tions and maybe more besides.

Thus Fermat's challenge to succeeding centuries will prove to have been much more than an elaborate brain-teaser. In itself, it has been a stimulant of efforts such as those of Kummer, which in turn have led to new conceptual structures. It will be a fitting outcome of the search for a proof if it now emerges that the lasting outcome is a conceptual unification of such disparate fields.

Andrew Wiles has not yet proved the full Weil–Taniyama conjecture, though that proof cannot be more than a few years off. But he has proved enough of it to be able to deduce Fermat's last theorem. His argument draws on results across almost the whole spectrum of modern pure mathematics. What was announced last week is far from being the end of the story. □

Peter Swinnerton-Dyer is at the Isaac Newton Institute for Mathematical Sciences, 20 Clarkson Road, Cambridge CB3 OEH, UK.

CONSERVATION BIOLOGY

A helping hand in succession

Peter D. Moore

CONSERVATION is in part becoming an exercise in global gardening, and the rehabilitation of ecosystems when the natural vegetation has become highly fragmented is being investigated from many angles. One imaginative strategy is currently being tried in two separate experiments on Staten Island, New York, and in central Florida, the results of both of which are reported in the latest issue of *Conservation Biology*. Robinson and Handel describe their study of the rehabilitation of landfill sites on Staten Island[1] and McClanahan and Wolfe discuss their approach to the reclamation of an abandoned phosphate mining site in central Florida[2]. Both teams have based their work on the idea that the process of succession, particularly the invasion of new species, can be accelerated if the appropriate treatment is applied.

Human land use, particularly urbanization, often has the effect of fragmenting natural habitats, and if any of those fragments are damaged their recovery may be delayed because reinvasion of any locally lost species is often slow as a result of isolation. Similarly, the development of vegetation on isolated reclaimed sites may be limited by the slow arrival rate of colonists. The establishment of new species is related inversely to the distance from any source of new organisms, directly to the area of the site and hence to its potential as a target for invaders, and also directly to the range of microhabitats and microclimates available at the site which may contribute to the successful establishment of new arrivals.

These criteria are essentially those developed in the study of island biogeographic theory by MacArthur and Wilson[3], and research such as that of Crowe[4] on the invasion of weeds into parking lots in Chicago shows that the general principles of the theory do indeed apply to urban 'islands' and reclamation sites. The speed of equilibration of such ecosystem fragments could theoretically be increased if the immigration rate of potential settlers were increased. This could be achieved entirely artificially by introducing organisms, or by the somewhat more natural technique of encouraging visits by those birds that operate as vectors of the plant species involved in natural succession.

A kind of hybrid approach, adopted in the landfill sites examined by Robinson and Handel, is the planting of trees and shrubs that may subsequently attract birds from other sites that carry the seeds of immigrant plants in their guts. A 1.5-hectare landfill site on Staten Island was covered with a 40-cm cap of compacted subsoil followed by sandy material and organic mulch. Three different vegetation types were then established by planting — an oak–shrub mix, a pine–shrub mix and an ericaceous cover. Further invasion of plant species was recorded within each of the three plantation types, particular attention being paid to species invading from other natural vegetation fragments in the area. In total 18 species had been deliberately introduced, but within a year this number had increased to 50. Nine of the 32 new recruits were wind-dispersed species and 20 were mammal or bird dispersed. The remaining three could have been brought to the site accidentally in the root balls of the planted species.

The arrival of bird-dispersed species depends upon the avian vector finding an appropriate place to perch and to shelter, which suggests that plantations with a higher structural complexity (that is, denser and taller trees and shrubs) should prove more attractive to them[5]. Robinson and Handel tested the density of avian-dispersed species against both the density and the height of the planted species and found a significant positive relationship in both cases. Dense planting of trees and shrubs that rapidly grow tall is evidently an effective means of increasing immigration rates of other plants, and in this way stimulates succession and thus general vegetation development and recovery.

If complexity of structure is one clue to encouraging plant immigration by the opportunities it offers to visiting birds, then it may be possible to attract the birds without having to wait for the development of vegetation architecture. In other words, if we simply provide perches then birds may well feel inclined to visit a site and defaecate in comfort. This is precisely the approach adopted in the Florida mine reclamation site where McClanahan and Wolfe have conducted their research.

A compacted, sandy soil covered the mine waste after reclamation in 1982. The area was devoid of vegetation but, instead of planting living trees, seven dead trees were erected (mean height about 11 m) and seed traps were positioned both close to them (1–3 m) and at some distance (10 m) to act as a control. A range of frugivorous birds was observed using the perches provided by the dead trees over the following seven years. In a study of seed fallout over a 20-month period, the density of seeds arriving in traps beneath the dead trees averaged 340 m^{-2}, while the control fallout was only 2 m^{-2}. The structural complexity of a dead tree is evidently acceptable to visiting birds and provides the necessary enhancement of plant immigration rate.

Actual establishment of species was considerably lower, however. By 1990 only two plants per square metre had become established beneath the dead trees; but this still far exceeded establishment away from the trees, where only 0.07 m^{-2} had gained a roothold. A bank of viable seeds (17 m^{-2}) was also present beneath the perches, whereas no seed-bank could be detected away from them.

This simple experiment demonstrates very clearly that it is possible for human management to facilitate a succession and short-cut the lengthy process of the development of vegetation canopy. The method is limited in the plant species it can encourage, however, because the changes in soil organic matter, microbiology and hydrology that accompany full vegetation development have not taken place and the residual edaphic rigours may preclude the establishment of all but the most tolerant plant species. But the simple provision of perches places a cheap and useful tool in the hands of the reclamation ecologist — more strength to the arm of the global gardener. □

Peter D. Moore is in the Division of Life Sciences, King's College, Campden Hill Road, London W8 7AH, UK.

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