolia	69	0.000331	-8.0128	-0.0027
Ochroma pyramidale	10	0.000048	-9.9443	-0.0005
Ocotea cernua	237	0.001138	-6.7789	-0.0077
Ocotea oblonga	162	0.000778	-7.1593	-0.0056
Ocotea puberula	131	0.000629	-7.3717	-0.0046
Ocotea whitei	374	0.001795	-6.3227	-0.0114
Oenocarpus mapora	1,787	0.008577	-4.7586	-0.0408
Ormosia amazonica	1	0.000005	-12.2469	-0.0001
Ormosia coccinea	105	0.000504	-7.5930	-0.0038
Ormosia macrocalyx	111	0.000533	-7.5374	-0.0040
Ouratea lucens	1,227	0.005889	-5.1346	-0.0302
Pachira quinata	1	0.000005	-12.2469	-0.0001
Pachira sessilis	15	0.000072	-9.5389	-0.0007
Palicourea guianensis	851	0.004085	-5.5005	-0.0225
Pentagonia macrophylla	300	0.001440	-6.5431	-0.0094
Perebea xanthochyma	233	0.001118	-6.7959	-0.0076
Picramnia latifolia	1,059	0.005083	-5.2819	-0.0268
Piper aequale	27	0.000130	-8.9511	-0.0012
Piper arboreum	19	0.000091	-9.3025	-0.0008

APPENDIX A (continued)

Species	Number	p_i	$\ln(p_i)$	$\ln(p_i)*p_i$
Piper colonense	16	0.000077	-9.4743	-0.0007
Piper cordulatum	50	0.000240	-8.3349	-0.0020
Piper perlasense	17	0.000082	-9.4137	-0.0008
Piper reticulatum	131	0.000629	-7.3717	-0.0046
Piper schiedeianum	5	0.000024	-10.6375	-0.0003
Platymiscium pinnatum	146	0.000701	-7.2633	-0.0051
Platyodium elegans	122	0.000586	-7.4429	-0.0044
Posoqueria latifolia	71	0.000341	-7.9843	-0.0027
Poulsenia armata	1,162	0.005577	-5.1890	-0.0289
Pourouma bicolor	104	0.000499	-7.6025	-0.0038
Pouteria fossicola	3	0.000014	-11.1483	-0.0002
Pouteria reticulata	1,204	0.005779	-5.1535	-0.0298
Pouteria stipitata	63	0.000302	-8.1038	-0.0025
Prioria copaifera	1,348	0.006470	-5.0406	-0.0326
Protium confusum	9	0.000043	-10.0497	-0.0004
Protium costaricense	698	0.003350	-5.6987	-0.0191
Protium panamense	2,853	0.013694	-4.2908	-0.0588
Protium tenuifolium	2,829	0.013579	-4.2993	-0.0584
Pseudobombax septenatum	35	0.000168	-8.6916	-0.0015
Psidium friedrichsthalianum	60	0.000288	-8.1526	-0.0023
Psychotria acuminata	8	0.000038	-10.1675	-0.0004
Psychotria chagrensis	13	0.000062	-9.6820	-0.0006
Psychotria deflexa	13	0.000062	-9.6820	-0.0006
Psychotria graciliflora	53	0.000254	-8.2766	-0.0021
Psychotria grandis	38	0.000182	-8.6093	-0.0016
Psychotria horizontalis	3,119	0.014971	-4.2017	-0.0629
Psychotria limonensis	65	0.000312	-8.0725	-0.0025
Psychotria marginata	581	0.002789	-5.8822	-0.0164
Psychotria pittieri	5	0.000024	-10.6375	-0.0003
Pterocarpus belizensis	2	0.000010	-11.5538	-0.0001
Pterocarpus rohrii	1,380	0.006624	-5.0171	-0.0332
Quararibea asterolepis	2,137	0.010257	-4.5798	-0.0470
Quassia amara	119	0.000571	-7.4678	-0.0043
Randia armata	958	0.004598	-5.3821	-0.0247
Rinorea sylvatica	2,277	0.010929	-4.5163	-0.0494
Rosenbergiodendron formosum	3	0.000014	-11.1483	-0.0002
Sapium 'broadleaf'	3	0.000014	-11.1483	-0.0002
Sapium glandulosum	52	0.000250	-8.2957	-0.0021
Schizolobium parahyba	23	0.000110	-9.1114	-0.0010
Senna dariensis	135	0.000648	-7.3417	-0.0048
Simarouba amara	1,477	0.007089	-4.9492	-0.0351
Siparuna guianensis	27	0.000130	-8.9511	-0.0012
Siparuna pauciflora	367	0.001762	-6.3416	-0.0112
Sloanea terniflora	461	0.002213	-6.1135	-0.0135
Socratea exorrhiza	540	0.002592	-5.9554	-0.0154
Solanum hayesii	69	0.000331	-8.0128	-0.0027
Solanum steyermarkii	4	0.000019	-10.8606	-0.0002

APPENDIX A (continued)

Species	Number	p_i	$\ln(p_i)$	$\ln(p_i)*p_i$
Sorocea affinis	2,539	0.012187	-4.4074	-0.0537
Spachea membranacea	13	0.000062	-9.6820	-0.0006
Spondias mombin	98	0.000470	-7.6620	-0.0036
Spondias radlkoferi	265	0.001272	-6.6672	-0.0085
Sterculia apetala	52	0.000250	-8.2957	-0.0021
Stylogyne turbacensis	691	0.003317	-5.7088	-0.0189
Swartzia simplex	2,784	0.013363	-4.3153	-0.0577
Swartzia simplex	2,926	0.014044	-4.2655	-0.0599
Symphonia globulifera	152	0.000730	-7.2231	-0.0053
Tabebuia guayacan	71	0.000341	-7.9843	-0.0027
Tabebuia rosea	230	0.001104	-6.8089	-0.0075
Tabernaemontana arborea	1,593	0.007646	-4.8736	-0.0373
Tachigali versicolor	2,234	0.010723	-4.5354	-0.0486
Talisia nervosa	722	0.003465	-5.6649	-0.0196
Talisia princeps	664	0.003187	-5.7486	-0.0183
Terminalia amazonia	47	0.000226	-8.3968	-0.0019
Terminalia oblonga	83	0.000398	-7.8281	-0.0031
Tetragastris panamensis	4,493	0.021566	-3.8367	-0.0827
Tetrathylacium johansenii	6	0.000029	-10.4552	-0.0003
Theobroma cacao	18	0.000086	-9.3566	-0.0008
Thevetia ahouai	91	0.000437	-7.7361	-0.0034
Tocoyena pittieri	7	0.000034	-10.3010	-0.0003
Trattinnickia aspera	66	0.000317	-8.0573	-0.0026
Trema micrantha	43	0.000206	-8.4857	-0.0018
Trichanthera gigantea	5	0.000024	-10.6375	-0.0003
Trichilia pallida	478	0.002294	-6.0773	-0.0139
Trichilia tuberculata	11,344	0.054449	-2.9105	-0.1585
Trichospermum galeottii	1	0.000005	-12.2469	-0.0001
Triplaris cumingiana	242	0.001162	-6.7580	-0.0078
Trophis caucana	149	0.000715	-7.2430	-0.0052
Trophis racemosa	253	0.001214	-6.7135	-0.0082
Turpinia occidentalis	72	0.000346	-7.9703	-0.0028
Unonopsis pittieri	621	0.002981	-5.8156	-0.0173
Urera baccifera	13	0.000062	-9.6820	-0.0006
Virola multiflora	44	0.000211	-8.4627	-0.0018
Virola sebifera	1,394	0.006691	-5.0070	-0.0335
Virola surinamensis	183	0.000878	-7.0374	-0.0062
Vismia baccifera	41	0.000197	-8.5334	-0.0017
Vismia billbergiana	4	0.000019	-10.8606	-0.0002
Vochysia ferruginea	27	0.000130	-8.9511	-0.0012
Xylopiya macrantha	1,414	0.006787	-4.9928	-0.0339
Xylosma oligandra	67	0.000322	-8.0422	-0.0026
Zanthoxylum acuminatum	93	0.000446	-7.7143	-0.0034
Zanthoxylum ekmanii	194	0.000931	-6.9791	-0.0065
Zanthoxylum panamense	178	0.000854	-7.0651	-0.0060
Zanthoxylum setulosum	1	0.000005	-12.2469	-0.0001
Zuelania guidonia	34	0.000163	-8.7206	-0.0014
TOTAL=	208341		$H' =$	3.9553

APPENDIX B: Animal Species present in Yosemite National Park

B.1 BIRDS

Bird	Elevation	Diet
Sooty Grouse (<i>Dendragapus fuliginosus</i>)	4,000-8,000	needles of conifers, berries, insects, flowers
Sharp-shinned hawk (<i>Accipiter striatus</i>)	2,000-9,000	mostly small birds, small mammals, frogs, lizards
Cooper's Hawk (<i>Accipiter cooperii</i>)	2,000-9,000	mostly birds, small mammals, reptiles
Northern Goshawk (<i>Accipiter gentilis</i>)	4,000-10,000	small and medium sized birds and mammals
Band-tailed pigeon (<i>Patagioenas fasciata</i>)	2,000-7,000	nuts and berries, pine seeds, acorns
Flammulated Owl (<i>Otus flammeolus</i>)	4,000-6,000	moths, beetles, spiders, grasshoppers, crickets,
Great Horned Owl (<i>Bubo virginianus</i>)	2,000-9,000	mice, squirrels, hare, crayfish, amphibians, reptiles
Northern Pygmy-Owl (<i>Glaucidium gnoma</i>)	2,000-6,000	rodents
Spotted Owl (<i>Strix occidentalis</i>)	2,000-7,000	mice, rats, occasionally small birds
Great Gray Owl (<i>Strix nebulosa</i>)	4,000-8,000	mice, rats, shrews, moles, rabbits, small birds
Northern Saw-whet Owl (<i>Aegolius acadicus</i>)	2,000-6,000	insects, rarely on mice
Vaux's Swift (<i>Chaetura vauxi</i>)	2,000-7,000	insects
Calliope Hummingbird (<i>Stellula calliope</i>)	4,000-7,000	nectar, insects, small spiders
Lewis's Woodpecker (<i>Melanerpes lewis</i>)	2,000-10,000	insects, fruits and berries, acorns and nuts
Acorn Woodpecker (<i>Melanerpes formicivorus</i>)	2,000-5,000	acorns, (pine) seeds, berries, fruits, sap, nectar
Williamson's Sapsucker (<i>Sphyrapicus thyroideus</i>)	6,000-9,000	Insects, sap, fruits and berries
Red-naped Sapsucker (<i>Sphyrapicus nuchalis</i>)	2,000-7,000	arthropods, tree sap (conifer),
Red-breasted Sapsucker (<i>Sphyrapicus ruber</i>)	2,000-8,000	arthropods, tree sap, nuts and fruits
Hairy Woodpecker (<i>Picoides villosus</i>)	2,000-10,000	insects arthropods, fruit and seed of conifer species
White-headed Woodpecker (<i>Picoides albolarvatus</i>)	4,000-7,000	insects and larvae, pine seeds, pine sap
Northern Flicker (<i>Colaptes auratus</i>)	2,000-10,000	ant and other insects, fruits and berries
Pileated Woodpecker (<i>Dryocopus pileatus</i>)	4,000-7,000	mainly ants, fruits: berries and nuts
Olive-sided Flycatcher (<i>Contopus cooperi</i>)	4,000-9,000	flying insects
Western Wood-Pewee (<i>Contopus sordidulus</i>)	2,000-9,000	flying insects
Hammond's Flycatcher (<i>Empidonax hammondii</i>)	4,000-8,000	beetles, moths, flies, bees and wasps
Dusky Flycatcher (<i>Empidonax oberholseri</i>)	4,000-10,000	moths and other flying insects
Cassin's Vireo (<i>Vireo cassinii</i>)	2,000-6,000	ants, stone flies, dragonflies
Warbling Vireo (<i>Vireo gilvus</i>)	2,000-9,000	insects
Stellar's Jay (<i>Cyanocitta stelleri</i>)	2,000-9,000	acorns, pine seeds, fruit, insects, snakes
Pinyon Jay (<i>Gymnorhinus cyanocephalus</i>)	3,000-9,000	seeds, insects, fruits , berries
Clark's Nutcracker (<i>Nucifraga columbiana</i>)	6,000-12,000	Insects, fallen nuts, seeds of pines
Common Raven (<i>Corvus corax</i>)	2,000-10,000	mammal scavenger, insects, berries

Mountain Chickadee (<i>Poecile gambeli</i>)	2,000-10,000	scratch feed, sunflower seeds
Chestnut-backed Chickadee (<i>Poecile rufescens</i>)	2,000-5,000	insects, spiders, conifer seeds
Red-breasted Nuthatch (<i>Sitta canadensis</i>)	2,000-8,000	seeds of conifers, insects
White-breasted Nuthatch (<i>Sitta carolinensis</i>)	2,000-10,000	fruit and seed of pines, sunflowers sees, insects
Pygmy Nuthatch (<i>Sitta pygmaea</i>)	2,000-7,000	pine seeds, insects
Brown Creeper (<i>Certhia americana</i>)	4,000-10,000	insects, nuts and seeds
Winter Wren (<i>Troglodytes hiemalis</i>)	2,000-6,000	insects, berries of red cedar
Golden-crowned Kinglet (<i>Regulus satrapa</i>)	4,000-8,000	insects and tree sap
Western Bluebird (<i>Sialia mexicana</i>)	2,000-10,000	insects and berries
Townsend's Solitaire (<i>Myadestes townsendi</i>)	5,000-10,000	insects, spiders, earthworms, berries, pine seeds
Hermit Thrush (<i>Catharus guttatus</i>)	2,000-10,000	nsects, berries in the fall and winter
American Robin (<i>Turdus migratorius</i>)	2,000-10,000	insects, earthworms, fruit, berries
Cedar Waxwing (<i>Bombycilla cedrorum</i>)	2,000-9,000	fruit, maple sap, insects
Orange-crowned Warbler (<i>Vermivora celata</i>)	2,000-10,000	insects
Nashville Warbler (<i>Vermivora ruficapilla</i>)	3,000-8,000	insects
Yellow-rumped Warbler (<i>Dendroica coronata</i>)	2,000-10,000	insects
Black-throated Gray Warber (<i>Dendroica nigrescens</i>)	2,000-7,000	insects
Townsend's Warbler (<i>Dendroica townsendi</i>)	2,000-10,000	insects, spiders
Hermit Warbler (<i>Dendroica occidentalis</i>)	4,000-7,000	insects, spiders
Western Tanager (<i>Piranga ludoviciana</i>)	2,000-8,000	insects, elderberries cherries
Chipping Sparrow (<i>Spizella passerina</i>)	2,000-10,000	seeds of grasses, forbs, shrubs; insects
Dark-eyed Junco (<i>Junco hyemalis</i>)	2,000-10,000	insects, seeds (not coniferous), berries
Black-headed Grosbeak (<i>Pheucticus melanocephalus</i>)	2,000-6,000	seeds of conifers, berries, insects
Brewer's Blackbird (<i>Euphagus cyanocephalus</i>)	2,000-10,000	spiders, grass and forb seeds, berries
Brown-headed Cowbird (<i>Molothrus ater</i>)	2,000-10,000	spiders, grass and forb seeds, berries
Purple Finch (<i>Carpodacus purpureus</i>)	2,000-6,000	seeds of deciduous trees, berries, insects
Cassin's Finch (<i>Carpodacus cassinii</i>)	4,000-11,000	seeds and buds of conifers, insects, berries
Red Crossbill (<i>Loxia curvirostra</i>)	4,000-11,000	seeds of conifers, insects
Evening Grosbeak (<i>Coccothraustes vespertinus</i>)	2,000-9,000	Insects, buds and seeds of maples and conifers

Sources: 1) del Hoyo J, Elliott A, Sargatal J. 1994. Handbook of the Birds of the World 2: 401-402. Lynx Edicions, Barcelona.

2) Terres J. 1980. The Audubon Society Encyclopedia of North American Birds. Alfred A. Knopf, Inc., New York

3) Yosemite Bird Checklist. 2009. National Park Service, U.S. Department of the Interior.

APPENDIX B (continued)

B.2 RODENTS

Species	Diet	Elevation
<i>Chaetodipus californicus</i>	granivore	193-1714
<i>Microtus longicaudus</i>	herbivore	1237-3287
<i>Microtus montanus</i>	herbivore	1217-3155
<i>Neotoma macrotis</i>	herbivore	183-1713
<i>Peromyscus boylii</i>	granivore	61-2469
<i>Peromyscus maniculatus</i>	omnivore	57-3287
<i>Peromyscus truei</i>	omnivore	651-1809
<i>Sorex monitcolus</i>	insectavore	1209-3287
<i>Sorex trowbridgii</i>	insectivore	1160-2286
<i>Spermophilus beecheyi</i>	omnivore	61-2484
<i>Spermophilus lateralis</i>	omnivore	1890-3200
<i>Tamias quadrimaculatus</i>	granivore	1494-2260
<i>Tamias speciosus</i>	granivore	1896-3220
<i>Tamiasciurus douglasi</i>	granivore	1229-3185
<i>Thomomys moticola</i>	herbivore	1905-3155
<i>Zapus princeps</i>	omnivore	1450-3185
<i>Glaucomys sabrinus</i>	omnivore	1300-1900
<i>Sciurus grisceus</i>	granivore	80-2500
<i>Tamias amoenus</i>	granivore	975-2900
<i>Tamias minimus</i>	omnivore	1700-2000
<i>Tamias merriami</i>	omnivore	below 2700

Source: 1) Moritz C, Patton J, Conroy C, Parra J, White G, Beissinger S. 2008. Impact of a century of climate change on small-mammal communities in Yosemite National Park, USA. *Science* 322(261).

2) Roberts S. 2011. *Wildlife Ecologist*. U.S. Geological Survey. Western Ecological Research Center. Yosemite Field Station.

APPENDIX B (continued)

B.3 OTHER MAMMALS

Species

American Badger (*Taxidea taxus*)
Western white-tailed hare (*Lepus townsendii*)
Sierra Nevada snowshoe hare (*Lepus americanus tahoensis*)
Little brown myotis (*Myotis lucifugus*)
Yuma myotis (*Myotis yumanensis*)
Long-eared myotis (*Myotis evotis*)
Finged myotis (*Myotis thysanodes*)
Long-legged myotis (*Myotis volans*)
California myotis (*Myotis californicus*)
Small-footed myotis (*Myotis ciliolabrum*)
Silver-haired bat (*Lasionycteris noctivagans*)
Western pipistrelle (*Parastrellus hesperus*)
Big brown bat (*Eptesicus fuscus*)
Western red bat (*Lasiurus blossevillii*)
Hoary bat (*Lasiurus cinereus*)
Spotted bat (*Euderma maculatum*)
Townsend's big-eared bat (*Corynorhinus townsendii*)
Pallid bat (*Antrozous palidus*)
Mexican free-tailed bat (*Tadarida brasiliensis*)
Western mastiff bat (*Eumops perotis*)
Ermine (*Mustela erminea*)
Pacific Fisher (*Martes americana*)
River otter (*Lutra canadensis*)
Spotted skunk (*Spilogale putorius*)
Striped skunk (*Mephitis mephitis*)
California wolverine (*Gulo gulo*)
Coyote (*Canis latrans*)
Grey fox (*Urocyon cinereogrgenteus*)
Sierra Nevada red fox (*Vulpes vulpes necator*)
Black bear (*Ursus americanus*)
Raccoon (*Procyon lotor*)

Source: Roberts S. 2011. Wildlife Ecologist. U.S. Geological Survey. Western Ecological Research Center. Yosemite Field Station.

