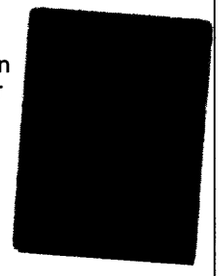
LETTERS

Influences

A geographer describes an insight about permafrost and carbon sinks that came to her as she flew over Siberia to Europe. Letter writers reflect a range of opinions expressed about an article that appeared in a special issue on "Human-dominated ecosystems" (25 July). The article focused on how lost ecosystems can be restored and endangered ones conserved. And an asthma specialist offers an explanation of why asthma cases have been "increasing in Western societies" and are "most severe" among the poorest populations of the United States.



High over the Permafrost

In August, on a return flight to Europe from Novosibirsk in Central Siberia, I observed an interesting phenomenon possibly adding a further dimension to the recent discussions about carbon sinks in your pages (Research News, 18 July, p. 315; Letters, 15 Aug., p. 883; Letters, 12 Sept., p. 1591).

We were flying over permafrost at around 35,000 feet. It was a beautiful day, with the continental anticyclone operating across the whole of Siberia. On the northern horizon there was a sheet of high cloud marking the position of the Polar Front. Below, for as far as the eye could see, pools of water and winding rivers, typical of permafrost regions, were giving off plumes of vapor that were being blown briskly downwind. Clearly, the water was warmer than the land, and evaporation was taking place followed by condensation.

If this phenomenon is a common occurrence and its frequency is increasing in line with changes in permafrost morphology in the Alps and on the Tibet Plateau over the last 15 years (*1*), there could be consequences for the vegetation (*2*) in this region of typically dry, short summers and long days. Previous work (*3*) suggests that an increase in growth would promote an increase in root structures and changes in carbon storage. A conservative rough estimate of the continental area involved could be around 8 million square kilometers.

We hear about the effects on climate of increases in methane from a melting tundra. Possibly some of this effect may be countered by an increase in carbon storage and increased cloud reflectance from the vapor plumes. A study of the meteorological data and the ecological consequences of increases in humidity and temperature in this region might provide data of interest to climate modelers.

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References

1. A. P. Gorbunov, *Permafrost Periglacl. Processes* **7**, 297 (1996).
2. R. B. Myneni *et al.*, *Nature* **386**, 698 (1997).
3. B. A. Hungate *et al.*, *ibid.* **388**, 576 (1997).

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Restoring Ecosystems

In their article, "Hopes for the future: Restoration ecology and conservation biology" (25 July, p. 515), Andy P. Dobson, A. D. Bradshaw, and A. J. M. Baker write optimistically about the prospects for ecological restoration of ecosystems damaged by conversion to human use. However, because they consider only direct conversion as a source of damage, their outlook appears overly positive. When other sources of human damage to natural ecosystems are considered, particularly the introduction and spread of nonnative species, the prospects for ecological restoration look considerably more remote.

Humans, both intentionally and inadvertently, have introduced a wide variety of species to ecosystems in which they were not originally found. Many of the species are aggressive colonizers, particularly, although not exclusively, of disturbed land; some, such as *Melaleuca quinquenervia* in southern Florida, form near monocultures that appear resistant to succession by native species. The widespread presence of these species may place severe constraints on our ability to effect meaningful restoration, because they become established in place of

the native flora and fauna. The result is ecosystems that not only differ radically in structure from those originally present, but are substantially different in function and support considerably reduced biological diversity. The problems caused by nonnative species vary around the world, but are substantial in many areas. Moreover, while phytoremediation techniques described by Dobson *et al.* offer exciting possibilities, they also inherently add to the danger that additional pest species may be introduced that could displace native species.

Although Dobson *et al.* have demonstrated the technological feasibility of returning some level of ecological function to converted lands, our ability to deal successfully with other aspects of the human assault on natural ecosystems remains unproved. One danger of a narrow focus is that practitioners of restoration may not account for biological factors important to their efforts. A greater danger is that the efforts of those who subscribe to the views put forth in the article may lead to a misplaced lessening of concern about habitat conversion.

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In Dobson *et al.*'s article, restoration ecology is presented primarily as something that should simply "become a standard part of the conservation biologist's armory." It has, in fact, a much larger role to play, not only in ecology (*1*) but in all matters related to sustainable land and bioresource use and "ecosystem management" (*2*). The current scope and direction of restoration ecology can be gauged by a survey of recent issues of the journal *Restoration Ecology*.

Several aspects of the article concern us. For instance, it is overly simplistic to use a single spatial scale to compare phenomena that may occur only once in a century (meteor strike) with others repeated hundreds or thousands of times in a small area (slash and burn agriculture). It is also unlikely that there is a straightforward, positive correlation between spatial scale and recovery time for disparate human activities, unwanted consequences thereof, and perturbations of nonhuman origins taking place in ecosystems and biomes of widely varying resistance and resilience to perturbations. The authors appear to assume that people never get it "right" and that all agricultural areas everywhere will eventually end up being abandoned. Their model predicts that "as the length of time for which land can be used for agriculture increases, the less forest remains in the final landscape." There is perhaps some truth in that, but cultural and biogeographical considerations should also be taken into account.

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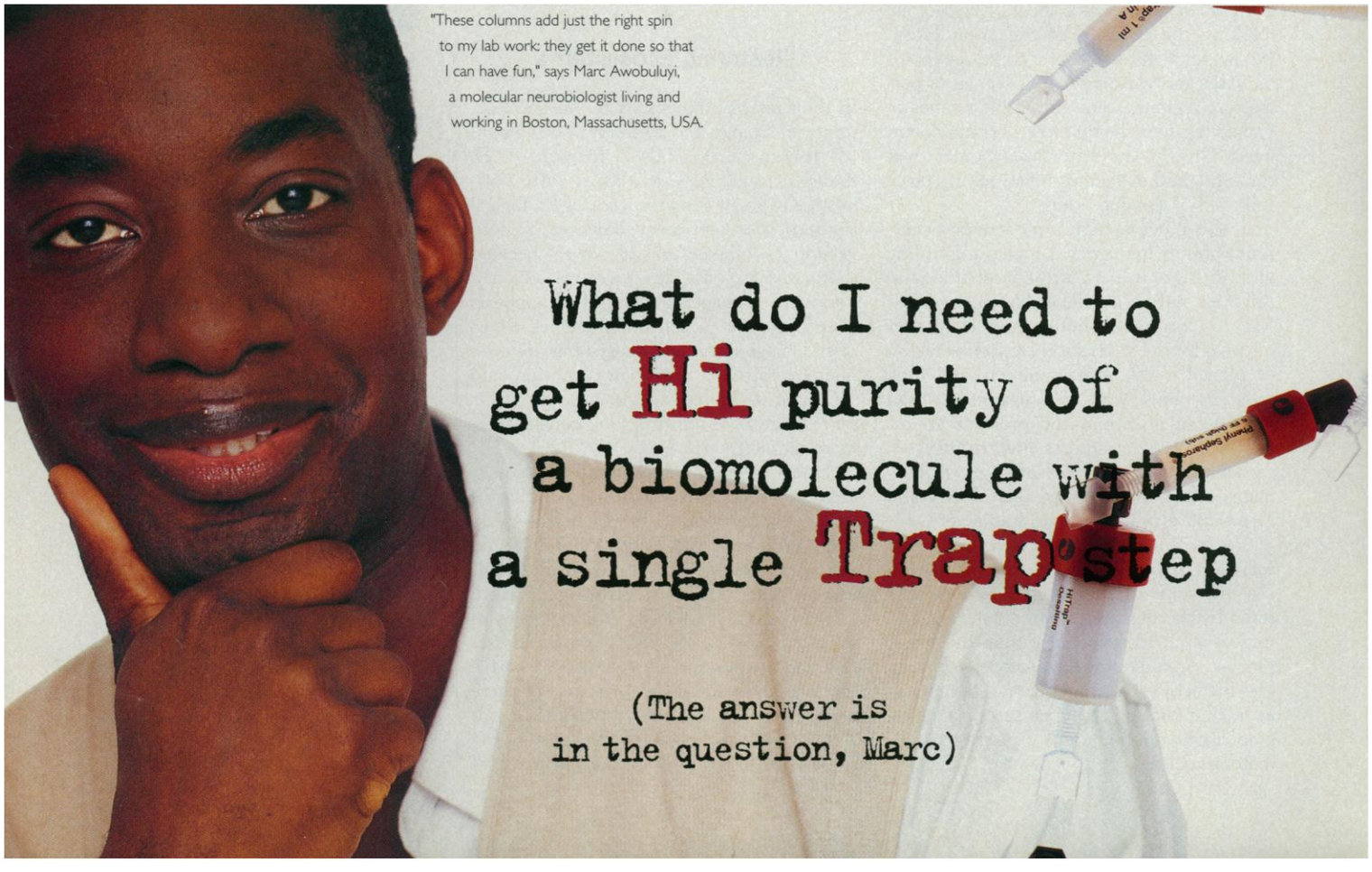
References and Notes

1. For example, E. O. Wilson has stated, "The next century will, I believe, be the era of restoration in ecology" [in D. Takacs, *The Idea of Biodiversity: Philosophies of Paradise* (Johns Hopkins Univ. Press, Baltimore, MD, 1997), p. 205].
2. N. L. Christensen *et al.*, *Ecol. Appl.* **6**, 665 (1996).

There are very good arguments for attempting to restore degraded landscapes and communities, and Dobson *et al.* address them. What they do not address is the serious philosophical case against the idea—if not



necessarily the practice—of restoration ecology. In 1982, Robert Elliot argued, in a famous paper entitled "Faking nature" (*1*), that a "restored" landscape is to a "real" one as a good forgery is to a work of art. Katz (*2*) reviewed the substantial literature that followed, arguing that ecological restoration is merely the domination of nature in disguise. The ground rules governing the ecosystem have changed since it was disrupted, and not all the changes are necessarily due to us. The selection of a time "before disturbance" and a condition to be "restored" are essentially arbitrary in a world where the ground rules are always changing. We can never know enough about the functioning of the predisturbance system to recreate it exactly. Components of the system may now be extinct; naturalized species may be excludable only by weeding; the probability of the system we create being self-sustaining without ongoing human intervention is often low. In short, "restoration ecology" is a specialized form of gardening in which the ideal to which we aspire is our notion of what was there before we disturbed it.

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References

1. R. Elliott, *Inquiry* **25**, 81 (1982).
2. E. Katz, *Restor. Manag. Notes* **9**, 90 (1991).

Response: The preceding letters illustrate points of view from alternative ends of the spectrum of questions that restoration biologists and conservation biologists need to address if they are to integrate their two fields. On the one hand, some will always see restored habitats as a poor substitutes for nature; their ultimate goal will be to only preserve pristine habitats. Unfortunately, there is a diminishing amount of natural habitat left in the world, and this approach places conservation biologists in the position of always trying to prevent development; this will ultimately prove psychologically damaging, scientifically constraining, and economically unviable.

On the other hand, restoration ecology offers conservation biologists the potential opportunity to create new habitats for agriculture, recreation, and perhaps conservation. Furthermore, it offers important scientific opportunities, such as the "developmental biology" of ecosystems. There will always be some enthusiasts who argue that restoration ecology can provide quick fixes that will allow development to proceed and that these fixes will replace natural ecosystems under the premise that the latter can be restored at a later date. This is far from the case.

We agree with Richter that the introduction of alien species presents a major threat to endangered species and ecosystems; nevertheless, recent studies indicate that approximately 85% of endangered species are threatened by habitat loss, while fewer than 50% are now threatened by invading species, although the threat is increasing (*1*). This suggests that it is crucial to develop a holistic approach to ecosystem management and to address habitat loss, invasions by exotic species, and other anthropogenic threats, such as potential climate change. The pressure for further loss of natural habitats may then be reduced.

We agree with Aronson and Hobbs that it is unwise to ignore spatial processes when considering the recovery of ecological systems from damage at different spatial scales. Nevertheless, there seems to be some relatively constant scaling between the spatial scale of ecological damage and the recovery time. Indeed, the fact that "recovery time" scales with the square root of the area of ecological damage implies that spatial scale is important and that systems recover relatively faster from large-scale damage.

We regret not citing anything from *Restoration Ecology*; it is an exciting journal that contains many interesting papers. We thoroughly checked back issues of the journal, as we thought the results presented in the first third of our article were so fundamental to the fields of restoration ecology and landscape ecology that they had to have been derived elsewhere. We could find no mention of them in *Restoration Ecology* nor in several textbooks on the subject. We fully appreciate that the basic model we presented ignores much ecological and sociological detail that may affect its results. Nevertheless, the results are considerably more sensitive to changes in ecological assumptions than they are to changes that reflect assumptions about human behavior. Essentially, we attempted to apply Occam's razor, in the form of a simple dynamic model, to the shaving foam of rhetoric that is beginning to surround the topic of human land use and sustainability.

Shapiro raises two interesting points from the other end of the spectrum.

1) Can we really replace *exactly* what was there before? The answer must surely be "no," but we can provide something that is *nearly* the same and *effectively* so. But since everything is in a state of flux, what are we going to take as being there before, and why does it matter anyway?

2) Restoration will *always* need intervention, so it is really gardening. Intervention may be necessary initially, but soon natural processes will do the job.

The fact that so much of biodiversity is irreplaceable is perhaps the central tenet of conservation biology. Although restoration ecology may provide economically viable ways of restoring land that is heavily degraded, it is more likely that this land will be used for human recreation or habitation, or as sites for less damaging industrial activities. Only a small portion of restored land will be used as new nature reserves, although any form of restoration is likely to reduce the pressure for further conversion of natural habitats, which will remain the main way of preserving biodiversity on Earth intact.

It remains one of the deeper ironies of modern science that we have a deep theoretical understanding of how the universe formed, yet we still have a long way to go in understanding how to restore natural ecosystems on Earth. While it can be argued that the human enterprise is ultimately dependent on our understanding of how the universe is structured, our need to understand, both theoretically and empirically, how natural ecosystems develop is rather more urgent. Restoration ecology and conservation biology offer real insights into this problem; unfortunately, the present scale of funding for them is considerably less than that for these more esoteric scientific enterprises.

Finally, we would like to take this opportunity to correct a typographical error in our original article. Equation 8 should have been

$$P^* = \frac{\left[F_0 - \left\{ \left(\frac{ah}{d} \right) \left(\frac{s}{s+b} \right) \right\} \right]}{h \left[1 + \frac{a}{b+s} \right]}$$

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References

1. D. S. Wilcove, D. Rothstein, J. Dubow, A. Phillips, E. Losos, *Bioscience*, in press; N. J. Collar, M. J. Crosby, A. J. Stattersfield, *Birds to Watch 2, The World List of Theatened Birds* (BirdLife International, Cambridge, UK, 1994); T. D. Sisk, A. E. Launer, K. R. Switky, P. R. Ehrlich, *Bioscience* **44**, 592 (1994); A. R. E. Sinclair *et al.*, *Ecol. Appl.* **5**, 579 (1995).

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Rise in Asthma Cases

Gretchen Vogel's Research News article "New clues to asthma therapies" (13 June, p. 1643) clearly acknowledges that asthma is an inflammatory disease and that it has been increasing in Western societies over the last 35 years. However, the United States is the only country in the world where asthma is most severe among the poorest population (*1*). In the villages of Africa and Papua New Guinea, as well as in traditional Eskimo society, asthma remains rare among children (*2*). Over the period when asthma has been increasing, evidence has come from many sources (*3*) that exposure to indoor allergens, including house dust, is a major cause. We do not know, however, whether increased allergen exposure is a convincing explanation for the increased prevalence and morbidity of asthma. It seems unlikely that changes in exposure to dust mites, domestic animals, and cockroaches have been sufficient or that these different sources have increased in parallel over a 35-year period (*4*). This has led many investigators to search for other factors in Western society that could have enhanced immune responses to common environmental proteins or decreased the physiological threshold for wheezing in allergic patients (*5*). The rise of indoor entertainment has had multiple effects, of which more time spent indoors is one (G. Vogel, "Why the rise in asthma cases?", Research News, 13 June, p. 1645). The more disturbing parts of the "Annette Funicello" effect (*6*) are prolonged periods of sitting and an accompanying decline in outdoor activity. Because of the scale of this phenomenon, the physiological and medical consequences should be taken seriously. The rise in obesity among children reported by the U.S. Surgeon General (*7*) leaves little doubt that changes in behavior have metabolic consequences, and this is highlighted by evidence for an increase in Type II diabetes among obese children.

Many of us live in a society where too many children have stopped playing outdoors. In part because of fear of crime, this phenomenon is most marked in the inner city. Prolonged exercise, that is, play or walking, appears to be protective against wheezing (*8*), and this may be a major reason why asthma remains rare in those countries where outdoor activity is a normal part of life.

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References and Notes

1. D. Lang *et al.*, *N. Engl. J. Med.* **331**, 1542 (1994); P. J. Gergen *et al.*, *Pediatrics* **81**, 1 (1988); A. J. Woolcock *et al.*, *The Rising Trends in Asthma* (Ciba, Wiley, New York, 1997).
2. L. N'Ganga, thesis, McGill University (1996); K. J. Turner *et al.*, *J. Allerg. Clin. Immunol.* **77**, 553 (1986); H. Herxheimer *et al.*, *N. Engl. J. Med.* **291**, 1419 (1975).
3. R. Sporik *et al.*, *N. Engl. J. Med.* **323**, 502 (1990); R. Sporik *et al.*, *Clin. Exp. Allerg.* **22**, 897 (1992); T. A. E. Platts-Mills *et al.*, *Bull. WHO* **66**, 769 (1989); D. Rosenstreich *et al.*, *N. Engl. J. Med.* **336**, 1356 (1997); R. Call *et al.*, *J. Paeds.* **121**, 862 (1992).
4. N. Aberg, *Clin. Exp. Allerg.* **19**, 59 (1989); T. Haahtela *et al.*, *Br. Med. J.* **301**, 266 (1990); E. A. Mitchell, *Arch. Dis. Child.* **60**, 376 (1985).
5. "Rising Trends in Asthma," CIBA Foundation Symposium (1997); A. Seaton *et al.*, *Thorax* **49**, 171 (1994).
6. Annette Funicello was the leader of the Mouseketeers on the television show "The Mickey Mouse Club" from 1954 to 1962. This show can be credited with persuading a large number of American children to sit indoors when they could have been playing outdoors.
7. *Surgeon General's Report* (U.S. Government Printing Office, Washington, DC, 1996); C. R. Scott *et al.*, *Pediatrics* **100**, 84 (1997); S. L. Gortmaker *et al.*, *Arch. Pediatr. Adoles. Med.* **150**, 356 (1996).
8. G. Skloot *et al.*, *J. Clin. Invest.* **96**, 2393 (1995); J. A. Nadel *et al.*, *J. Appl. Physiol.* **16**, 717 (1961); W. M. Parham *et al.*, *Am. Rev. Respir. Dis.* **28**, 240 (1983).

Corrections and Clarifications

In the Random Samples item "Odd visitor from the Oort cloud" (10 Oct., p. 229), Paul Weissman was incorrectly described as the discoverer of object 1996 PW. The asteroid was found by Eleanor Helin and colleagues on the Jet Propulsion Laboratory Near Earth Asteroid Tracking team, and the unusual orbit of 1996 PW was recognized by Gareth Williams of the Minor Planet Center.

Letters to the Editor

Letters may be submitted by e-mail (at science_letters@aaas.org), fax (202-789-4669), or regular mail (*Science*, 1200 New York Avenue, NW, Washington, DC 20005, USA). Letters are not routinely acknowledged. Full addresses, signatures, and daytime phone numbers should be included. Letters should be brief (300 words or less) and may be edited for reasons of clarity or space. They may appear in print and/or on the World Wide Web. Letter writers are not consulted before publication.