Indicating Climate in the Western Pacific Northwest with the Forest Inventory and Analysis Lichen Communities Indicator

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I. Introduction

We demonstrate with data from the FIA Lichen Community Indicator in the western Pacific Northwest (PSW) how lichen communities can indicate shifts in temperature regime (Geiser and Neitlich 2007; Jovan 2007). Temperature and precipitation are both of central importance to lichen distributions because they influence photosynthetic rates and basic metabolic processes. Lichens also lack a vascular system and so cannot store water like plants can.

In climate change monitoring, fast-responding lichens are the “canaries in the coal mine” for the vegetation community. Shifting lichen distributions provide early warning of shifting climate in a region, which helps us foresee how plant communities will respond. Moreover, tracking climate-driven changes in lichen communities is important because wildlife and plants depend on lichens for food, shelter, and nutrients that will be adversely impacted. For example:

- “Fungi” lichens provide critical winter sustenance for many wildlife species (Fig. 1). They can be found throughout the tree line and subalpine forest zones.
- “Cyanolichens” fix nitrogen, which leaves into the soil and fertilizes plants.

A variety of birds and rodents use lichens for nesting material and camouflage.

II. Data Collection

Data for the Lichen Community Indicator are periodic surveys of lichen ("lichening") abundance for various species in western North America. Surveys are conducted on a circular, 0.5-ha plot centered on an existing PSW inventory plot (Fig. 2). Surveys last 30 minutes to 2 hours during which an observer estimates the abundance of each species present.

The plots are selected to provide a data set representative of the geographic distribution and extreme climatic variation within the Pacific Northwest. This is achieved by selecting plots within the US Forest Service Forest Inventory and Analysis (FIA) plot network. FIA plots are used so that long-term trends can be assessed and future surveys can be compared to existing data sets.

III. Climate Scoring (Fig. 3a, 3b)

Lichen surveys are used to assess climate at each plot with the help of a model. The presence of lichen species can indicate factors such as temperature and moisture levels. The model is used to predict the most likely species present on the plot, and thus the climate type.

IV. Climate Projections (Fig. 3c)

Geiser and Neitlich (2007) compared current mean temperature for climate zones to temperatures predicted for 2040 (Fig. 3). Differences were calculated from the PREM (Chunak et al. 2007) and Taylor (2007) models.

V. Species and Communities at Risk

Specificity of each lichen species for a particular climate zone was investigated with Indicator Species Analysis (ISA; Dufrêne and Legendre 1997). A strong indicator pollutant is defined as a species that is significantly more likely to occur at one site than the other, using a Monte Carlo test of significance. ISA identifies 7 to 23 statistically significant indicator species per zone. A being a significant indicator for one zone suggests greater sensitivity to climate change than species with weak distributions spanning multiple zones. Highlighted from the ISA are species whose 95% confidence intervals do not include zero. These species are likely to be highly susceptible to climate change.

VI. Conclusions

This early warning system shows considerable potential to alter the lichen flora of the western PSW. Similar patterns were observed using the FIA Lichen Indicator data for northern and central California (Jovan 2007). Lichensologists in Europe have already documented the occurrence of tropical and subtropical lichen species into higher latitudes while also witnessing a decrease in more temperate species (Van der Meulen 2002). With continued warming it is possible that some of the lichen flora will be altered. This can be seen in the Pacific Northwest as well. Further study is needed to better understand the effects of climate change on lichens in this region.