Study: Can nature's leading indicators presage environmental disaster?

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Economists use leading indicators — the drivers of economic performance - to take the temperature of the economy and predict the future.

Now, in a new study, scientists take a page from the social science handbook and use leading indicators of the environment to presage the potential collapse of ecosystems. The study, published today (Jan. 5) in the *Proceedings of the National Academy of Sciences* by two ecologists and an economist, suggests it may be possible to use nature's leading indicators to avert environmental disaster.

Ecosystems worldwide — lakes, ocean fisheries, coral reefs, forests, wetlands and rangelands — are under constant and escalating pressure from humans and many are on the brink of collapse, according to Stephen R. Carpenter, a University of Wisconsin-Madison professor of zoology and an author of the new study.

"It's a big problem because they are very hard to predict. It is hard to get a handle on statistically," says Carpenter of what ecologists call "regime shift," a disastrous change in the way an individual ecosystem functions. Such change can be dramatic, as in the collapse of the North Atlantic cod fishery or increasing desertification in Africa and the Middle East, and can have serious economic, political and social consequences.

The idea of using leading indicators in science is not new. Geologists use seismic indicators to try to predict earthquakes and physicians use

measures of such things as cholesterol and blood pressure to try to predict patient health. But applying the same kind of monitoring and statistical tools to forecast the health of ecosystems and, ultimately, to prevent serious ecological harm is only now coming into play, says Carpenter.

In the new study, Carpenter, Reinette Biggs of Stockholm University and William A. Brock, an economist at UW-Madison, used northern Wisconsin's sport fishery as a laboratory to see if leading indicators of ecological collapse can be detected far enough in advance to avert disaster.

"The answer is 'yes' if the policy interventions can be swift and 'no' if there are delays," says Carpenter of the study's results.

Northern Wisconsin has the largest concentration of freshwater lakes in the world, and the sport fishery is a critical economic engine for the region. The researchers looked at two major threats to the fishery: overfishing and habitat destruction caused by lake home-building and the loss of trees that would otherwise fall into the lake and provide habitat for sport fish.

"If you are a fish, woody habitat is perfect. It's a place to hide and it has food. It's like a room with a refrigerator," says Carpenter. "But there is way less habitat in lakes with a lot of houses. We are particularly concerned about woody habitat loss."

In both the case of habitat loss and the case of overfishing, indicators of potential harm to the fishery can be detected before a breakdown in the lake ecosystem occurs, Carpenter explains. "However, only in the case of overfishing can policy change fast enough to avert the damage. It is not possible to act fast enough to avert the damage from habitat destruction because it takes too long to grow the trees. In that case, you have to start

over."

The key to avoiding disaster, Carpenter argues, is monitoring: "We really need to be monitoring and analyzing the data from these ecosystems as a way to keep them healthy. Otherwise, by the time the problem surfaces it is too late."

Carpenter says it is possible to sense impending ecosystem regime shifts by carefully monitoring the changing variables that are likely to damage an environment. For example, daily measuring of chlorophyll in a lake could reveal an impending transition to a state where water quality will decline to the point that plant and animal communities in the lake are at risk.

"The behavior of the system becomes extremely variable in the run up to change. You see a lot of variability, and right at the point of regime shift, it becomes very unstable," Carpenter notes.

According to Carpenter, in addition to expanded monitoring and analysis of ecosystem data, averting regime shifts depends on effective policy. Enabling society to respond more rapidly to information about looming change, he says, is necessary to keep ecosystems producing the things people need.

Source: University of Wisconsin-Madison