

operate as they once did. Some of its large mammals are extinct. Many new species have arrived through human agency. And climate change is altering the seasonal timing and hydrological cycles of the forest.

The only alternative is proactive management — by humans. Already, conservationists in some forests set small fires to burn out underbrush before it reaches levels that could produce catastrophic fires. They shoot prey species whose populations are out of control because the top predators have been exterminated. And they have begun to control water flows into wetlands where the natural flow has been disrupted. In the future, as climate change takes hold, management may become even more radical. Some ecologists are beginning to talk about moving slowly dispersing plants and animals pole-wards or upslope to keep them in climates they can thrive in, or introducing non-native ‘functional equivalents’ in some ecosystems to play certain key roles.

Such talk will undoubtedly raise hackles among those ecologists for whom intervention in natural ecosystems is anathema. Yet our species’ all-pervasive impact on this planet has already doomed that hands-off approach to failure.

Unfortunately, would-be managers of natural regions still know very little about how to save natural places without continuing *Homo*

*sapiens*’ legacy of destruction. Ecologists have conventionally studied the workings of intact ecosystems, but have focused much less attention on how to keep them intact. Scientific research on the best ways to manage natural ecosystems needs to become a much higher priority.

Meanwhile, economists, ecologists and ethicists need to seek ways to bring natural ecosystems into the economic system, instead of just assuming that they exist outside of or in opposition to economics. If nothing else, this will require continued research on how to put a fair economic value on ecosystems that provide humankind with services — a classic example being wetlands that absorb storm run-off and help prevent flooding — while not dooming ecosystems such as deserts and tundras that contribute in a less obvious way.

For now, the custodians of Białowieża are letting the never-logged core area alone, even going so far as to prohibit entry to tourists except when accompanied by a guide. But the day may come when hands-off means waving goodbye. Will science know how to save Białowieża when that day comes? ■

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## Virtues of visualization

Mapping techniques, used with care, can offer fresh insights into data about the world around us.

Maps are powerful, but imperfect, visualizations of the world. They are never true in any absolute sense; rather, they express certain aspects of the truth in ways that are useful for the task at hand, using rules and conventions that have to be understood in context. No flat map of Earth’s curved surface can preserve both area and angle; some aspect of the reality is always distorted. So geographers have invented a plethora of projections that allow them to choose the distortions judiciously. One projection might sacrifice the accuracy of shapes and areas to preserve bearings, for example, whereas another might facilitate precision measurements in a field survey. But even this panoply often falls short — and can be downright misleading — when it comes to representing more abstract forms of information.

A classic example is the use of maps to visualize scientific and social data about nations, states or counties. Mapmakers usually do this by simply adding, say, a colour scale to represent the value of indicators such as disease outbreaks. In addition, because this technique by itself is often misleading — it takes no account of differences in population density, for example — the data are frequently normalized to per capita values. But this means that the map loses crucial data — in this case, total incidences.

The cartogram technique, in which the sizes and shapes of geographical areas are distorted to represent the population or some other variable, can overcome these issues and preserve the full richness of the data (see page 270). Used correctly, it can free statistics from the shackles of geography, allowing richer visualizations of anything from

election results, to census tabulations, to species biodiversity.

Cartograms have yet to be widely adopted, despite being the best choice for many sorts of data. One reason is that initially they can seem confusing, as most viewers’ brains are more at home with the size and shape of countries and states as they appear in an atlas. Another is that efficient algorithms to create not only cartograms, but many other forms of visualizations, have generally been the preserve of a handful of specialized laboratories. That is now changing.

IBM’s Visual Communication Lab in Cambridge, Massachusetts, for example, has created Many Eyes ([www.many-eyes.com](http://www.many-eyes.com)). This free site provides the public with tools to create visualizations such as network diagrams, which depict nodes and connections within networks, and treemaps, which display hierarchical data as groups of nested rectangles. Similarly, Google Earth and other virtual globes are providing scientists and non-scientists with unprecedented tools for geographical visualization of data. The obvious, and perhaps unexpected, enthusiasm of the public for such visualizations suggests that it is a rich vein for educators and scientists, both to explain their own work and as a means to engage young minds in critical analysis of data.

Visualizations are not a panacea. The adage ‘rubbish in, rubbish out’ still applies. But when used well — and, in the future, when combined with emerging surface-computing and other interactive displays — visualization can provide different views of data that force us to ask new questions, and generate fresh hypotheses.

The flood of data now coming online and the emergence of new forms — such as the data on social networks, e-mail and mobile-phone patterns that are rejuvenating the social sciences — means that visualization will be increasingly important for scientists. Such diverse windows on data should also strengthen civil society by giving scientists and citizens alike the power to sift through the data generated by governments and other institutions, and to challenge their and our own preconceptions of the world. ■