Lowly Icelandic midges reveal ecosystem's tipping points

March 5 2008

The midges that periodically swarm by the billions from Iceland's Lake Myvatn are a force of nature. At their peak, it is difficult to breathe without inhaling the bugs, which hatch and emerge from the lake in blizzard-like proportions. After their short adult life, their carcasses blanket the lake, and the dead flies confer so much nutrient on the surrounding landscape that the enhanced productivity can be measured by Earth-observing satellites.

Now, however, the midge Tanytarsus gracilentus and its periodic, sky-darkening hatches are giving scientists an opportunity to assess how the slightest environmental perturbation can tip the precarious balance of an ecosystem and push it into altered states with unknown consequences. Writing this week in the journal *Nature*, a team led by University of Wisconsin-Madison zoologist Anthony Ives describes an ecosystem population dynamics model built on the flies of Lake Myvatn, showing how even slight human-induced changes can irreversibly alter the balance of nature.

"If our model is correct, the magnitude of these cycles should be sensitive to even the smallest changes in the hydrology of the lake," explains Ives, who conducted the research in collaboration with Árni Einarsson and Arnthor Gardarsson of the University of Iceland, and Vincent A. A. Jansen of Royal Holloway, University of London.

The new study is important because it suggests the possibility of constructing powerful models that scientists can use to assess what may

occur as a result of both natural changes and human-induced changes such as those linked to global warming.

"It doesn't take much noise to cause big changes in the pattern," says Ives of phenomena, natural or human-induced, that can tip the balance of an ecosystem. "Even small amounts of environmental noise cause very different biological processes to dominate. And even if you understand the causes, you can't predict the effects."

In short, the study implies that humans are very likely and unknowingly imposing profound, unpredictable and irreversible changes on ecosystems of all kinds with very little effort.

Lake Myvatn, which means "midge lake" in Icelandic, makes a perfect laboratory for studying such environmental change. The algae-munching midge Tanytarsus gracilentus alone makes up two-thirds of the herbivores in the lake's biomass and is an important food source for birds and fish. But the populations of the midge fluctuate dramatically: "They fluctuate in abundance by six orders of magnitude; in some years you hardly see any, while in others you have to fight not to inhale them," according to Árni Einarsson who directs the Myvatn Research Station.

"The odd thing about the Myvatn midges," Ives adds, "is that the fluctuations are not random, but neither are they regular."

The model developed by Ives and his colleagues reveals an exotic mathematical property known as "alternative dynamical states." In short, the midges of Myvatn can appear in cycles of great and regular abundance, or at stable high abundances, and natural variables or "noise" such as temperature or wind can unpredictably push the dynamics between these alternative patterns.

"A practical, and serious, implication of these dynamics is that they

make midges potentially susceptible to even minor disturbances," says Ives. "The magnitude of the fluctuations could be highly sensitive to disturbances that affect how low the populations crash during the cycling phase. In the last 40 years, the fluctuations in midge populations seem to have become more extreme. "

So extreme, Einarsson notes, that the Lake Myvatn fishery, a resource used by local farmers for 1,000 years has collapsed. "The fluctuations in midge populations became so extreme that the fish populations couldn't cope during midge crashes. Basically, the fish ran out of food."

The model developed by Ives' team implicates dredging in the lake, an operation initiated in the 1960s and now abandoned that was coincident with changes in the fluctuation of midge populations.

"Our model suggests that this dredging could, in principle, have caused greater fluctuations in midge populations," according to the Wisconsin biologist.

Although there are only a few species in the case of Lake Myvatn, the fragility of their dynamics makes the lake's ecosystem and the forces at play a valuable model for understanding discrete ecosystems of all kinds.

"These forces involve few species," notes Ives, "yet they have huge ramifications. They become an important test bed for looking at ecosystems in general."

Source: University of Wisconsin-Madison