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

A giant elliptical galaxy in Virgo.

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.

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

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