Science Societies

Environmental outcomes from on-farm agricultural production in the United States

Part 2: Biodiversity

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Larvae of the monarch butterfly.

This article is brought to you by the SPARC Initiative created in partnership between the American Society for Agronomy, the Agricultural Retailers Association, Environmental Defense Fund, and Field to Market: The Alliance for Sustainable Agriculture to empower trusted advisers to deliver services that drive continuous improvement in the productivity, profitability, and environmental outcomes of farmers' operations. Learn more about the SPARC Initiative and access additional resources, including the six-module series on sustainability at **www.fieldtomarket.org/SPARC**. This article is an excerpt from Field to Market's Fourth *National Indicators Report*, released in December 2021. Access the entire report at **www.fieldtomarket.org/report**. Sections covering soil carbon and water quality will be included in future issues of *Crops & Soils* magazine.

Recent scientific reports have highlighted historical biodiversity losses in agricultural regions and found that the growth in agricultural land use since 1970 is unsustainable with respect to the natural systems impacted, including declines in soil health and pollinator diversity. These reports call for renewed efforts to protect and restore nature (Diaz et al., **2019**).

Biodiversity, or the variety of plants, animals, fungi, and microorganisms found in nature, is a critical natural resource for the health of the planet and human society, including agriculture. Supporting diverse organisms requires diverse habitats, many of which can be found in and around farms. Sustainable, productive farming systems ultimately rely on biodiversity. For example, native pollinators provide most of the crop pollination and support resilience where domesticated honeybee populations are facing threats. Integrated pest management is an agricultural management strategy that relies on ecosystems that support sufficient populations of natural pest predators to reduce threats to crops.

North America supports a wide diversity of species, with approximately 13,000 species of plants, 650 birds, 450 mammals, 300 amphibians, and 430 reptile species. However, the overall trends indicate that this diversity is threatened—across the Americas, one-quarter of all species are threatened or face the risk of extinction. In North America, more than 75 species of freshwater fishes have become extinct since 1950 (IPBES, **2018**).

Trends in Crop Diversity

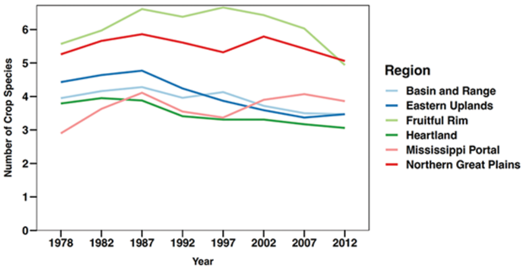

Figure 1, *Number of crop species for four USDA Economic Research Service Farm Resource Regions (Aguilar et al.,* ***2015****). Numbers represent county averages.*

Agricultural lands can support biodiversity through growing diverse species for food production and taking other measures to support both habitat aboveground and habitat for soil micro-organisms that are important for soil health. However, from 1978 to 2012, the diversity of crops grown in the United States dropped significantly (Figure 1). The lowest crop diversity is found in the American Corn Belt where high-yielding corn and soybean varieties dominate the agricultural landscape. The trend toward corn and soy is also evident in the Eastern

Uplands region of the U.S., which includes portions of Ohio, Pennsylvania, West Virginia, Virginia, Tennessee, Kentucky, Alabama, Mississippi, Oklahoma, and Arkansas. Crop diversity remained fairly high and consistent in regions growing most of the fruits and vegetables in the country, as seen in California, Oregon, Washington, New York, Pennsylvania, New Jersey, and Massachusetts. The Mississippi Portal region is the only region in the nation to record greater crop diversity over time, attributed, at least in part, to declines in cotton acreage, which may have opened to the door to more diverse crop rotations (Aguilar et al., 2015).

Trends in Bird Abundance and Diversity in North America

The conversion of lands to agriculture in North America has contributed to declines in bird species—between 1966 and 2013, populations of bird species associated with farmland declined by 74%. The most significant decline has been in populations of aerial insectivores, or birds that eat insects on the wing. No single factor has been identified for this decline, but important contributing factors include inadequate insect prey populations on and around farms, which is linked to several factors including agricultural insecticide use, compromised or insufficient surface water, and lack of suitable habitat and forage (Stanton et al., 2018).

Lands fragmented by agriculture provide less suitable habitat for diverse bird populations. Smaller, discontinuous grassland habitats produce greater edge effects, which leads to greater pressure on bird populations by nest predation compared with larger continuous grassland areas (Stanton et al., 2018). In addition, shrinking wetlands has led to fewer habitats for riparian birds, such as red-wing blackbirds whose young depend on larger habitats to provide more available food. Rangeland or pasture lands, particularly when planted to multi-species grasses, offer better bird habitat than those cultivated in row crops. Farm operations can also cause direct harm to birds through pesticide exposure, soil preparation, planting, tillage, mowing, and other harvest practices that can directly kill birds and destroy nests.

Crop advisers can help farmers reduce these risks and support avian biodiversity in their regions with the right information. For example, in soybean fields, bird mortality can be almost eliminated by delaying planting by two weeks, which allows time for the young to fledge before the equipment destroys the nests. However, there are trade-offs with production as such a delay may lower crop yields. Greater density and diversity of nesting birds can be found in no-till corn and soybeans, compared with those that are conventionally tilled, most likely because the standing vegetation offers greater cover from predators. In forage crop production, planning the timing of mowing to avoid cuttings during the breeding season can reduce the risk to birds. This can be a challenge in some systems, such as for cool-season forages because they produce more biomass earlier in the season, sometimes necessitating mowing before young birds have fledged. Mowing exposes young birds to direct destruction from equipment and exposure to predators resulting from less dense plant cover. Wet years, though they depress yields, are associated with greater nest success in certain bird species due to fewer and later cuttings of forage crops (Stanton et al., 2018).

Trends in Pollinator Abundance and Diversity in North America

Pollination is a necessary process for crop seed production and may be mediated by non-living factors such as wind or water, or by living pollinators, including bees, butterflies, and birds (IPBES, 2017). Worldwide, approximately 75% of all cultivated crops depend on living pollinators. In 2012, the value of pollination for food production was estimated at $351 billion globally. Although some commodity crops commonly cultivated in North America self-pollinate, like cotton and soybeans, or are wind-pollinated like corn and sorghum, other crops such as alfalfa and many specialty crops depend on insect pollinators for reproduction.

In the United States, managed pollination by domesticated, non-native honeybees (European or Western honeybees and Asian or Eastern honeybees) is common. Commercial production of cherries, blueberries, almonds, tomatoes, and watermelon are dependent on managed Western honeybee hives. These hives have been under threat of colony loss, which has been escalating since 1990. These losses have been largely attributed to infestation by the parasitic varroa mite, which feeds on bee pupae and transmits viruses that compromise the bee’s immune system, leaving them vulnerable to other transmittable disease (IPBES, **2017**).

Although a few species of domesticated honey and bumble bees are widely deployed to pollinate crops, there are at least 20,000 species of other organisms that provide pollination services, many of which are wild bees. Between 2008 and 2013, wild bee abundance decreased by 23% in the United States, mostly in the agricultural lands of the Midwest, Great Plains, and Mississippi River valley. Threats to wild and domesticated bees are tied to land use changes, changing climate, and pesticide toxicity, among others. Using an integrated approach to pest management can decrease the amount of insecticide applied and reduce the risk of exposing pollinators (IPBES, **2017**).

Land use changes lead to habitat fragmentation and loss for wildlife, including pollinators. A USDA report (Hellerstein et al., **2017**) reviewed the impacts of these land use patterns on pollinators and found that the ability of a given area to support pollinators is highest in forests, rangeland, rural roadsides, and certain farmland that produces sunflowers and berries. This ability is lower in lands producing cotton, soybeans, nuts, and grapes and further reduced in farmland producing corn, wheat, rice, barley, and sorghum. While there is not a clear national trend, regional patterns in this ability, as measured by a Forage Suitability Index (FSI), have been observed. Nationwide, from 2002 to 2012, FSI remained the same in 85.8% of land, improved in 6.9%, and decreased in 7.3%. Decreases were concentrated in areas of central California, Montana, North and South Dakota, Iowa, Illinois, Indiana, northeast Nebraska, northwest Kansas, and along the Mississippi River with most significant decreases occurring in the Dakotas, which are primary summering grounds for honeybees. The greatest improvements from 2002 to 2012 were observed in Washington, Nevada, eastern Kansas, Oklahoma, and eastern Texas (Hellerstein et al., **2017**).

Conservation Reserve Program Effect on Cropland Biodiversity

While there are ways in which agricultural lands can be managed to support biodiversity and reduce their impact on important species, setting aside sensitive lands out of production and providing areas in the agricultural landscape for diverse species to flourish can also be an option where it aligns with the needs and goals of a farm operation. Here we look at the trend over time in lands enrolled in the USDA's Conservation Reserve Program (CRP), which was established in 1985 to "retire highly erodible and other environmentally sensitive cropland and pastureland" from production (USDA, **2020**).

Farmers receive yearly rental payments from the USDA over a period of 10 to 15 years, during which time valuable land cover, such as prairie grass, is re-established. While the principal motivation is to reduce soil erosion, there are additional conservation benefits including supporting diverse plants and ecosystems. Land area in CRP rapidly

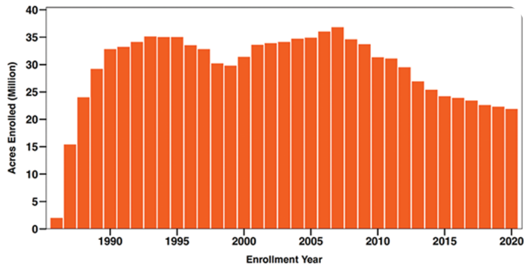

Figure 2, *Cumulative enrollment in the Conservation Reserve Program (USDA,* ***2020****).*

increased in the early years of the program and stayed relatively constant from the early 1990s through the mid-2000s (Figure 2); however, enrollment began to decline after 2007. This decline is partly attributed to higher crop prices, which serve as an incentive to bring the set-aside lands back into production, as well as reductions in the funds available for the CRP program. As of November 2020, there were more than 300,000 farms enrolled in CRP, covering more than 20 million acres with a total financial outlay of more than $1.8 billion in combined rental, cost-share, and incentive payments.

How CRP land is managed is important in determining how well it will be able to support biodiversity. For example, in the Southwest High Plains, lands enrolled in CRP are frequently seeded with non-native grasses, resulting in low plant species diversity and low-quality forage and habitat for pollinators. Patches of land in CRP that are greater in area than 100 acres and planted with diverse plant species have been shown to support pollinators and other wildlife (Begosh et al., 2020).

Summary

No singular measure can provide an adequate understanding of the trend in biodiversity in and near agricultural fields. However, studies show that bird and insect populations in the U.S. have been declining for decades while at the same time, native tallgrass prairies have been nearly eliminated. Further, the diversity of crops grown has declined overall with the exception of the Mississippi Portal region. Together, these results signal an overall negative trend in biodiversity in and around farms.

Habitat loss continues to be a primary threat to biodiversity, not just in the U.S., but worldwide. The declining numbers of acres set aside in the Conservation Reserve

Program over the past 10 years contribute to challenges of efforts to restore habitat and protect biodiversity on farms. And with increasing reliance on chemical management with non-selective herbicides, populations of certain pollinator larval host plant, like milkweed, have been significantly reduced.

Agricultural landscapes across the U.S. have opportunities to support diverse and native species and ecosystems that provide important ecosystem services to humanity. Understanding the trends in both the diversity and abundance of species can help to identify what management practices lead to the greatest risk of further biodiversity loss and also what can be done to prevent loss and transform landscapes to support regeneration of biodiversity in agricultural landscapes. This article has highlighted some of the notable trends and what those imply for the risks to biodiversity associated with agriculture in the U.S. and begun to explore what management practices can reduce risk and support greater abundance and higher biodiversity of species. Biodiversity is a natural resource concern of national and global consequence, but it is inherently local. Farmers and their trusted advisers have a deep understanding of agricultural lands and are well positioned to identify both the risks and the best mitigation strategies that align with using the land to produce food, fiber, feed, and fuel.

Species Highlight: Monarch Butterflies

The plight of the monarch butterfly is well known outside of the agricultural community. The butterfly is famous for long migrations and a tendency to overwinter en masse in trees and structures along the coast in California and in the mountains of Central Mexico. Populations of the monarch have dropped precipitously since 1950, which has been directly linked to commensurate declines in the 10 milkweed species utilized as their larval host plants. Declines in milkweed populations are related to land use changes. For example, one of the monarch's preferred hosts, swamp milkweed, lives in wetlands that have been in decline in the U.S. A study in Illinois found a nearly 94% decrease in common milkweed populations after croplands were treated with glyphosate but no significant losses in areas treated with non-glyphosate herbicides. In Iowa, that trend is replicated: milkweed populations dropped steeply since 2000 with some plant populations extirpated following glyphosate treatments (Zaya et al., **2017**).

Weeds are loosely defined as a plant growing where it is not wanted by the land manager. Allowing milkweed and other weedy plant populations to become established in cultivated areas is not feasible for a several reasons. Weeds can compete with crops for space, light, water, and nutrients; may interfere with harvest operations; and their seeds may contaminate harvests. Landowners and managers are encouraged to allow milkweeds and other pollinator host plants to grow and complete their lifecycles in non-cultivated areas of the farm and adjacent landscapes.

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