Predictable ecosystems may be more fragile

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Holding strands of loose native pondweed that floated to the surface, Center for Limnology Director Steve Carpenter is pictured in Lake Mendota just offshore of the UW-Madison campus in 2009. Credit: Jeff Miller

When it comes to using our natural resources, human beings want to know what we're going to get. We expect clean water every time we turn on the tap; beaches free of algae and bacteria; and robust harvests of

crops, fish and fuel year after year. As a result, we try to manage the use of our resources in a way that minimizes their variability.

We seek a predictable "status quo."

But a new study published online this week in the *Proceedings of the National Academy of Sciences* says managing our environment for predictable outcomes is risky. In fact, more often than not, it backfires.

"By making things predictable in the short term, we make them unpredictable in the long term," says Steve Carpenter, director of the Center for Limnology at the University of Wisconsin-Madison and lead author of the report. "We actively make things worse."

At the heart of the problem, says Carpenter, is the fact that while we can reduce variability on short time frames, "variability doesn't go away, it just goes somewhere else." And, he warns, "it has to come back."

Take, for example, our attempts at flood control on rivers. By installing levees, engineers are able to constrain flow and curb the fluctuations in water levels that once led to routine flooding of low-lying areas. These levees work so well that whole communities now exist in what were once floodplains. But the levees can't remove all variability from the system. Sometimes a levee breaks or a river reaches levels higher than what the levee was built to withstand. The end result is a flood that's much more destructive than before.

"So, you do get better predictability," says Carpenter. "For many years the river stays in the levee and everything's fine. It's just that, every once in a while, it goes out and everything is worse."

Carpenter and his colleagues ran a series of simple computer models looking at three human endeavors: controlling nutrient pollution in lakes;

maintaining cattle production on rangelands invaded by shrubs; and sustaining harvest in a fishery.

In all cases, when they tried to control variance—by tightly controlling fish harvest, or shrubs in grasslands, for example—unexpected outcomes occurred. Fish stocks collapsed at lower harvest levels. Grasslands were replaced by shrubs with even light pressure from cattle grazing.

The results are counterintuitive: Reduced pressure on a resource ends up being bad for business. Part of the explanation, Carpenter says, is that "the minute humans try to manage the system, they become part of the system." And our involvement may help explain some of these unintended outcomes.

"Living systems need a certain amount of stress," Carpenter says, noting that as they evolved, "they continually got calibrated against variability." Just as our immune systems rely on exposure to bacteria and viruses to sharpen their skills at responding to disease, natural systems also need that kind of stimulation.

This does not mean we shouldn't try to responsibly and sustainably manage our natural resources, Carpenter says; it just means that we may need to redefine acceptable levels of variability. It's a philosophy that he says is the hallmark of an approach called "adaptive management," which allows for greater natural variability in a system and encourages a diverse set of management approaches. By exploring what does and does not work in a system, resource managers can better learn how to sustain ecosystems as they change over time.

Whether the practice becomes the standard approach to managing our resources remains to be seen but, says Carpenter, the new study may help people see there's no alternative to living with variability.

"By allowing variability, learning from it and trying alternatives that seem sensible and safe, we can navigate change," he says. "When we make complex systems too predictable, we set the stage for collapse."

More information: "Allowing variance may enlarge the safe operating space for exploited ecosystems." *PNAS* 2015 ; published ahead of print October 5, 2015, DOI: 10.1073/pnas.1511804112

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