Pacific fuzzwort: Rare Species Modeling in a Dynamic Habitat

GIS II Project by Jenny Moore, Portland State University , June 2016

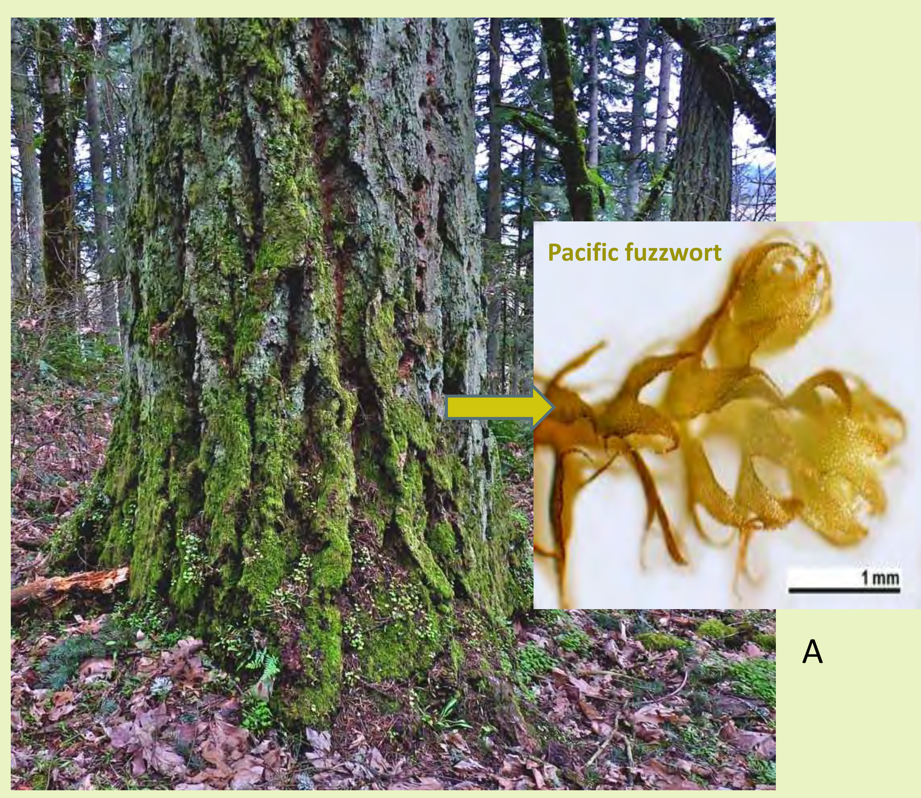
Background

Species at Risk

Pacific fuzzwort (*Ptilidium californicum*) is a tiny leafy liverwort. Pacific fuzzwort has a North Pacific distribution, from northern California to Oregon, Washington, British Columbia, Alaska, and according to some sources may be found in Russia and Japan. Despite its specific epithet, is uncommon or rare in California (California Rare Plant Rank 4.3, "limited distribution"; NaturServe Rank S3, "vulnerable"; US Forest service rank Sensitive), although it is more common further north. In Northern California, it is most commonly epiphytic, found growing on the bases of conifer trunks in older forests (A). With leaves not much over 1mm long (A), it can be a difficult bryophyte to detect.

Because this species is at the southern extent of its range in Northern California, it could be susceptible to extirpation from California as a result of a warming climate. Its relative scarcity in disturbed habitats implies that it is likely a slow-growing species with limited dispersal capabilities. Its fire ecology has not been studied, but preliminary investigations suggest that it is not tolerant of severe fire.

Habitat suitability models can be a useful tool for prioritizing field surveys for rare species. For Pacific fuzzwort, disturbance history and environmental changes could be important variables in determining suitable habitats.

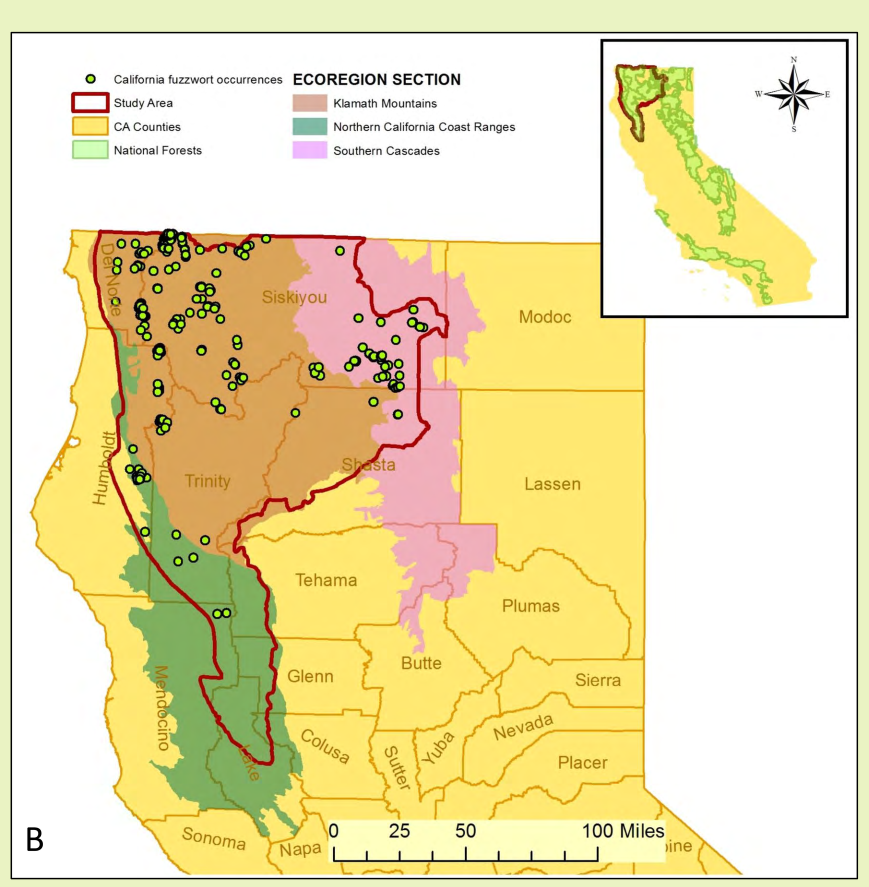


Common epiphyic habitat for Pacific fuzzwort in California, and a magnified inset of the species.

Study Site

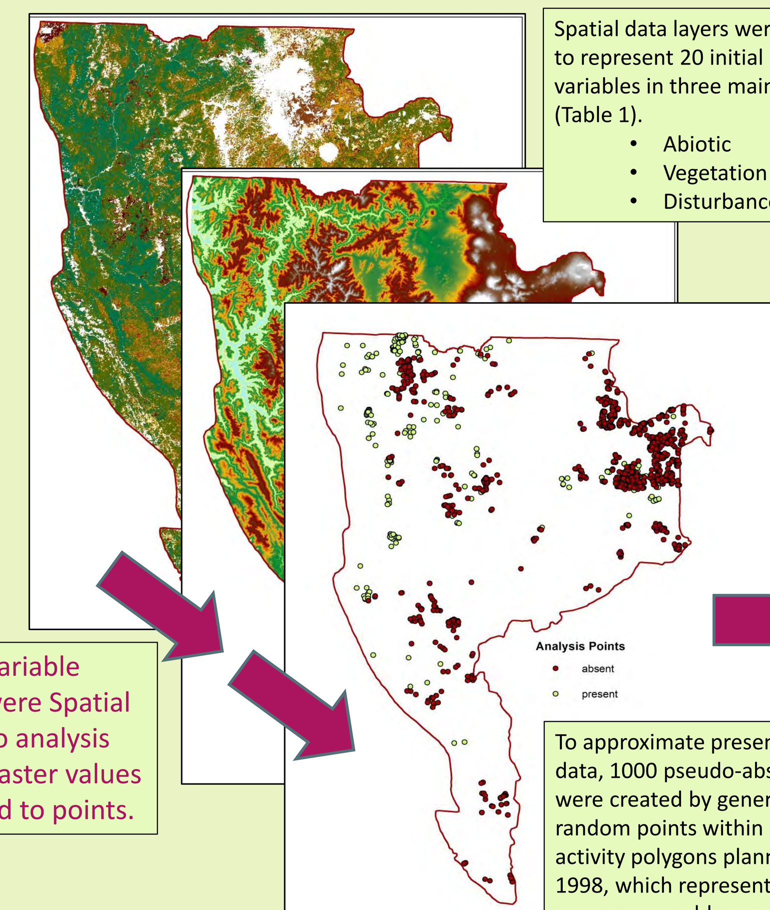
The study area for this analysis is the Northwest Forest Plan boundary within California, which encompasses over 99% of the known range of Pacific fuzzwort in California (USDA FS, 2014), and basically represents the National Forest portion of the Pacific Northwest. Site data was only available for U.S. Forest Service Land, which is mainly where Pacific fuzzwort has been found. Ecoregion sections where it occurs are the Klamath Mountains, Northern California Coast Ranges, and Southern Cascades.

Occurrence locations for Pacific fuzzwort were obtained from the US Forest Service, (USDA FS NRIS 2016) , and multi-part polygons were split during conversion to points (n=325).



1. Study Area, showing Pacific fuzzwort locations and distribution in California.

Methods



Spatial data layers were collected to represent 20 initial habitat variables in three main categories (Table 1).

- Abiotic
- Vegetation
- Disturbance

Vector variable values were Spatial Joined to analysis points, raster values Extracted to points.

To approximate presence-absence data, 1000 pseudo-absence points were created by generating random points within FACTS activity polygons planned after 1998, which represent areas that were presumably surveyed for fuzzwort or ruled out based on habitat assessment (n = 986).

Linear regression analyses were run on all candidate variables to rank the most predictive ones. 18 variable groups were divided into discrete categories if they weren't already categorized, from which Frequency Ratios (FR) were calculated based on the number of occupied and unoccupied points.

Frequency Ratio
FR = POF/PA
where
PA = percent of total points in each category (Percent Area)

POF = percent of occurrence points in each category (Occurrence Frequency) (Lee and Pradhan 2007).

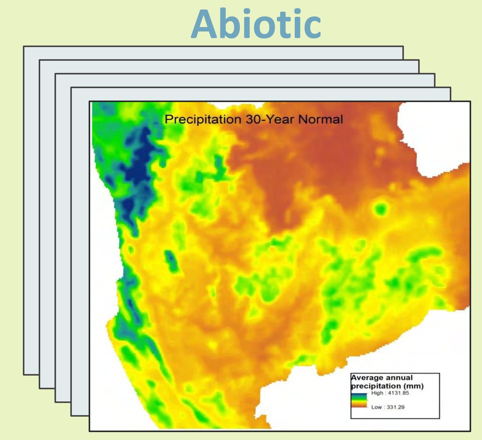
To build a Habitat Suitability Index (HSI) based on Frequency Ratios, 11 explanatory variables were chosen based on the significance of the p-value ($p < 0.05$) and the adjusted R^2 value (Table 1). These layers were converted to raster data format and Reclassified to the FR values. "No Data" values were assigned either an average value (FR = 100), zero, or "no data", depending on the circumstance. All layers were overlaid and summed to produce a map.

Habitat Suitability Index:
$HSI = FR_1 + FR_2 + FR_3 .... FR_n$

HSI values ranged from 287-2790. The HSI map was calibrated using the Index values extracted to known fuzzwort occurrence points, which ranged from 895-2741. The value range for the known sites was then divided into four equal intervals, and 25% thresholds were used to classify the HSI map. The top 25% of the value range was considered the most suitable habitat.

Rasterized, Reclassified Explanatory Variable Layers:

Abiotic



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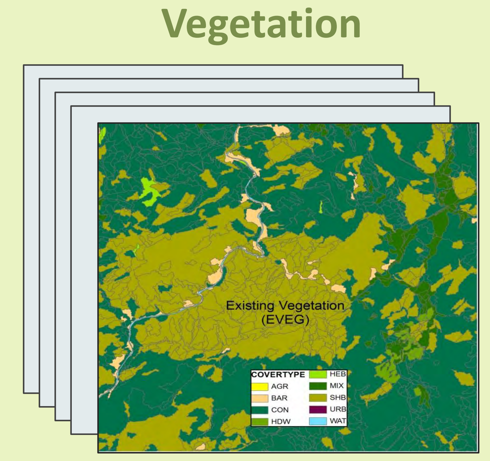
Vegetation



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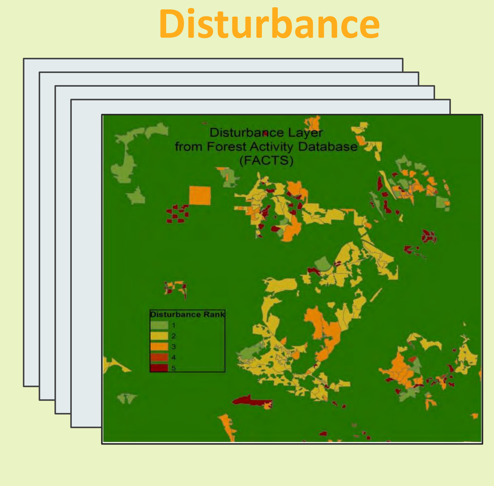
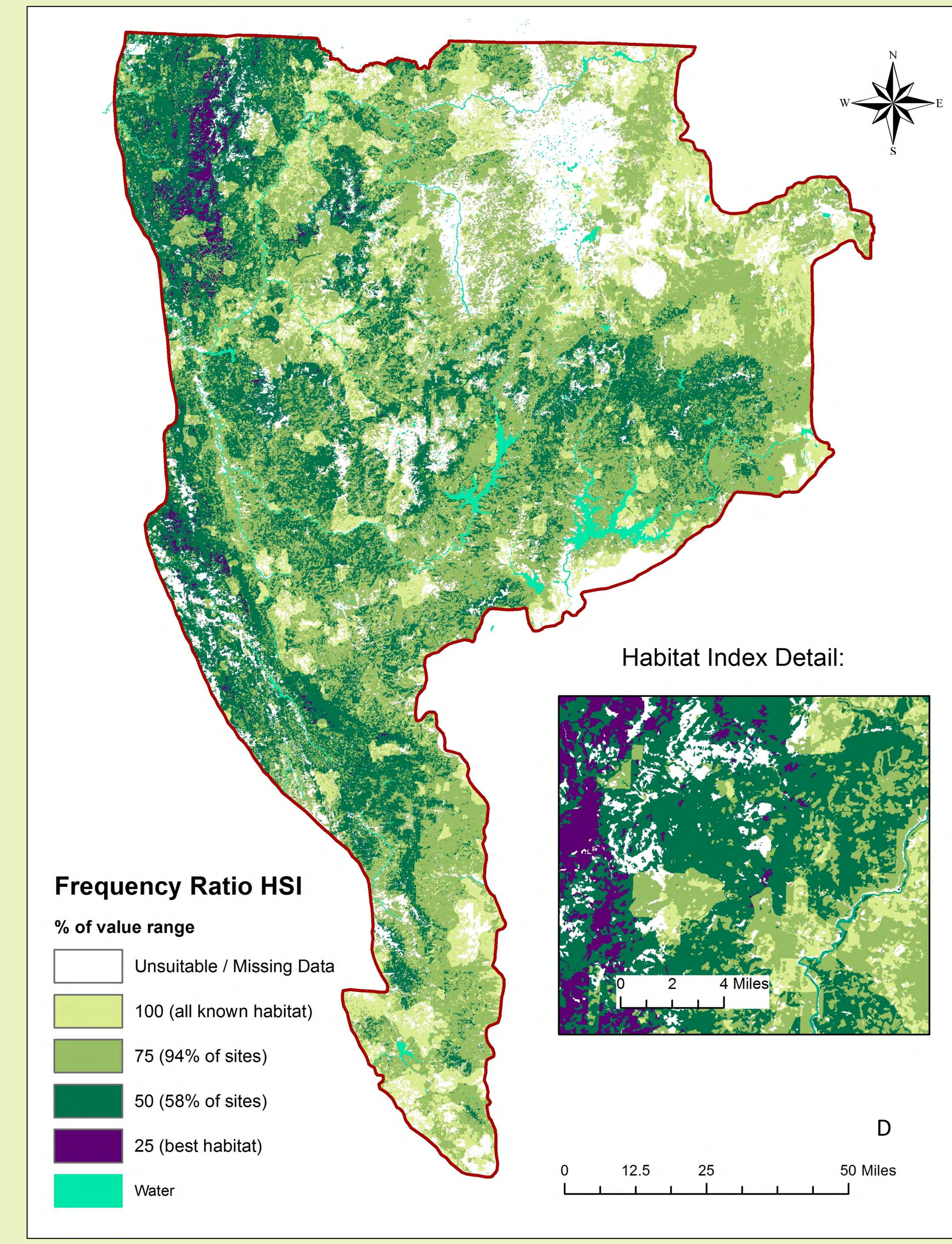
Disturbance



Results

HABITAT VARIABLE	CLASSES	POINTS IN CLASS	PROPORTION OF AREA (PA)	OCCUPIED POINTS	OCCURRENCE FREQUENCY (POF)	FREQUENCY RATIO (FR = POF/PA*100)	R^2
VEGETATION							
Cover Type	Water	1	0.001	0	0.000	0	
	Bare	5	0.004	0	0.000	0	
	Herbaceous	4	0.003	1	0.003	101	
	Shrub	17	0.013	3	0.009	71	
	Hardwood	5	0.004	1	0.003	81	
	Mixed Forest	28	0.021	7	0.022	101	
	Conifer	1196	0.912	313	0.963	106	
SAF Dominant Cover Type	Non-forested	14	0.011	1	0.003	29	0.1
	Red Fir	21	0.016	7	0.022	134	
	White Fir	276	0.211	113	0.348	165	
	Western White Pine	9	0.007	2	0.006	90	
	Lodgepole Pine	9	0.007	0	0.000	0	
	Douglas Fir	273	0.208	132	0.406	195	
	Port Orford Cedar	5	0.004	5	0.015	403	
	Interior Ponderosa	79	0.060	2	0.006	10	
	Western Juniper	4	0.003	0	0.000	0	
	Sierra Mixed Conifer	436	0.333	55	0.169	51	
	Western Hemlock	28	0.021	1	0.003	14	
	Pacific Ponderosa	126	0.096	3	0.009	10	
	CA Black Oak	2	0.002	1	0.003	202	
	Jeffrey Pine	5	0.004	0	0.000	0	
	Knobcone Pine	5	0.004	0	0.000	0	
	Canyon Live Oak	3	0.002	0	0.000	0	
	Blue Oak-Grey Pine	1	0.001	0	0.000	0	
	CA Mixed Subalpine	2	0.002	0	0.000	0	
	Hard Chaparral	13	0.010	3	0.009	93	
Canopy Cover (% CFA)	0	19	0.016	2	0.006	40	0.19
	15-25	78	0.065	2	0.006	10	
	35-45	261	0.218	9	0.029	13	
	55-65	462	0.386	92	0.294	76	
	75	241	0.202	132	0.422	209	
	85-95	135	0.113	76	0.243	215	
Overstory DBH Class (in)	00-07	158	0.132	10	0.032	24	0.13
	15	450	0.376	60	0.192	51	
	25	533	0.446	204	0.652	146	
	40	55	0.046	39	0.125	271	
Canopy Structure	single-storied	20	0.267	5	0.111	42	0.05
	multi-storied	55	0.733	40	0.889	121	
ABIOTIC							
Precipitation (mm)	445-1000	296	0.226	7	0.022	10	0.33
	1500	579	0.443	92	0.283	64	
	2000	256	0.196	136	0.418	214	
	2500	51	0.039	39	0.120	308	
	3000	23	0.018	22	0.068	385	
	3500	9	0.007	9	0.028	402	
	4000	20	0.015	20	0.062	402	
Mean Temp 30-Yr Normal °C	6	4	0.003	1	0.003	101	0.13
	7.5	71	0.054	9	0.028	51	
	9	353	0.270	62	0.191	71	
	10.5	500	0.383	161	0.495	129	
	12	254	0.194	72	0.222	114	
	13.5	107	0.082	19	0.058	71	
	15	12	0.009	1	0.003	34	
Max July 30 yr °C	22.8-24	17	0.013	3	0.009	71	0.03
	26	127	0.097	56	0.172	177	
	28	394	0.301	125	0.385	128	
	30	512	0.392	107	0.329	84	
	32	137	0.105	22	0.068	65	
	34	108	0.083	11	0.034	41	
	34.1-34.7	10	0.008	1	0.003	40	
Min Jan 30 yr °C	< -5.58	20	0.015	5	0.015	101	0.14
	-4.19	140	0.107	5	0.015	14	
	-2.8	489	0.374	23	0.071	19	
	-1.42	189	0.145	87	0.268	185	
	-0.03	297	0.227	144	0.443	195	
	1.36	134	0.103	52	0.160	156	
	2.75	32	0.024	9	0.028	113	
DISTURBANCE							
Historic Fire	No	244	0.186	299	0.923	495	0.017
	Yes	1066	0.814	25	0.077	9	
Disturbance Rank (Logging)	0	277	0.211	277	0.855	404	0.53
	1	42	0.032	2	0.006	19	
	2	748	0.571	22	0.068	12	
	3	209	0.160	18	0.056	35	
	4	12	0.009	1	0.003	34	
	5	22	0.017	4	0.012	74	

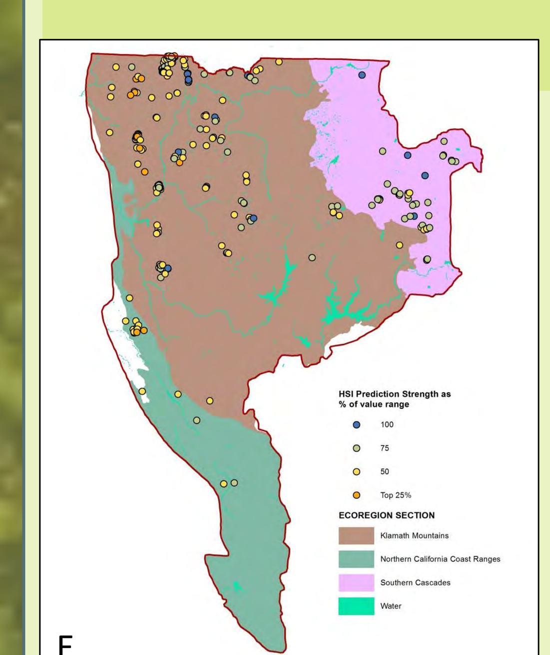
Table 1. Frequency Ratios (FR) for final explanatory variables for each of their classes. FR = 100 represents an average value. Values higher than 100 show a positive association, and values much lower than 100 show an avoidance. High positive or negative FR relationships are highlighted. Cover type is shown only for informative purposes and was not included in the HSI.



The strongest predictive factors for Pacific fuzzwort presence were logging history ($R^2 = 0.53$) and precipitation ($R^2 = 0.33$). Elevation, dewpoint, aspect, Late Seral management designation, burn severity, and distance from streams were not significant at p=0.05, probably due to a geographic trend. Minimum January temperature was more predictive than maximum July temperature.

The variable data are generally somewhat bimodal, with two distinct groups, one representing the Klamath Mountains and Northern CA, and the other representing the Southern Cascades. The Suitability Index fits better for the western occurrences (E), and perhaps the interior Cascade portion warrants a separate analysis.

Conclusions



The Frequency Ratio HSI wasn't very satisfactory, perhaps due to problems with the pseudo-absence points (which have some inherent biases because they are based on the assumption of pre-disturbance surveys, which aren't conducted in protected areas such as Wilderness). Another Index was generated for comparison using only the fuzzwort presence sites (F). Again, the index was more predictive in the western portion of the range. Some variables may have been redundant (i.e. mean temperature) and should be weighted accordingly so as to not skew the Index in favor of those variable suites.

Because the minimum temperature was found to be more predictive than the maximum temperature, perhaps the species will show more resilience to global warming than was feared. However, increases in wildfire frequency and severity are likely to have a detrimental impact.

To compare with the Frequency Ratio technique, a presence-only modeling program such as BioMapper could be employed, which would avoid the potential pitfalls of pseudo-absences.

Citations

1. USDA Forest Service, 2014. Annual Species Review: *Ptilidium californicum*. Unpublished.
2. Lee, S. and B. Pradhan, 2007. Landslide hazard mapping at Selangor, Malaysia using frequency ratio and logistic regression models. Landslides, 4: 33-41.

Data Sources

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USDA Forest Service, Pacific Southwest Region, Fire and Aviation Mgmt.
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WFDSS (Wildland Fire Decision Support System) http://wfdss.usgs.gov/wfdss/WFDSS_Home.shtml