Human rules may determine environmental 'tipping points'

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A new paper appearing in the *Proceedings of the National Academy of Sciences* (*PNAS*) suggests that people, governments, and institutions that shape the way people interact may be just as important for determining environmental conditions as the environmental processes themselves.

"Tipping points," qualitative changes in an ecosystem that often result in reduced ecosystem health and are difficult and costly to reverse increasingly concern environmental scientists.

The prevailing assumption among scientists has been that tipping points are fixed values. However, a unique research collaboration involving a team of biologists and economists that included University of Notre Dame ecologist David Lodge, Michigan State University economist Richard Horan, Arizona State University economist Eli Fenichel and Bethel College biologist Kevin Drury, indicates that these tipping points are not fixed in human-impacted ecological systems and depend, instead, on human responses to a changing environment.

The authors point out many instances of tipping points that resulted in catastrophic changes in ecosystems, such as climate change, collapsed freshwater and marine fisheries and changes wrought by invasive species. For example, the invasive species sea lamprey changed the Great Lakes from an environment productive of lake trout and whitefish to a collapsed fishery. If not for the $17 million spent annually by the United States and Canada to control them, sea lamprey would continue to devastate Great Lakes fisheries.

In the research described in the PNAS paper, the researchers studied invasive rusty crayfish, which have transformed many Michigan and Wisconsin lakes from luxuriant underwater forests inhabited by many smaller animals that supported sport fish to clear-cut forests with diminished production of sport fish. This outcome occurred despite the fact that there are many fish like smallmouth bass that readily consume crayfish.

"Our work explored whether a shift from one lake condition with excellent habitat to another lake condition with barren lake bottom is the inevitable result of invasion by crayfish or whether it is just one possible outcome," Lodge said. "In other words, we asked whether we humans need to passively accept undesirable outcomes or whether, instead, the institutions and rules by which we make decisions can change the landscape of possibilities."

The institutional rules shape the relationship among managers, users, and ecological systems. If the system is mapped using only ecological characteristics, then managers may not account for human responses to change, such as changing decisions about whether or how much to fish as fishing quality changes.

The research results showed that tipping points in human-impacted ecosystems are affected by regulatory choices that influence human behavior.

"This gives us reason for optimism: if we give regulators sufficient flexibility it may be possible and cost-effective to manage ecological systems so that only desirable ecological outcomes arise and tipping points are eliminated," Horan said.

"Our results also create concern: if natural resource managers' policy choices are overly restricted, then it might be too difficult or costly to

avoid tipping points," Fenichel added.

In particular, the researchers stress that their results highlight the importance of giving strong institutional support to regulatory agencies that aim to enhance societal wellbeing.

"Without strong institutional support, tipping points might disappear but not in a good way," Horan said. "Suppose lake managers invest in crayfish removal but do not properly alter the behavior of anglers, who overharvest fish. In such a scenario, crayfish removal may be ineffective at restoring the lake system if anglers continue to pull the ecosystem toward an undesirable state. Investing in crayfish removal without also addressing angler behaviors is therefore a waste of money. Why would we invest to protect the system from crayfish if we are unable or unwilling to protect the system from humans?"

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