

# Pacific fuzzwort: Rare Species Modeling in a Dynamic Habitat

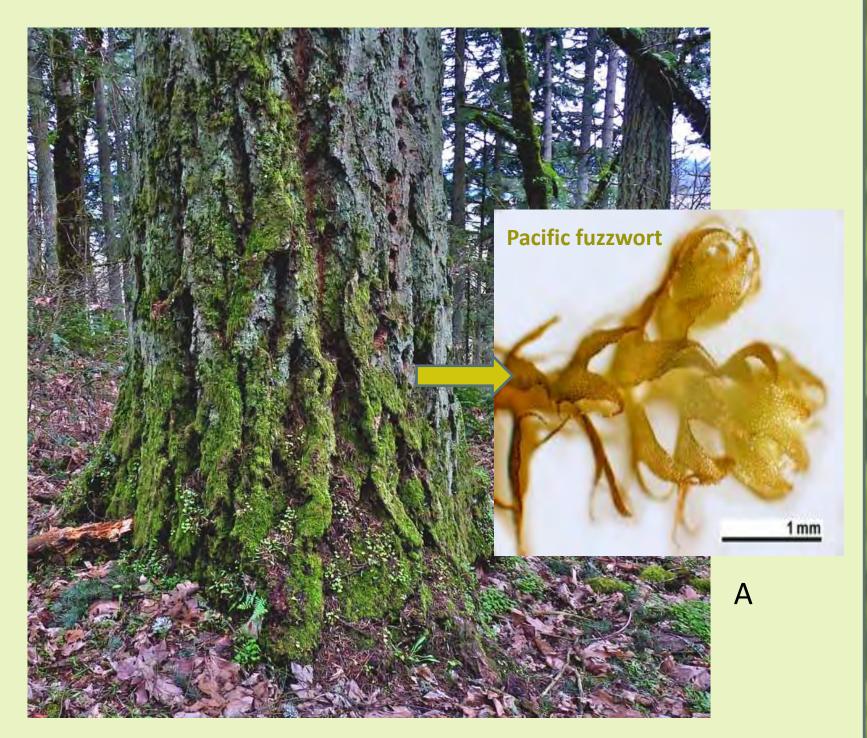
### Background

#### **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.

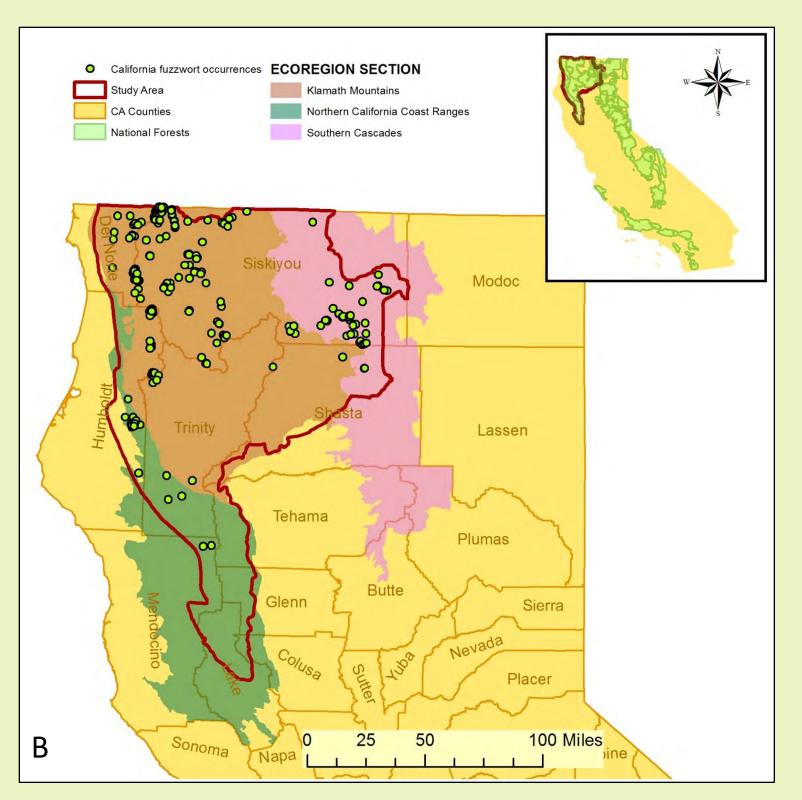


Common epiphyic habitat for Pacific fuzzwort in California, and a magnified inset of the species.

#### **Study Site**

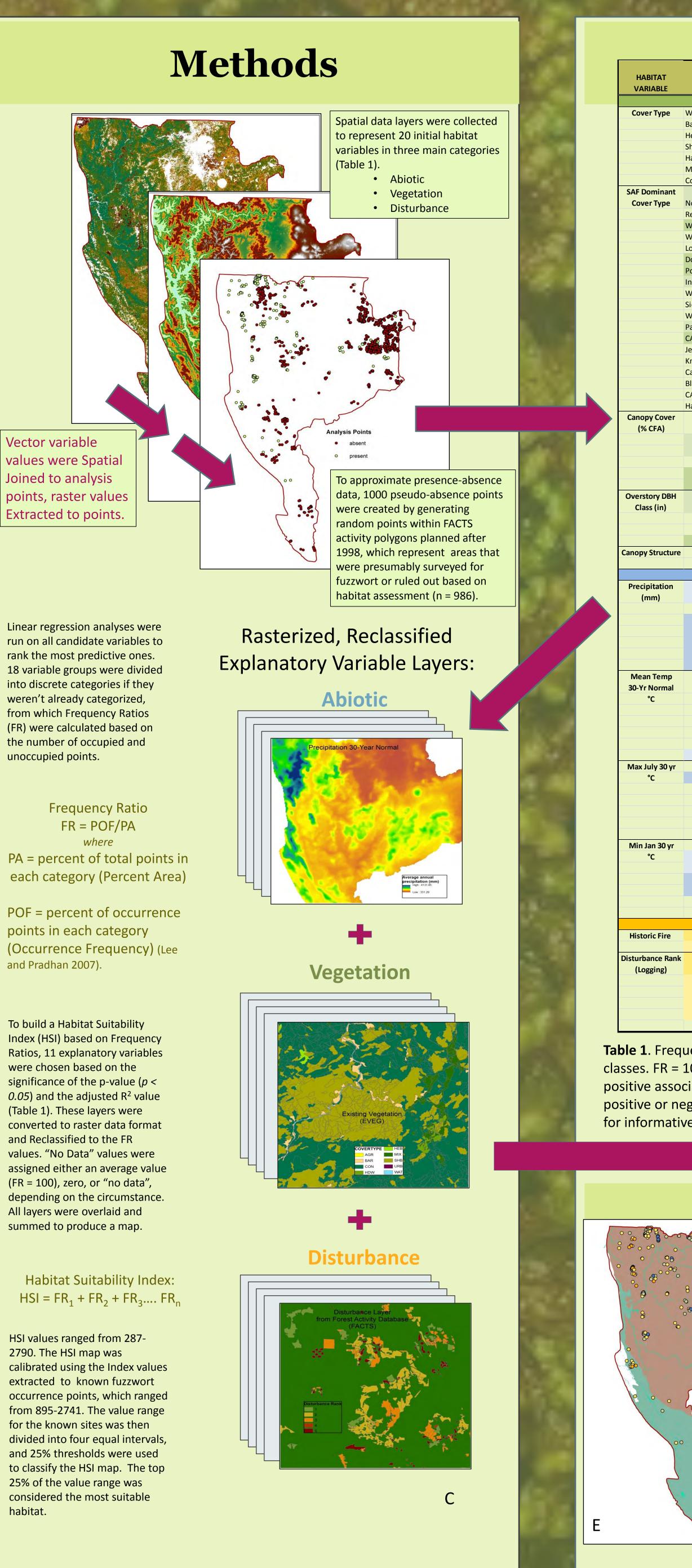
The study area for this analysis is the Northwest Forest Plan boundary within California, which encompasses over 99% of the known range of Pacific fuzzwort in California (USDA FS, 2014), and basically represents the National Forest portion of the Pacific Northwest. Site data was only available for U.S. 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.

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



Unit         Unit <th< th=""><th>CLASSES</th><th>POINTS IN CLASS</th><th>PROPORTION OF AREA (PA)</th><th>OCCUPIED POINTS</th><th>OCCURRENCE FREQUENCY (POF)</th><th>FREQUENCY RATIO (FR = POF/PA*100)</th><th>R<sup>2</sup></th><th>Results</th></th<>	CLASSES	POINTS IN CLASS	PROPORTION OF AREA (PA)	OCCUPIED POINTS	OCCURRENCE FREQUENCY (POF)	FREQUENCY RATIO (FR = POF/PA*100)	R <sup>2</sup>	Results
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istratedor       3       0.006       1       0.008       11       0.008       10         carefir       1.26       0.001       17       0.027       10       0.00       0.01         carefir       2.26       0.001       17       0.027       0.00       0.01       0.01         the fire       2       0.002       12       0.006       0.01       0.01       0.01       0.01         the fire       2       0.007       12       0.000       0.01								
Carrier       139       1902       1912       1912       1912       1912       1914         Marcia       1       2013       1       2012       211       1         Marcia       1       2012       211       1	Hardwood							
Miler faret A       H       Drift       I       Drift       I       Drift       I       Drift       I         Miler faret A       J       Drift       J       Drift       J       Drift       Drift <thdrift< th="">       &lt;</thdrift<>	Mixed Forest	28	0.021	7	0.022	101		
Note of the function       20       0.001       7       0.002       144         Whenese function       9       0.002       1       0.002       1         Whenese function       9       0.003       1       0.003       12         Whenese function       9       0.003       1       0.003       12         Whenese function       2       0.003       2       0.003       2         Whenese function       2       0.004       0       0.003       2         Whenese function       2       0.004       0       0.003       2       0.003       2         Name function       3       0.002       2       0.003       4       0.003       4       0.003       4         Notes function       3       0.002       2       0       0       0.003       4       0.003       4       0       0       0         1       0.002       2	Conifer	1196	0.912	313	0.963	106		
Nime F       77       0.131       115       0.738       447         Nime F       7       0.047       2       0.058       447         Nime F       7       0.047       2       0.058       447         Nime F       7       0.047       2       0.058       2       0.058       2         Nime F       7       0.047       2       0.058       2       0.058       2       0.058       2       0.058       2       0.058       2       0.058       2       0.058       2       0.058       2       0.058       2       0.058       2       0.058       2       0.058       2       0.058       2       0.058       2       0.058       2       0.058       2       0.059       1       0.059       1       0.059       1       0.059       1       0.059       1       0.059       1       0.059       1       0.058       1       0.059       1       0.059       1       0.059       1       0.059       1       0.059       1       0.059       1       0.059       1       0.059       1       0.059       1       0.059       1       0.059       1       0.059       1 <td>Non-forested</td> <td>14</td> <td>0.011</td> <td>1</td> <td>0.003</td> <td>29</td> <td>0.1</td> <td></td>	Non-forested	14	0.011	1	0.003	29	0.1	
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Composition         1         0.007         0         0.000         0           Designs for         22         0.038         12         0.000         0           Stress formation         5         0.000         0         0         0           Stress formation         5         0.001         0         0         0         0           Stress formation         7         0.002         0         0         0         0         0           Stress formation         7         0.005         0         0         0         0         0         0           Stress formation         5         0.004         0         0.007         0         0         0         0           Number formation         7         0.005         0 <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>								
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Bire Markets       194       0.033       0.53       0.66       91         Microsovers       198       0.005       3       0.007       13         Microsovers       198       0.005       1       0.000       14         Microsovers       198       0.005       0       0       0         Microsovers       19       0.003       0       0.000       0         Microsovers       1       0.003       10       0.000       0         Microsovers       1       0.003       10       0.000       0       0.000         Microsovers       0       0.000       10       0.000       0.000       0       0.000         Microsovers       0       0.000       0       0.000       0       0.000	Interior Ponderosa							
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33-45       201       0.236       9       0.009       13         75       244       0.222       312       0.642       205         75       244       0.222       312       0.642       205         00.67       118       0.132       10       0.032       24       0.13         15       400       0.276       50       0.13       24       0.13         15       400       0.276       50       0.13       24       0.05         16       10       0.37       5       0.118       24       0.05         10       0.38       24       0.05       0.05       0.06         2000       256       0.266       7       0.012       10       0.3         2000       256       0.266       7       0.028       140       0.277         2000       254       0.268       13       0.13       13       0.13         2000       254       0.038       140       0.028       140       0.13         13       200       0.276       0.328       12       0.05       140         13       200       0.38       16       0.13							0.19	
95-65       4/4       0.386       92       0.294       76         75       135       0.113       76       0.248       275         00-077       154       0.137       76       0.248       275         25       353       0.469       224       0.13         25       353       0.466       204       0.652       146         40       05       0.066       30       0.132       211         single-storied       20       0.267       5       0.111       42       0.05         153       0.066       32       0.128       271       0.05         153       0.077       5       0.111       42       0.05         2000       2.54       0.038       2.21       0.03       2.21         153       0.077       9       0.038       2.21       0.06         2000       2.54       0.23       0.068       31       0.03         153       0.077       9       0.038       11       0.03         12       2.26       0.338       116       0.458       127         32       117       0.38       127       0.23 <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></td<>								
95       241       0.202       152       0.422       200         00       07       158       0.132       10       0.032       24       0.13         15       400       0.376       60       0.202       51       0.13         15       400       0.376       60       0.202       251       0.13         16       0.068       30       0.11       42       0.65         170       0.55       0.066       30       0.13       42       0.65         16       0.26       7       0.022       10       0.33       0.33         2000       256       0.26       7       0.022       10       0.33         2000       256       0.076       0       0.022       10       0.33         3000       23       0.016       20       0.022       114       0.13          13       100       0.38       101       0.038       11       0.13         13       100       0.38       11       0.038       12       0.14         13       101       0.038       11       0.038       12       0.14         13       10								
00-07         158         0.112         10         0.012         24         0.13           15         430         0.376         60         0.192         51         0.13           25         345         0.046         201         0.052         216         0.05           will storied         35         0.046         201         0.027         5         0.11         22         0.05           single-storied         36         0.278         7         0.012         10         0.3           1500         256         0.155         0.163         224         0.05         20           2002         256         0.155         0.023         64         0.33         64           2003         215         0.023         20         0.024         402         10         0.13           200         200         0.024         0.02         11         0.13         11         0.033         11           215         117         0.035         20         0.024         0.24         11         0.13           35         000         0.33         11         0.033         21         0.14         11         0.033								
15       450       0.036       44       0.132       5.1         315       533       0.046       20       0.62       2.0         single-sorie       20       0.237       5       0.111       4.2       0.05         milti-sorie       20       0.257       5       0.111       4.2       0.05         single-sorie       20       0.256       7       0.022       50       0.33         1500       779       0.443       92       0.238       64       0.33         2000       256       0.156       1.366       0.44       0.33       0.33         3000       23       0.028       1.017       308       -       -         3000       23       0.028       1.17       308       -       -         15       107       0.022       1.04       -       -       -         15       107       0.028       1.1       0.03       0.01       0.13         12       244       0.031       3       0.03       1.1       -       -         13       107       0.028       1.1       0.02       0.07       -       - <t< td=""><td>85-95</td><td>135</td><td>0.113</td><td>76</td><td>0.243</td><td>215</td><td></td><td></td></t<>	85-95	135	0.113	76	0.243	215		
15       450       0.036       44       0.132       5.1         315       533       0.046       20       0.62       2.0         single-sorie       20       0.237       5       0.111       4.2       0.05         milti-sorie       20       0.257       5       0.111       4.2       0.05         single-sorie       20       0.256       7       0.022       50       0.33         1500       779       0.443       92       0.238       64       0.33         2000       256       0.156       1.366       0.44       0.33       0.33         3000       23       0.028       1.017       308       -       -         3000       23       0.028       1.17       308       -       -         15       107       0.022       1.04       -       -       -         15       107       0.028       1.1       0.03       0.01       0.13         12       244       0.031       3       0.03       1.1       -       -         13       107       0.028       1.1       0.02       0.07       -       - <t< td=""><td>00.07</td><td>150</td><td>0.422</td><td>10</td><td>0.022</td><td>24</td><td>0.12</td><td></td></t<>	00.07	150	0.422	10	0.022	24	0.12	
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multi-sourced         53         0.73         40         0.899         121           HeloTic         HeloTic         HeloTic         HeloTic           445-1000         996         0.226         7         0.002         0.03         0.33           9000         250         0.414         92         0.038         64         0.33           9000         250         0.015         20         0.022         0.038         9000         9000         90007         9         0.038         402           6         4         0.0015         20         0.002         402         10         0.13           9         0.33         100         0.13         101         0.13         101         0.13           101         23.6         0.232         107         0.038         122         103         100         0.13           102         23.0         0.233         163         0.049         1003         3         0.097         103           12         23.0         0.233         163         0.017         17         0.03           102         0.333         102         0.055         103         0.14         0.14 </td <td>40</td> <td>55</td> <td>0.046</td> <td>39</td> <td>0.125</td> <td>271</td> <td></td> <td></td>	40	55	0.046	39	0.125	271		
ABUTIC           445-1000         296         0.225         7         0.022         10         0.33           1500         276         0.136         136         0.418         214           2500         256         0.136         136         0.418         214           2500         251         0.039         22         0.062         402           3000         23         0.019         22         0.062         402           6         4         0.003         1         0.003         101         0.13           75         71         0.054         9         0.022         114         135           10.5         500         0.383         161         0.455         129         0.45           135         107         0.062         19         0.03         44         0.03           135         107         0.063         11         0.03         44         0.4           141         14.0         0.03         44         0.4         0.4         0.4           141         0.008         1         0.03         44         0.4         0.4           24         0.37 <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>0.05</td> <td></td>							0.05	
445-1000       295       0.226       7       0.002       10       0.33         200       256       0.059       136       0.448       224         200       23       0.018       22       0.068       885         3000       23       0.018       22       0.062       402         6       4       0.003       1       0.002       402         7.5       71       0.062       402       -         9       333       0.270       62       0.131       71         12       224       0.344       72       0.028       422         13       10       0.033       101       0.13       0.13         12       224       0.344       72       0.028       71       0.09         22.8-24       17       0.033       101       0.034       14       10.09       1         13       108       0.015       0.003       34       1       0.09       71       0.09         22.8-24       17       0.017       5       0.015       101       0.14       1       1       0.09       1       0.09       1       0.09       1	multi-storied	55	-	40	0.889	121		
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2000       256       0.096       136       0.418       224         2000       23       0.018       22       0.068       336         3000       23       0.018       22       0.068       336         3000       23       0.015       20       0.062       402         6       4       0.003       1       0.0062       402         7.5       71       0.064       9       0.222       114         105       500       0.333       161       0.495       129         12       254       0.194       9       0.022       114         135       107       0.062       19       0.03       34         22.8       24       17       0.013       3       0.009       71         15       127       0.0097       50       0.172       177         28       394       0.0015       5       0.005       10       0.14         30       512       0.922       107       0.33       101       0.14         4.13       108       0.048       11       0.034       44         2.8       449       0.174       23 <td>445-1000</td> <td>296</td> <td>0.226</td> <td>7</td> <td>0.022</td> <td>10</td> <td>0.33</td> <td></td>	445-1000	296	0.226	7	0.022	10	0.33	
2000       51       0.099       99       0.120       908         3000       23       0.007       9       0.028       402         4000       20       0.015       20       0.062       402         6       4       0.003       1       0.028       51         7       7       71       0.054       9       0.228       51         9       333       0.270       62       0.191       71       15         12       2.04       0.033       161       0.495       129       129         15       12       0.007       1       0.003       34       0.03       14         2.8       107       0.003       101       0.03       34       0.03       14         2.8       137       0.016       22       0.028       14       0.03       40         <-4.19								
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900       9       0.007       9       0.028       402         4000       20       0.015       20       0.028       402         6       4       0.003       1       0.003       101       0.13         7.5       7.1       0.054       9       0.22       114       7.5         9       353       0.270       62       0.495       129       12       254       0.134       72       0.222       114       7.5         12       254       0.034       72       0.222       114       7.7       0.03         15       12       0.009       1       0.003       34       0.03         26       17       0.03       34       0.03       71       0.03         26       17       0.03       34       0.03       71       0.03         21       254       0.301       125       0.385       128       65         34       0.003       1       0.003       40       0.015       14         34.1       10       0.015       14       100       (all known habitat)         1.36       134       0.105       22       0.028								
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32       137       0.105       22       0.068       65         34       108       0.083       11       0.003       40         34.134.7       10       0.003       10       0.14         <-5.58								
34       108       0.083       11       0.034       41         34.1-34.7       10       0.008       1       0.003       40         < -5.58								% of value range
34.1-34.7       10       0.008       1       0.003       40         < 5.58								
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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         Disturbance         O       277       0.814       25       0.017         9       O.017       9       0.227       0.028       113         0       277       0.814       25       0.017       9       50 (58% of sites)         0       277       0.211       277       0.855       404       0.53       25 (best habitat)         1       42       0.032       2       0.066       12       3         3       209       0.160       18       0.056       35       4         4       12       0.009       1       0.003       34       4         5       22       0.017       4       0.012       74								100 (all known habitat)
-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         DISTURBANCE         0       244       0.186       299       0.923       495       0.017         Yes       1066       0.814       25       0.077       9       50 (58% of sites)         0       277       0.211       277       0.855       404       0.53         1       42       0.032       2       0.006       19       25 (best habitat)         2       748       0.571       22       0.068       12       40								
1.36       134       0.103       52       0.160       156         2.75       32       0.024       9       0.028       113         DISTURBANCE         DISTURBANCE         0       244       0.186       299       0.923       495       0.017         Yes       1066       0.814       25       0.077       9       50 (58% of sites)         0       277       0.211       277       0.855       404       0.53         1       42       0.032       2       0.066       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								
No         244         0.186         299         0.923         495         0.017           Yes         1066         0.814         25         0.077         9         50 (58% of sites)           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	1.36	134	0.103	52	0.160	156		75 (94% of sites)
No       244       0.186       299       0.923       495       0.017         Yes       1066       0.814       25       0.077       9       25       0.077       9       25       25 (best habitat)         0       277       0.211       277       0.855       404       0.53       0.53       25 (best habitat)         1       42       0.032       2       0.006       19       25 (best habitat)       25 (best habitat)         3       209       0.160       18       0.056       35 (best habitat)       26 (best habitat)         4       12       0.009       1       0.003       34 (best habitat)       26 (best habitat)         5       22       0.017       4       0.012       74 (best habitat)       26 (best habitat)	2.75	32		9	0.028	113		
Yes       1066       0.814       25       0.077       9         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	No	244		299	0.923	495	0.017	50 (58% of sites)
0       277       0.211       277       0.033       404       0.33         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								
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	0	277	0.211	277	0.855	404	0.53	25 (best habitat)
3       209       0.160       18       0.056       35         4       12       0.009       1       0.003       34         5       22       0.017       4       0.012       74								
3     209     0.160     18     0.056     35       4     12     0.009     1     0.003     34       5     22     0.017     4     0.012     74								Water
5         22         0.017         4         0.012         74	3							
	4							
unney Pation (EP) for final explanatory variables for each of their								

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.

predictive than maximum July temperature.

## Conclusions

000 • ( 000 HSI Prediction Strength as % of value range • 100 O 75 O 50 O Top 25% ECOREGION SECTION Klamath Mountains Northern California Coast Ranges Southern Cascades Water

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 Natural Resource Information System (NRIS), USDA Forest Service, Chief Information Officer. PTCA\_CA\_NWFP20160421. 2016. PRISM Climate Group, 2016. http://prism.oregonstate.edu/

USDA Forest Service USDA Forest Service, Pacific Southwest Region, Remote Sensing Lab.

USDA Forest Service, Pacific Southwest Region, Fire and Aviation Mgmt.

U.S. Geological Survey, 2013, USGS NED n42w124 1 arc-second 2013 1 x 1 degree ArcGrid: U.S. Geological Survey: Reston, VA, http://ned.usgs.gov/, http://nationalmap.gov/viewer.html. WFDSS (Wildland Fire Decision Support System) http://wfdss.usgs.gov/wfdss/WFDSS\_Home.shtml

