PNAS COMMENTARY

Diet for a small footprint

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Some environmentally conscious consumers make dietary choices with the carbon footprint of their meals in mind. Whether eating a more plant-based diet, wasting less of the food they buy, or purchasing food grown closer to home, people with the luxury to choose their diets can reduce the greenhouse gas emissions required to produce their daily nourishment by making informed decisions (1). However, dietary choices affect more than the atmosphere. In PNAS, Read et al. (2) explore the effects on biodiversity of five diets—ranging from the baseline American diet that includes processed foods and meats to the Planetary Health diet, which includes some meat, but is dominated by fruits, vegetables, whole grains, and plant proteins (3). Read et al. (2) cross each of these diets with two food waste scenarios, the current baseline and a 50% reduction, to ask how each of the 10 resulting combinations affects extinction risks for plants and animals.

Globally, up to 1 million of the estimated 8 million plant and animal species on Earth are at risk for extinction (4). This dire calculation comes just as the benefits of living with a richness of biodiversity have become increasingly clear. A recent meta-analysis, for example, demonstrated that high diversity in agricultural systems increases pest control, pollination, water regulation, nutrient cycling, and soil fertility, all without reducing crop yields (5). We now know too that biodiversity often prevents the emergence and transmission of pathogens that jump from animals to humans (6), a particularly vivid benefit amid the ongoing ravages of the COVID-19 pandemic.

The conversion of land for agriculture is one of the biggest drivers of biodiversity loss (7). With this in mind, Read et al. (2) built a model of the American food system to estimate the amount of land used to grow the crops and raise the livestock we eat. To build their model, they used a compilation of publicly available data on food production, keeping track of food sources by county in the United States or by country for imported goods. By coupling these data with county-level records on cropland and pastureland, they could estimate the total area in each county of each type of land required for each diet scenario.

To estimate the effects of these land uses on biodiversity, Read et al. (2) relied on a method developed by Chaudhary and colleagues (8,9) to estimate how land use affects species in five taxonomic categories (mammals, birds, amphibians, reptiles, plants). Chaudhary and colleagues (8,9) localized these impacts to 804 distinct ecoregions on Earth. Using data on thousands of species derived from multiple sources (10–12), they calculated the vulnerability of members of each group to land-use change and used these data to develop an index of the impact on each taxonomic group of the localized conversion of 1 m^2 of habitat to 1 m^2 of cropland or pastureland. One additional innovation incorporated into these estimates was the countryside species–area relationship (SAR), which differs from the classic SAR by incorporating the fact that human-altered habitats support the occurrence of some species (13).

Combining all of these data, Read et al. (2) evaluated how five alternative diets would affect extinction risk for this same set of terrestrial species. If everyone in the United States ate the baseline American diet, the results would be grim, with 122 extinctions in the United States alone. Fully two-thirds of these would occur from conversion of natural habitat to pastureland for livestock. The situation in other countries would be only slightly better, with an additional 78 species lost. Indeed, Read et al. (2) found that 40% of the biodiversity footprint caused by current American food consumption occurs outside US borders, caused by plants and animals going extinct in the countries growing the food required to meet US demand.

Could changing diets protect biodiversity? If everyone in the United States adopted either a vegetarian diet or the Planetary Health diet, there would be 30% fewer global extinctions, largely because of a smaller footprint for pastureland to raise livestock for meat. The work by Read et al. (2) is distinguished from some similar studies (but see 3, 14) in that they considered each of their diet scenarios with two levels of food waste, the current baseline and a 50% reduction. Combining either of the biodiversity-friendly diets with less waste resulted in an even more dramatic effect on conservation, effectively preventing the extinctions of dozens of species (Fig. 1).

Two of the alternative diets considered by Read et al. (2)—the American diet recommended by the US Department of Agriculture and the Mediterranean diet—actually increased extinctions relative to the baseline American diet, largely because of greater cattle production to supply milk for higher dairy consumption. These eating plans had another less obvious effect on biodiversity as well. Because Read et al. (2) assumed that any increased seafood consumption would have to come from farmed rather than wild fish, diets including more seafood required land conversion to provide grain to feed the fish. These impacts added up. The Mediterranean diet, touted as being healthy for people (14), was distinctly unhealthy for biodiversity, increasing extinctions by almost 40%.

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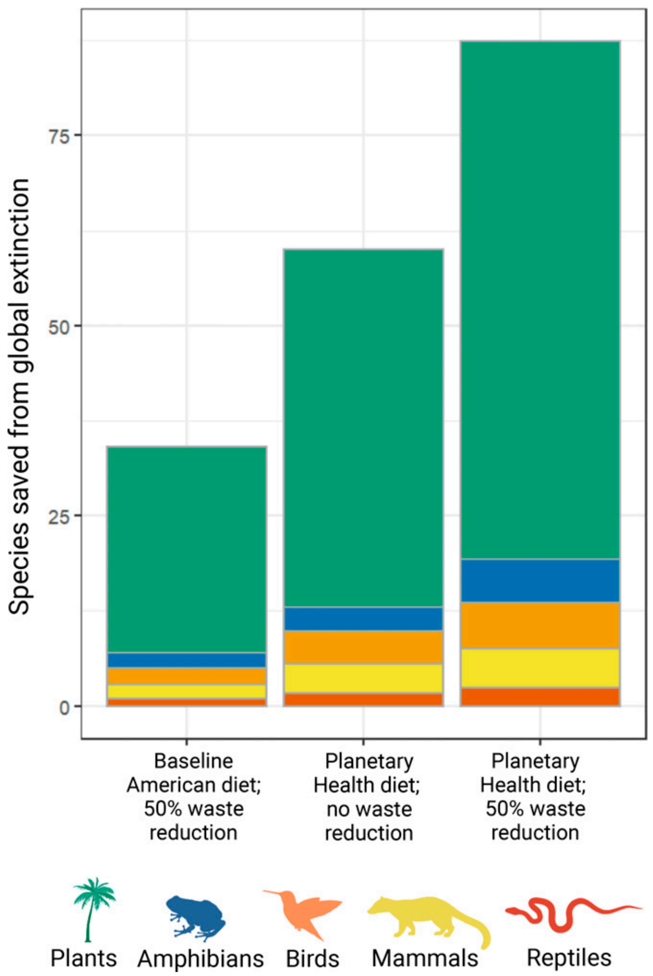

Fig. 1. Estimated numbers of plant, amphibian, bird, mammal, and reptile species saved from global extinction under three diet and food waste scenarios. The Planetary Health diet includes fruits, vegetables, plant proteins, and some meat. Fifty percent waste reduction includes reduced pre- and postconsumer food waste. Details are in Read et al. (2). This figure was created with R using data provided by Read et al. (2) at https://qdread.shinyapps.io/biodiversity-farm2fork/.

The impacts on biodiversity estimated by Read et al. (2) were not uniformly distributed. Meat-heavy diets had a particularly big impact on mammals and reptiles in western states with high beef production, for instance. Diets heavy in beef and dairy also impacted biodiversity in foreign countries, including Canada, Australia, and Mexico, where cattle for US consumption are raised. In contrast, diets that included more fruits and vegetables, foods that are often imported, had a big effect in countries with high endemic biodiversity, such as Colombia, Ecuador, and Mexico. Within the United States, the biodiversity in most counties would benefit from all four alternative diets, but there are exceptions. In several counties in California, Florida, and Hawaii, threats to biodiversity would actually increase because of higher fruit and nut consumption.

However sobering the extinction estimates provided by Read et al. (2), these calculations are a vast underestimate since they include just a small fraction of life (15). No invertebrate losses are estimated, for example, and invertebrates, like insects and mollusks, represent ~97% of all animals. Perhaps at least as important, Read et al. (2) include only global extinctions, not local ones, in which a species disappears from a location or region but still survives somewhere else. These losses might be less permanent than global extinctions, but their consequences can also be severe. The species that thrive when local diversity declines, for example, are often reservoirs for pathogens that are readily transmitted to vulnerable species, including humans (6, 16).

How feasible are the alternative diet and waste scenarios explored by Read et al. (2)? The challenges with implementing them range widely, but all are sizeable. First, in their analysis, Read et al. (2) explored "counterfactuals," or what-if scenarios, that quantify how biodiversity impacts would be different if our food systems were instantly converted to one of the alternatives. That is quite different from the biodiversity impact that would be expected if, say, some pastureland in Nebraska were left fallow so that it could be slowly repopulated by plants and animals. Keeping that pasture set aside for wildlife would be its own challenge. Another daunting issue, of course, is that large-scale diet shifts would be hard to achieve (17, 18). Read et al. (2) argue that the effects of waste reduction alone would be substantial and would face less resistance than dietary changes, so that waste reduction might be a good focus for policy innovations. In prior studies, both Willett et al. (3) and Leclère et al. (19) showed that combining dietary changes with waste reduction and improvements to agricultural practices could slow the impacts of land conversion for agriculture, potentially even reversing biodiversity losses.

Going forward, Read et al. (2) have provided estimates of the effects of diets and food waste on biodiversity that are localized for each county in the United States. Increases in local conservation efforts are also part of any coherent strategy to reduce biodiversity losses (19), and these should be informed by the new and vastly improved resolution of localized biodiversity in the United States that includes more than just plants and some vertebrate taxa (20). Changing people's diets at a large scale will remain a formidable challenge, but changes by individual consumers do have an impact (18). Fortunately, the same diets can simultaneously reduce the impacts of agriculture on biodiversity and greenhouse gas emissions while providing delicious, healthy, and nutritious food (3, 21). The will to make the systemic and personal changes necessary to achieve these cobenefits remains the biggest barrier, but the new work by Read et al. (2) provides greater resolution of the way forward.

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