Study shows impacts of invasive species transcend ecosystem boundaries

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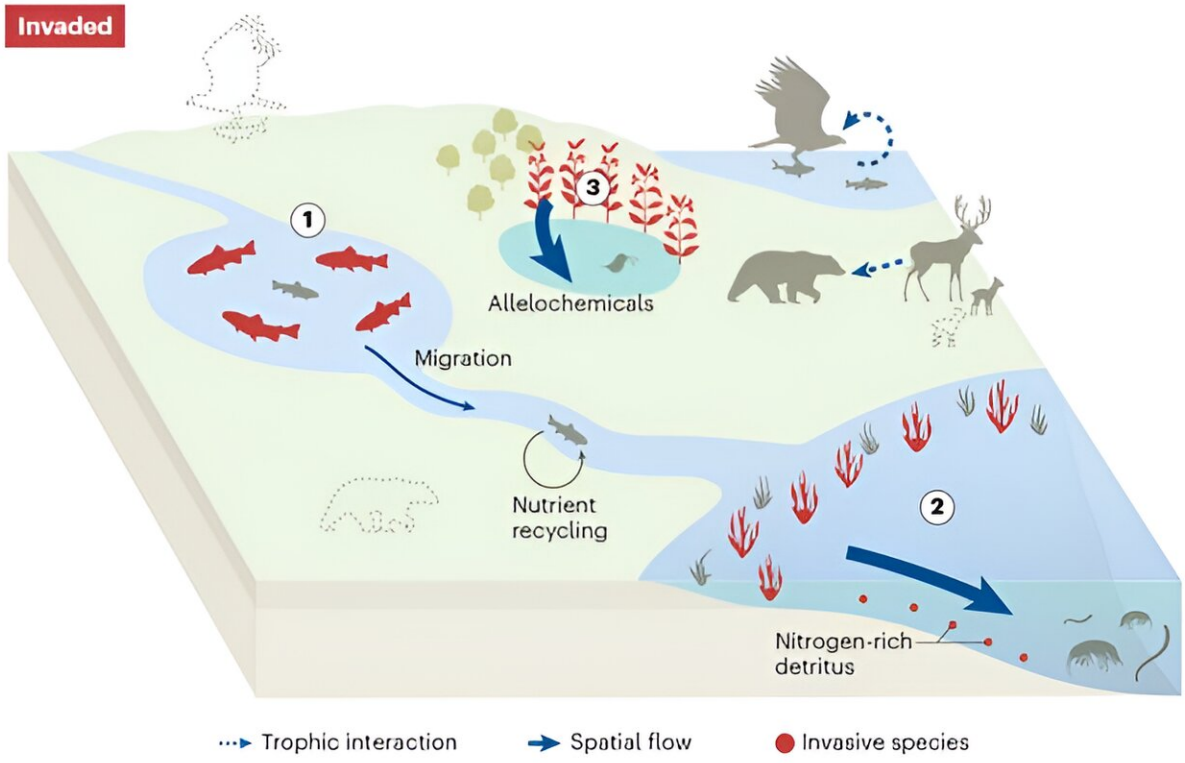

Invasive species (red) lead to cross-ecosystem effects: (1) Invasive lake trout feed on native trout, causing their population to decline and disrupting their migration from lakes to rivers. This eliminates an important source of prey for bears. This has an impact on the food web on land, as the bears have to feed on other prey, such as young moose. The invasion of lake trout also has an impact on distant lakes: birds that fed on native trout before the invasion of lake trout shift their foraging to lakes with sufficient available prey. (2) The displacement of native algal forests by invasive green macroalgae alters the quality of the dead algae biomass that is washed from coastal to deeper marine ecosystems where it

is an important food source. This affects the quantity and diversity of deep ocean organisms. (3) Invasive terrestrial plants, which displace native forest plants – such as the Himalayan balsam – introduce new chemical substances into the forests, which are washed into ponds, where they reduce the growth rate of zooplankton. This changes the dynamics of the food web in the ponds. Credit: Morgane Brosse, Eawag

Invasive species influence biodiversity across larger spatial extents than previously thought. In a recently published study, researchers from Eawag and the University of Zurich show that the impacts of invasive species extend far beyond the ecosystems they invade and that three mechanisms are primarily responsible for this. These findings are of great importance for the management of ecosystems.

Invasive species are widespread around the world and have a profound impact on the ecosystem they invade. They are therefore considered to be one of the five most important threats to global biodiversity and ecosystems.

However, in a study just published in the journal *Nature Ecology & Evolution*, two researchers from the aquatic research institute Eawag have now shown for the first time that their impact frequently extends beyond the boundaries of the invaded ecosystem.

Postdoctoral researcher Tianna Peller and Florian Altermatt, group leader at Eawag and professor of aquatic ecology at the University of Zurich, have compiled examples of the cross-ecosystem impacts of invasive species worldwide for the first time in a global overview. From this, they have gained insights that shed new light on the extent of the ecological threat posed by invasive species.

"Our work shows that the impact of invasive species across ecosystem boundaries is a ubiquitous phenomenon," explains Tianna Peller, "leading to changes in biodiversity and ecosystem functions around the world." A holistic management of invasive species is therefore necessary, the researchers conclude.

Three main pathways for cross-ecosystem impacts

Interactions between ecosystems are widespread in nature and connect, for example, forests and lakes, grasslands and rivers as well as coral reefs and the deep ocean. In their work, the researchers show that invasive species influence these interactions in three different ways.

Firstly, they can change the amount of organisms and materials that flow across ecosystem boundaries. Secondly, they can change the quality of these flows, which may, for example, influence how valuable they are for the animals that consume them as food. And thirdly, invasive species can cause new spatial flows between ecosystems that did not exist before the invasion of the species, for example through secondary plant substances produced by invasive terrestrial plants, which flow into aquatic ecosystems.

"As a result, invasive species can have ecological impacts that extend up to 100 kilometers beyond the ecosystem they invade," explain the authors of the study. "While we often categorize invasive species as aquatic or terrestrial, our results suggest that the impacts of invasive species often transcend the aquatic-terrestrial interface."

Invasive species examples

How invasive species disrupt spatial processes and set in motion a whole cascade of effects on other ecosystems is well illustrated by the example

of rats (Rattus spp.), which were introduced to islands in the Chagos Archipelago in the Indian Ocean. The predatory invaders have significantly reduced the bird populations on the islands.

Fewer birds means less bird droppings, which has disrupted the flow of nitrogen from the islands to the coral reefs. This in turn has had an impact on the fish in the reefs, whose biomass has decreased by up to 50 percent. Critical ecosystem functions performed by the fish, such as grazing and bioerosion, have thus been drastically affected.

An example from Switzerland shows how invasive species can introduce new spatial flows between ecosystems. The invasion of the Himalayan balsam (Impatiens glandulifera), originally native to the Himalayas, has led to the secondary plant substances produced by this species being leached into neighboring aquatic ecosystems and impacting growth and reproductive rates of aquatic organisms.

The invasive lake trout (Salvelinus namaycush) in the U.S. is another impressive example of the spatially cascading effects an invasive species can trigger. This invasive species voraciously eats the native Yellowstone cutthroat trout, which has interrupted their migration from lakes to rivers. This affects nutrient cycles and food webs in the rivers, but also on land.

Overall, the study emphasizes the importance of considering the broader spatial context when assessing the ecological impacts of invasive species. In particular, it shows that non-native species should not only be considered within conventional ecosystem compartments such as marine, terrestrial or freshwater, but that their management requires a more holistic perspective. "By understanding how invasive species affect exchanges between ecosystems, management efforts can be better targeted to mitigate their effects," says Florian Altermatt.

More information: Tianna Peller et al, Invasive species drive cross-ecosystem effects worldwide, *Nature Ecology & Evolution* (2024). DOI: 10.1038/s41559-024-02380-1

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