Chapter 4
Assessment of Effects on Natural Ecosystems

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Abstract

Assessing effects of adopting transgenic maize on natural ecosystems in Mexico depends on obtaining information that can reliably detect changes in natural ecosystems in Mexico and on comparing such information to existing baseline agricultural practices in Mexico. Appropriate baseline comparisons in Mexico will vary due to the diversity of production systems that exist. Similarly, the choice of what indicators to use to detect changes in natural ecosystems will vary due to the diversity of ecosystems in Mexico. Although different ecosystems have general similarities in function (e.g., nutrient cycling, energy flow) and categories of goods and services (water purification, decomposition, pest control, pollination, foods, fuel, fibers and drugs), the specific factors or combinations of factors that affect ecosystem function may vary regionally depending on characteristics of biodiversity. At least four factors associated with biodiversity may affect ecosystems: what species are present, how many individuals of each species, how a species functions within the ecosystem (e.g., energy producer (photosynthetic plant), energy consumer (herbivore, predator, decomposer), and what biological interactions affect species' function(s) within the ecosystem. An assessment of effects of transgenic maize on natural ecosystems must recognize the general uncertainty in predicting the consequences of alterations to populations, species or communities upon ecosystems.

Mexico's biological richness is widely recognized as one of the largest in the world. Paralleling this, Mexico has a rich cultural diversity and ancient agricultural history. It is currently recognized as center of origin for as many as 100 crops from which fruit, seeds, roots, condiments, tubers, drugs, textiles, dyestuffs, resins, ornamental plants, and other natural products or services are derived. Taken together, the considerable diversity of biological species, communities, and ecosystems; of maize landraces; of culture and of agricultural practices underscores the importance of defining the scale of an assessment. The impacts of introducing transgenic maize have the potential to vary considerably according to any combination of factors associated with biological organization, maize genetic composition, culture or agricultural practices.

Potential effects on natural ecosystems of introducing transgenic maize should be assessed using comparisons with the baseline conditions of local or regional agriculture that would be replaced. Effects on natural ecosystems may arise if adoption of transgenic maize alters the abundance of individuals and if those alterations have resulting effects on population, species or communities. Effects on individuals of a species could arise if the transgenic organism is toxic and produces lethal or sublethal effects on individuals. Technological changes associated with the use of the transgenic organism (i.e., abandonment of some traditional farming practices) could also have effects on individual organisms that could cascade into higher order interactions. Alternatively, transgenic maize and its associated farming practices may have fewer effects on natural ecosystems than the existing agricultural practices of a given region. Higher levels of ecological

organization and interactions are critical to ecosystems; therefore, relying on experiments focused at quantifying individual effects will underestimate any effects on natural ecosystems of introducing transgenic maize. Furthermore, small sample sizes and few replicates undermine the power of experiments to detect differences and will also produce underestimates of any effects on natural ecosystems.

The commercialization in the United States of Bt corn with insecticidal properties to control pests related to butterflies and moths has produced concerns about impacts on non-target butterflies and moths, as well as other insects that may ingest corn or corn pollen containing Bt toxin. Effects of Bt corn pollen dispersal on the three species of non-target butterflies studied so far suggest no adverse effects associated with currently available transgenic events (MON 810 and Bt11). Bt toxin in these transgenic events is toxic at high doses, but in the field the amount of Bt pollen encountered by the three species is considered below a level that could cause negative impacts. Prey-mediated effects (effects on insect predators that eat prey items that have fed on Bt plants or plants with Bt corn pollen) have been studied in two main taxa: the green lacewing (*Chrysoperla carnea*) and minute pirate bugs (*Orius* spp). Effects on individuals vary according to prey items. Where population level effects have been studied, no differences between Bt corn and non-Bt cornfields have been detected.

The applicability of this literature to assess natural ecosystem effects of introducing transgenic maize in Mexico has several limitations. First, recently compiled lists of potential species underscore the fact that a relatively small percentage of butterflies in the United States have been studied. How representative they are of Mexican biodiversity and natural ecosystems is tentative. Butterfly diversity in Mexico is substantially higher than in the United States, and from the existing data, it is clear that species sensitivity varies. Therefore, research on Mexican species will address the potential for impacts on butterfly and moth populations in Mexico. Similarly, predicting or testing effects on populations within natural ecosystems in Mexico will need experiments designed to consider valued or important Mexican species. Given the high degree of local and regional biodiversity, these valued and important species are likely to vary according to natural ecosystem, by culture, and by agricultural practices.

Equally important to assessing impacts on biodiversity and on natural ecosystem is quantifying and predicting how the introduction of transgenic maize may alter farming practices and landscapes and what impact, if any, these would have on natural ecosystems that interact with or intergrade into agro-ecosystems. Again, what changes may occur will depend on the transgenic event, the transgenic trait, adoption rates, and whether the transgenic maize also affects species important for agriculture (e.g., pollinators, pests). From recent work conducted in the United Kingdom, changes in farming practices associated with using herbicide-tolerant oilseed rape, beets or corn had impacts on insect and plant populations and diversity.

Our chapter highlights the need for further research and consideration of the link between biodiversity and ecosystem functioning and also the need for determining what magnitude of effects on individuals or populations is desirable to detect in order to predict higher order ecological effects. Also important will be identifying and understanding aspects of biodiversity and ecosystem functioning that are highly valued by those parties affected by the introduction of transgenic maize. We recognize that studying and quantifying all possible effects on natural ecosystems are not possible. As a high priority, we urge the use of data that reflect species and ecological functions of value at a regional scale. Therefore, case studies from North America or elsewhere are not easily generalized or applicable to Mexican biodiversity or ecosystems. In order to assess consequences of transgenic maize on biodiversity and on natural ecosystems, species within the areas of Mexico where the introduction of transgenic maize may occur must be studied.