Why Dynamiting Vampire Bats Is Wrong

A new report argues that it is not the lack of ecological information that leads to poor environmental planning, but simply the lack of its proper application

"THERE is still a great deal of ecological knowledge to be gained, of course, but the problem is that we tend to use less information than is already available." Gordon Orions, of the Institute of Environmental Studies, University of Washington, expressed this sentiment in relation to the management and control of environmental effects of construction and other major development projects. "Our main focus, therefore, is to find ways to use ecological information more effectively in dealing with environmental problems."

Orions is chairman of the National Research Council's (NRC) Committee on the Applications of Ecological Theory to Environmental Problems, which presented its report at the end of March.*

The committee considered a wide range of environmental issues, including prediction and management of environmental impacts, management of renewable resources, protection and restoration of species and ecosystems, control of pests in agriculture and forestry, and use of generic ecological studies to promote understanding of classes of environmental problems. "Rather than focus on what is wrong with the way ecology is often applied, we use successful applications to show how ecological knowledge can be valuable when used appropriately," states the report.

One of the committee's principal conclusions is that environmental impact statements as currently operated represent lost opportunities. At present, environmental impact statements are written to meet various legal requirements, but they could be viewed instead as true scientific hypotheses about how the environment will be affected by a particular project. Correct monitoring of various environmental parameters throughout the project would then constitute an ecological experiment on a scale far beyond what would be feasible through conventional funding agencies. The information gained by such means would then be applicable to future projects of a similar nature.

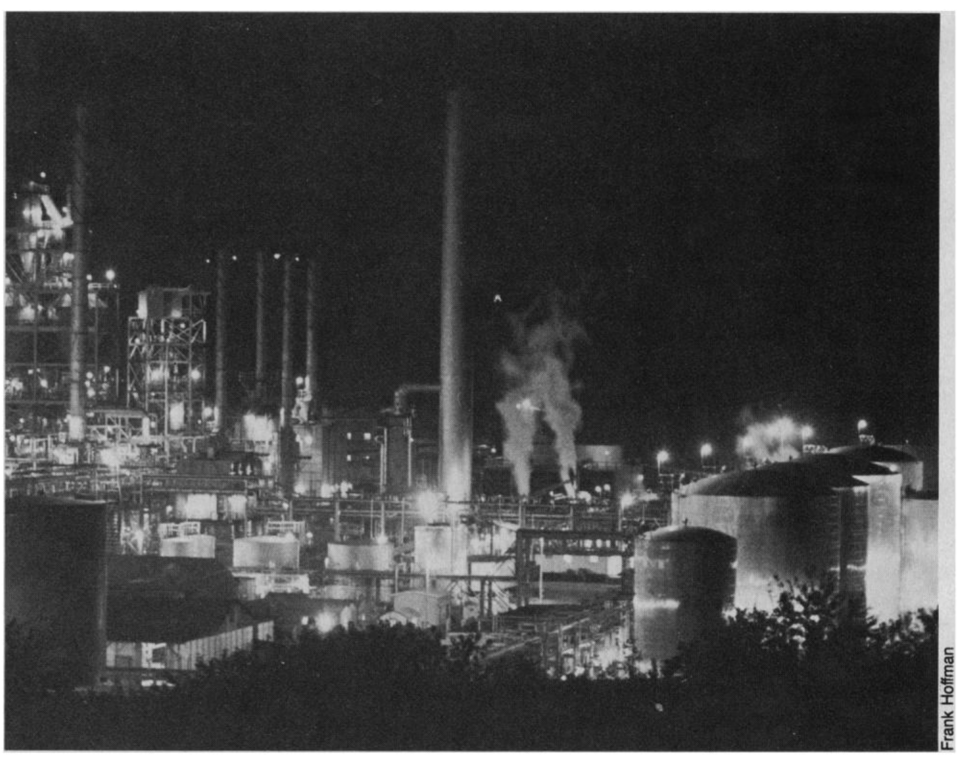
As things stand at present, says Orions, too many arguments about development projects are based on prejudice rather than knowledge. "There are a lot of people on both sides of the arguments who find it convenient not to know what actually happens when a project goes ahead. That way they can go into the next environmental battle with their positions unchanged."

A second major focus of the report is the insidious effect of cumulative perturbations of the environment. Examples of such perturbations might include the impact of effluent from a single power plant, the draining of a couple of hectares of salt marsh for building purposes, and the laying of a road through virgin forest. Individually, each disturbance is small and perhaps acceptable, but in aggregate they might be catastrophic.

The problem, says Orions, is that "Environmental laws approach problem-solving on a case-by-case basis. This makes it very difficult to recognize the cumulative impact of the environmental changes under consideration." At present, no one has the clear regulatory responsibility for recognizing such aggregate changes. "How often are projects stopped because they appear to be contributing (however slightly) to a trend in environmental deterioration?" asks the report. "What happens if scientists recognize a trend, but cannot detect or distinguish the effects of individual actions? The problem of multiple 'insignificant' effects is at the core of our failure to deal with the continued nibbling of coastal and other habitats."

In particular, thresholds are often extremely difficult to predict. "Below what population size will a species be unable to recover? Beyond what degree of fragmentation will an ecosystem begin to lose species rapidly or change markedly in its functioning? At what concentration will an environmental contaminant cause qualitative changes in community organization?" These types of questions, of course, are at the heart of the continuing debate over acid rain.

Any group of nine experts on ecology that sits down to consider the contribution of their science to problems of the environ-



A drop in the environmental pool. *One new petrochemical plant in a locality might seem acceptable, but its effects have to be counted together with other similar impacts on the environment. The cumulative effect of individual, acceptable environmental perturbations might be catastrophic.*

*"Ecological Knowledge and Environmental Problem-Solving," $24.50, available from the National Academy Press, 2101 Constitution Avenue, NW, Washington DC 20418.

ment can expect to field a wide variety of opinions, not least because so many societal values tend to intrude. However, the NRC's committee attempted to focus only on the biological aspects of the problems. Even here there was scope for differences in outlook between the academic ecologists, who may not appreciate the problems of environmental change in the "real" world, and the industrial ecologists, who take a more pragmatic approach to ecological complexity.

The committee discovered that one way around this potential conflict was to present a series of environmental case studies that illustrate how ecological knowledge might suggest an approach to a problem that is not otherwise obvious. The case studies also reveal that, no matter how much information there might be about a particular issue, almost certainly there will be surprises. The reason is simply that within complex ecological settings there are usually nuances—such as indirect and threshold effects—that are not necessarily predictable.

"Even with the best scientific information there will be some surprises," says Orions. "There is bound to be uncertainty and we must become used to dealing with probabilities. Most of all, we should be careful not to oversell ecology, claiming that we know it all."

There are 13 case studies in all, which range from attempts to destroy or preserve single species to management of perturbations on whole ecological communities (see box for examples). The case studies represent the real strength of the report.

The report states that it is not a "cookbook" for solving environmental problems. "Rather it is a guide to the process of 'cooking,' indicating where useful approaches to particular problems can be found in the literature and suggesting how appropriate knowledge and skills might be integrated for dealing with complex problems." In short, it is an appeal for the intelligent utilization of existing information.

Some of the major recommendations are as follows:

■ *Involve scientists from the beginning*. The evaluation of any particular project depends on many different types of consideration, including societal and economic. Where ecologists can make a special contribution is in identifying those parts of the ecosystem that might be particularly important. "The involvement of scientists does not guarantee success, but it should increase the probability that project plans are appropriate," notes the report.

■ *Treat projects as experiments*. Basic ecological science and its practical application would benefit from such an approach. "Careful monitoring is essential to anyone who

Case Studies in Ecology

The bulk of the NRC's committee's report on "Ecological Knowledge and Environmental Problem-Solving" is composed of specific case studies of various categories. The rationale is that knowledge of the ecology of individual species and complex communities can contribute to effective environmental control, as illustrated by the following examples:

■ *Vampire bat control in Latin America*. The common vampire bat, *Desmodus rotundus*, has been an agricultural pest for centuries, costing the lifestock industry some $350 million a year. Dynamiting and gassing caves proved ineffective and hazardous to other components of the ecological community. The Denver Wildlife Research Center therefore instituted a study based on knowledge of the life history of this species. The study revealed two vulnerable points in the bats' life history characteristics. First, the bats produce only one or two offspring each year, which means that recovery from a successful assault on the population would be slow. And second, the bat populations are concentrated near herds of livestock upon which they feed each night. One solution that emerged from this was to capture a bat, topically apply an anticoagulant to the animal's back, and release it to its home cave. Because the bats roost in dense colonies and spend at least 2 hours a day grooming each other, the poison is spread throughout the community. Typically, 19 bats would be killed for every one treated by this route of transmission of poison. The approach is now the control method of choice.

■ *Conserving a regional spotted owl population*. The spotted owl, *Strix occidentalis*, is endangered in the Pacific Northwest principally because its habitat of old coniferous forest is an important resource for the forestry industry. Logging activities fragment and destroy the bird's habitat. Until recently attempts to protect the owl have concentrated on ensuring the survival and reproductive success of individuals and breeding pairs. This is obviously important, but it is now realized that small local populations may be vulnerable and interactions between populations have to be taken into account. Numerous small, isolated but interacting populations are known collectively as a metapopulation, which has special genetic and demographic implications that are only now beginning to be understood. "This recognition is the crucial first step toward maintaining the long-term viability of threatened species, but the scientific issues raised will not be easy to deal with, and the social and political steps required will not be easy to accomplish," notes the report. Mathematical modeling of the spotted owl's predicament leads some authorities to be more concerned about genetic problems of small communities while others point to dangers of population collapse from demographic factors. The issues remain to be resolved.

■ *Raising the level of a subarctic lake*. In 1976 the outlet to Southern Indian Lake, in northern Manitoba, was dammed and the water level eventually rose 3 meters. As a result, water flow through the lake dropped by some 75 percent, new shorelines initiated substantial erosion, the water temperature dropped and its turbidity increased. The geological and biological impact of inundation was expected to be large and complex, but most predictions seriously underestimated the extent of the changes that eventually occurred. Mostly because shoreline erosion was much more severe than predicted, the resultant modifications in physical, chemical and biological characteristics of the water had rather different effects on the animal and plant life than had been expected. Some organisms fared better than forecast, some worse. The dramatic alteration in patterns of water flow also had a greater than expected impact on certain fish productivity. For instance, the commercial whitefish catch was predicted to decline by 13 percent, but instead collapsed to one third of its preinundation level. As a result of the differences between the forecasts and the actual outcome of the flooding, "future studies for similar projects will be based on better models," notes the report. "From a strictly scientific point of view, the project was exploited very profitably, in that new principles were uncovered and present paradigms have been enriched. But the knowledge was gained at a cost: the native peoples of the Southern Indian Lake region who suffered the loss of livelihood and threats to the quality of their food did not share in the scientific adventure." From a societal point of view, the compensation paid for the lost fisheries was "somewhat arbitrary and inequitable." ■ **R.L.**

would understand the effects of projects, test the predictions made in impact statements, detect changes in baseline conditions, and detect cumulative effects."

■ *Use natural history information.* For instance, the fact that cave-living vampire bats roost extremely close to each other and vigorously groom their neighbors was exploited in their highly targeted extermination using vampiricides, which were administered to captured individuals that were then released. This strategy, based on a knowledge of the animals' social and community behavior, replaced extermination attempts using dynamite, which had undesirable effects on other members of the cave community (see box).

■ *Be alert for possible cumulative effects.* As mentioned earlier, this component was identified as a major problem, and was the subject of a joint study with the Canadian Environmental Assessment Research Council, the results of which will be published separately.

■ *Prepare for uncertainty and think probabilistically.* Because each new environmental problem is in a real sense unique, and because of the potential hidden interactions between components of an ecological community, there will always be uncertainty in predicting the outcome of perturbation. "Scientists and managers must be willing to think in terms of probabilities and to deal with them, as weather forecasters and farmers, sailors, fliers, and the general public do every day."

■ *Set proper boundaries on projects.* It is a cliche, but nonetheless true, that ecological and meteorological systems are usually not constrained by political boundaries. Perturbations within these systems are therefore often difficult to regulate. "The appropriate jurisdiction for management should be chosen carefully," says the report. Again, acid rain is a good example here.

In contemplating the implementation of these recommendations, the professional ecologist has to come down somewhere between two extremes, says Orions. At one extreme is the temptation to treat every potential environmental perturbation as unique in a practical as well as theoretical sense. And at the other is the tendency to overgeneralize. According to Orions, the science of ecology has emerged from a period when some rather general theoretical models developed in the 1960's and 1970's proved to be inappropriate. It is now in a phase of "regrouping around more modest models," he says. It is the combination of these more modest models with empirical evidence that has the potential to contribute to sound environmental planning. ■

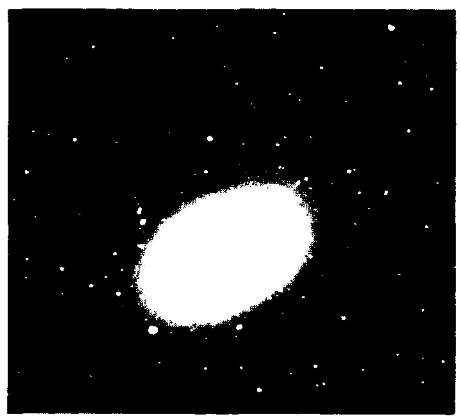
ROGER LEWIN

Briefing:

The Currents of Space

In a classic example of serendipity, a survey originally designed to improve the way astronomers estimate the distance to elliptical galaxies has now revealed large-scale bulk motions among the galaxies. These motions, in turn, seem to be saying something important about the origin and development of large-scale structure in the universe—although astronomers are only just beginning to understand what that something is.

The results of the survey, which was conducted by a seven-member team of astronomers* working at observatories in both hemispheres, were reported by team member David Burstein at a meeting last January in Hawaii.† With a total of 390 elliptical galaxies, it is the most complete survey of its type ever done: it covers the sky uniformly in all directions and includes a volume of space some 100 million parsecs in diameter. As an immediate payoff, said Burstein at the meeting, the team has derived a new distance calibration for ellipticals accurate to about 23 percent, which is considered quite good in cosmological circles.



A giant elliptical galaxy in Virgo.

More surprising, however, is what happens when the astronomers analyze the velocities of their ellipticals. First, having determined the distance to each galaxy, they use the Hubble law to find out how fast the galaxy ought to be receding from Earth because of cosmic expansion; then they subtract that quantity from the observed recession velocity as determined from the galaxy's redshift. The remainder is a purely local motion that presumably indicates how a given galaxy is interacting with its neighbors. However, the local velocities obtained in this fashion are still expressed as velocities relative to Earth, said Burstein. To see how the galaxies in their sample are moving relative to the universe as a whole, the group next subtracts out the known value for Earth's motion relative to the 3 K cosmic background radiation: 600 kilometers per second. (The background radiation is a relic of the Big Bang and comes as close as anything can come to being a stationary reference point for the universe.) And when all this is done, a striking pattern begins to appear.

First, for roughly 50 million parsecs in every direction clusters and superclusters of galaxies are streaming through the cosmos as a group, at some 700 kilometers per second. Indeed, most of Earth's own velocity through the cosmic background arises because the Milky Way galaxy shares in this motion. Second, the superclusters that participate in this overall streaming behavior also happen to lie in a fairly well-defined plane, the "supergalactic plane"; moreover, the bulk motion of the galaxies is roughly parallel to this plane. Finally, superimposed on the bulk motion is a patchwork pattern of motions on a scale of 10 million to 30 million parsecs, or about the size of a single supercluster.

"Our view of what this means is still unfolding," Burstein later told *Science*. Qualitatively, at least, the smaller scale patchwork motions are not all that surprising: since the galaxies themselves are distributed in a patchwork pattern, one would expect the lighter clumps to be falling toward the more massive clumps. The only real question is whether the numbers will work out quantitatively.

The large-scale streaming motion, however, is *very* surprising. The survey team has made a strong case that the effect is real: they have now reanalyzed two independent surveys of spiral galaxies that overlap the same volume of space as their ellipticals, and have found that both of them are consistent with the large-scale streaming. In all three surveys, the movement appears to be in the general direction of the Hydra-Centaurus supercluster, which lies near the Southern Cross in Earth's sky. On the other hand, Hydra-Centaurus is moving too. Is there some huge, undiscovered concentration of mass on the other side? Is the motion a relic of whatever processes formed the galaxies in the first place? At this point, no one is able to say, says Burstein. "But we're coming up with ideas from this that could change the way we model the nearby universe." ■

M. MITCHELL WALDROP

*David Burstein, Arizona State University; Roger L. Davies, Kitt Peak National Observatories; Alan Dressler, Mount Wilson and Las Campanas Observatories; Sandra M. Faber, Lick Observatory; Donald Lynden-Bell, Cambridge University; Roberto Terlevich, Royal Greenwich Observatory; and Gary Wegner, Dartmouth College.

†The NATO Workshop on the Extra-Galactic Distance Scale and Deviations from Hubble Expansion, Kona, Hawaii, 13–17 January 1986.