species are less well adapted? To produce his third data set, Case recorded the populations of native and exotic species in natural and exotic habitats at ten locations. The proportion of native individuals or species in natural forest habitats was over 80%, but in modified grasslands and other non-natural habitats the proportion was reduced to around 50%. Case's literature surveys for New Zealand and Australia produced similar results to those stemming from his field work, although the proportions in the two countries differed somewhat because New Zealand has a far richer exotic bird fauna than does Australia.

Interestingly, using one line of reasoning, Case's finding that there is an approximate match between the number of native species lost and exotic species gained suggests that the new habitats have impoverished species diversity. We know that the number of species roughly increases with area raised to the 0.25 power. Other things being equal, this means that if part of a native habitat on an island is destroyed and replaced by new habitat which is invaded only by exotics, the total number of species on the island should increase.

Suppose, for instance, that the loss of 50% of native habitat on an island is matched by a gain in new habitat that can be exploited only by exotics, then in a simplistic limit we might expect the number of native species to diminish by 16% but the total number of species on the island as a whole to increase by 68% as exotics become established in the modified region. The fact that the total number of species remains approximately constant indicates that other factors are at work: we know that neither natives nor exotics are wholly confined to particular habitats; it is likely that the new habitats are not able to support as many species as the old habitats; and frequently there has not been enough time for sufficient exotics to establish themselves.

Preventing extirpation of species in the first place is, of course, to be preferred over reintroducing them. After all, in the second instance habitats must be re-created, often with reintroductions of species from a variety of taxonomic groups. So that limited resources can be optimally used, increasing effort in recent years has gone into identifying endangered species that are most under threat of extinction⁴.

This is the background to the paper by Dobson *et al.*². These authors use the endangered species lists for both animal and plant taxa occurring in the various counties of the United States of America (and therefore including Hawaii) to determine whether hotspots for endangered species coincide across taxa, and to help identify those areas most in need of conservation resources. Using a complementarity algorithm, they first identify the county with most endan-

gered species, then the county with most endangered species that are not included in the first county, and so on. Most endangered species occur in Hawaii, southern California, the southeastern coastal states and southern Appalachia. Their complementarity algorithm also selects counties in those same regions. Overall, between 1% and 5% of total land area delimits those counties which are required to sample more than 50% of endangered species for particular taxa.

In Britain, which is smaller and less speciose than the United States, Prendergast *et al.*⁵ found that the locations of hotspots for one taxon are not good predictors of locations of hotspots for other taxa. Dobson *et al.* come to the same, unfortunate conclusion. For example, they applied the complementarity algorithm to birds to identify the minimum number of counties required to locate all endangered species. That area contained only 30 to 40% of endangered herptile (amphibian and reptile), mammal and plant species, just over 10% of arthropod and fish species, and about 2% of mollusc species.

Would it, then, be possible to find a taxon that is a much better predictor than birds of the presence of endangered species? At first sight the answer appears to be plants. By identifying the minimum area required to conserve all plant species, we would also be conserving 94% of birds, and between 39% and 76% of species in other taxa. The downside to this is that the area containing all the plants is almost 10% of the area of the United States, whereas that for birds is less than 2%.

Dobson *et al.* conclude that birds are, in fact, probably the best indicator species for other taxa when constraints of land area have to be taken into account. As with other hotspot studies, it is possible to identify critical areas for some combinations of taxa, but others tend to be excluded. As an unsurprising example, locations containing threatened species in water bodies are not necessarily found in the same areas as those containing threatened terrestrial species.

Nevertheless, the general patterns revealed by Case, Dobson *et al.* and others are beginning to give us a better understanding of the general factors causing both the loss of native populations and the successful invasion by exotic species. Only through that understanding can we hope to slow down, halt or even reverse those processes. □

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Daedalus

The sap also bubbles

How does water get to the top of a tree? Botanists claim that it is sucked up by its evaporation at the top. For trees taller than ten metres, however, the liquid xylem must be sucked so hard that it experiences negative pressure, that is, tension.

This is not quite as absurd as it seems. In clean conditions, a column of liquid can withstand many atmospheres of tension before it breaks, cavitating into bubbles of vapour. This could be checked by measuring the xylem tension in a tree. Daedalus once proposed to cool down a section of tree, to measure the freezing point of its xylem. This is lowered by pressure, and must be raised by tension. The moment of freezing could be detected by ultrasound or X-ray diffraction. Sadly, ultrasound might itself cause cavitation, relaxing the tension to be measured, while X-rays could create bubbles in the xylem, bubble-chamber fashion.

But Daedalus now argues that this must happen all the time anyway. Cosmic rays and wind vibration must constantly cavitate the xylem in trees. To live at all, they must have some mechanism for compressing and collapsing the bubbles in their xylem as fast as they form. Perhaps the xylem ducts have pressure-sensitive valves at each end, which detect cavitation. When they do, the valve at the top opens, the one at the bottom closes, and the xylem above the bubble slowly descends to collapse it. Pumping then resumes, and the metabolism of the tree is soon restored.

So Daedalus now sees his erstwhile experiment as a powerful way to control the growth of a tree. In parks, gardens, town squares and landscaped grounds, trees need constant attention. Foresters and tree surgeons must always be cutting them back, maintaining their elegance while keeping their branches from overshadowing lawns, or their roots from damaging foundations.

The DREADCO xylem cavitator will change all this. Attached to a tree, it will launch a succession of ultrasonic pulses, or a well-judged trickle of high-energy particles, into its trunk. It will challenge but not overwhelm the tree's cavitation-repair system. With proper calibration, it will not kill the tree, but will exactly arrest its growth. Smaller versions could be attached to specific branches, sabotaging their growth while allowing others to extend without opposition. The tree could thus be sculpted into any desired shape. With no sawing or mutilation, ornamental trees will be formed to perfect shape and condition, making silviculture an even finer art.

David Jones