

Lichens as bioindicators of forest health, biodiversity and ecological continuity

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Lichens are complex organisms and their thalli are the result of cyclic symbiotic associations between at least two very different organisms: a heterotrophic fungi (**mycobiont**) and a photosynthetic partner (**photobiont**) which provides the necessary sugars for the metabolism and releasing oxygen during the process. Photobionts are the primary producers in the lichen symbiosis. From the interaction between the mycobiont (-s) and the photobiont (-s), through a process of **symbiogenesis** (Margulis & Barreno, 2003), the lichen thalli produced are stable "micro-ecosystems" having, as a result of the integration of the symbionts, new emergent properties, different from those of the isolated components. These non-linear properties found lichens to be particularly effective 'early warning indicators' of changes due to the impact of humans on ecosystems. Environmental changes produce varying responses in lichen symbionts, including: variations in diversity, morphology, physiology, genetics and ability to accumulate pollutants. Lichens tend to be long-lived and highly habitat specific organisms, they tolerate extremes of heat and cold environments and grow on all types of substrata and habitats. Thus, they make ideal monitors and can be used to estimate species diversity and habitat potential at all times of the year. Lichens differ substantially from higher plants because of their poikilohydrous nature and combined with other physiological processes makes lichen growth particularly susceptible to climatic variations, pollution and other environmental factors and liable to changes at genetic, individual, population and community levels.

Lichens have been used as predictive tools for investigating landforming processes and rates of environmental change. They have also been used to resolve environmental issues involving management of natural resources such as the effects of fragmentation and habitat alteration; the structure and management of forested stands, the ecological continuity on space and time of the natural or semi-natural forests, effects of development on biodiversity, the effectiveness of conservation practices for rare or endangered species, and the protection of genetic resources. Because of their excellence as predictive organisms, lichens have been used in different countries as bioindicators of high value forests for conservation and to identify important biodiversity sites, with thousands of papers published in the last decades.

The significant correlations found between stand age and lichen species-richness in several forests substantiates the importance of old or died trees, and related factors, as a habitat for lichens (Humphries et al., 2002). There are a distinctive group of lichen species associated with the bark of the trunks of old trees, which are not found in any of the other young stands. These are the species of the *Lobarion* community. During our studies in the Lichen flora and diversity of the Natural Reserve of Muniellos (Spain, SW-Asturias) an area important for conservation -being included in the UNESCO-MAB reserves network (Barreno & Pérez-Ortega, 2003), covering 5542 hectares mostly in the montane bioclimatic belt, we have identified 474 taxa of lichens and 28 lichenicolous fungi -25% of Iberian Lichen Flora-, including the collection of 60% of the taxa of the genus *Cladonia* and maximum size thalli of the most sensitive species of *Lobaria*, *Peltigera*, *Pannaria*, *Usnea*, *Sticta*, and *Nephroma* in the adult non-senescent stage. Anthropogenic sources of nitrogen, in its various forms, are the main pollutant influencing the loss of biodiversity in terrestrial ecosystems. Nitrophytic species are displacing the potential vegetation in the forests. It can be asserted that there are no nitrophytic habitats within this Reserve, being Muniellos a hotspots of lichen diversity, with numerous species that are indicators of ecological continuity, an exception in Atlantic Europe. Several results centered in territories under the influence of power plants as La Robla (León) or photooxidants by local and long-range transport (Els Ports and Maestrat, Castellón) show the differences in the visible symptoms and the lowest lichen diversity found in relation to direction of prevailing winds, humidity, topography, land-use and other local factors.

Examples of guidelines in different countries will be considered: FHM (Forest Health Monitoring) established by the EPA, USA included Epiphytic lichen communities to assess the condition and trend of forests of the United States. BioASSESS or MOEBIOS in the EU or the Italian Environmental Protection Agency ended in 2003.