Forecasts needed for retreating forests

As tree habitats shift towards the poles in response to climate change, we must study the neglected, trailing edges of forests, warns **Csaba Mátyás** — they are economically and ecologically important.

Ecologists generally agree that trees and forests in the temperate zone will shift polewards in a warming world. Much research has been focused on the advancing edges of these ranges. Oddly, the retreating low-latitude and low-elevation limits of forests have been left largely unexplored until very recently. This is despite grim forecasts: the retreat threatens multiple ecological and socioeconomic services, and will require an active human response. Our understanding of how forests will behave at these trailing ends is surprisingly insufficient.

In the 1970s and 1980s, central Europe was hit by mass forest dieback. The damage affected many commercial species, wiping out about 15% of oaks in a decade. Losses were so serious that some countries kept their tree mortality data secret to avoid scaring importers. The culprit was thought to be acid rain, pests or disease.

Looking for alternatives to replace the threatened conifers in my native Hungary, I visited Morocco in 1992 to investigate the Atlas cedar. I was struck by how the dense cedar forests of the Moyen Atlas mountain range were bordered on southerly slopes with only scattered trees, neighbouring crests on which all the trees were dead, and barren, stony hills in the distance. This was the climatic tolerance limit of the Atlas cedar — a northward-shifting drought was gradually killing trees, leaving ugly mass mortality at the trailing edge. I realized that the main cause of forest decline in my own country could also be progressive climate change, challenging the limits of genetically set aridity tolerance in local species, and making weakened trees more vulnerable to assault. The line between life and death — the 'xeric limit' — was probably on the move.

Tracking the trend

Reports of forest mass mortality surfaced again, sporadically, in the early 2000s, consistent with what would be expected from shifting xeric limits. Droughts in the mountainous, arid southwest United States in 2000 and 2004, for example, caused the deaths of 30–60% of the trees in about 10% of all aspen forest types in the region, with greater mortality at lower altitudes. In the western Mediterranean, some plant species have shifted to higher altitudes and the dominant type of vegetation at various altitudes has changed — oak forests have turned to scrub lands, for example.

But these events have typically been treated as isolated, transient problems, rather than as a consequence of a larger, persistent cause. In some regions they are not even considered problematic in the short term, as dying trees simply make room for more goat pastures in Morocco, or provide extra salvageable timber for European foresters. Over time, however, such losses will have more dramatic social and economic consequences.

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Dead cedars at the 'xeric limit' of their range in the Atlas mountains.

How exactly xeric limits will move in future is poorly explained by current ecological and genetic models. Ecologists tend to overlook the role of genetics in the ability of subpopulations to survive changing conditions, whereas genetic methods cannot handle ecologically important processes. The problem is seldom addressed in scientific papers or in textbooks. Perhaps one reason for the neglect is that much of the research on tree growth is supported by the forestry sector, which is more interested in studying where trees grow well than where they do not grow at all. Also, such studies require long-term monitoring and field work in often remote areas, neither of which is particularly attractive to potential funders.

In Europe, an international monitoring program (the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests, or ICP Forests) has gathered an immense body of information about the decline of tree health. But the data have been of limited use because of low representation of threatened regions and insufficient ecological and genetic background data.

A workshop on xeric limits that I convened in May 2009 was unanimous that the issue has wide-ranging ecological and evolutionary consequences, and requires a transdisciplinary approach. Researchers should prioritize studies of how forest ecosystems respond to extreme environmental stress, and of their mechanisms of persistence. More monitoring systems and test plots of dominant species need to be established in areas where they will be threatened by aridity. Long-term, ground-based or remote-sensing monitoring networks have to be adjusted to improve the observation of forests, especially in drought-threatened flat-lands. These data will be needed to improve models of xeric-limit shift and for adaptive resource management, land-use policy and nature conservation.

Tree populations that are close to xeric limits should be conserved, as they are better adapted to water stress and thus are genetically valuable. Programmes for conservation of forest genetic resources in Europe and North America should devote more attention to endangered subpopulations, rather than simply concentrating on species as a whole.

Some scientists argue that the climate selection effects on trees are ineffective and slow, or that the large genetic variability and long lifespan of temperate trees will support their persistence and regeneration. These views lead to the doubtful conclusion that there is no urgency to develop a better understanding of the ecological and genetic conditions that lead to local extinctions. Such arguments are particularly tenuous with regard to landscapes that have been transformed by humans; here, little room is left for the balancing forces of spontaneous natural processes.

By understanding xeric limits, we can initiate prudent human support of threatened forests, and intervene in ecosystem retreat. ■

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