**Guidelines to measure the impact of reactive nitrogen on ecosystems: the use of lichens as biomonitors under global change**

P. PINHO1,2\*, C. MÁGUAS1, C. BRANQUINHO1

*1 Universidade de Lisboa, Faculdade de Ciências, Centro de Biologia Ambiental (UL-FCUL), Lisboa, Portugal*

*2 Centre for Natural Resources and the Environment, Instituto Superior Técnico, Universidade de Lisboa (CERENA-IST-UL), Lisboa, Portugal*

Contact: [ppinho@fc.ul.pt](mailto:ppinho@fc.ul.pt)

When deposited in natural and semi-natural ecosystems, excessive reactive nitrogen has negative effects on biodiversity and cascading impacts on ecosystems functioning. It is therefore critical to recognize and even anticipate these effects. However, the available monitoring stations are clearly insufficient to properly characterize nitrogen deposition in space and do not provide a measure of impact on ecosystems, nor do the modelling approaches. We have used ecological indicators to solve these problems, focusing on atmospheric ammonia. Of all extensively monitored organisms, lichens were shown to be amongst the most sensitive to nitrogen and can be regarded as early-warning tools, anticipating sudden and sometimes irreversible effects on ecosystems. We present here our research lines on the establishment of guidelines to the use of lichens on monitoring the effects of nitrogen on ecosystems.

We have used measures of lichens nitrogen concentration and isotopic composition to map nitrogen pollution on several spatial scales and to identify nitrogen sources in areas where multiple sources of reactive nitrogen are located, including industrial and agriculture ones. These works were based on spatial explicit analyses that were required to reply questions on the where and what nitrogen sources were found. We have also used lichen diversity to establish the threshold concentration that aim at protecting ecosystems, the critical levels (for nitrogen atmospheric concentration) and critical loads (for nitrogen deposition). Although lichen richness has been used to monitor the impact of industrial pollution, nitrogen was shown to have more subtle impacts. Thus our approach was based on the use of functional response groups, and was very successful in determining thresholds for Mediterranean ecosystems on a number of different situations and spatial extends, including large regions where multiple pollutants were present, including NOx and other typical Mediterranean pollutants such as dust. This type of indicators has the potential of being universal, as although species may change across biomes, functional groups will not. Further work includes the importance of climate and historical background on the effect that excessive nitrogen has on ecosystems.