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CAST Commentary

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Developing and Adopting Economically Effective Pesticide Mitigation Strategies: Critical to the Survival of Agriculture and Endangered Species

Introduction

As the United States Environmental Protection Agency (EPA) Office of Pesticide Programs (OPP) strives to fulfill its five-decade old obligations under the Endangered Species Act (ESA) when registering or reregistering a pesticide, their vision of a pathway to success is outlined within the 2022 Workplan "Balancing Wildlife Protection and Responsible Pesticide Use: How EPS's Pesticide Program Will Meet its Endangered Species Act Obligations" (EPA 2022a). One of the strategies to achieve compliance as highlighted by the EPA within the workplan is to begin "mitigating for potential impacts to ESA listed species." By identifying, coordinating, and incorporating pesticide mitigation measures that reduce exposure to threatened and endangered species (listed species) into the regulatory process, the EPA is attempting to establish meaningful protections prior to consultations with the federal agencies charged with implementing the ESA: the U.S. Fish and Wildlife Services (FWS) and National Oceanic and Atmospheric Association (NOAA) Fisheries.

However, developing a mitigation approach that fulfills the statutory obligation of protecting listed species under ESA, but also strikes a balance between economic feasibility, environmental soundness, and continued use of pesticides in a practical manner for agricultural entities is proving to be a significant challenge. Production agriculture, especially family farms, can provide the space and resources for habitat and protection for many listed species and other wildlife. If ESA mitigations are not implemented carefully, regulatory actions taken with the intent to protect listed species will

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threaten the sustainability of these farms, and thereby may inadvertently destroy the wildlife and habitat they aim to protect. Without the ability to effectively control pests in a practical manner, many farmers will not be able to grow an economically productive crop and may be forced to sell the land for development or other industrialized purposes to continue providing for their families, resulting in changes in land configuration that could effectively eliminate habitat for listed species.

Thus, the approach of incorporating mitigation measures must be transparent, scientifically sound, flexible, and developed in cooperation with stakeholders. As it is required to implement mitigation measures when making pesticide applications moving forward, it is critical to understand: (1) how pesticide use, mitigation measures, and ESA-listed species interact with each other, (2) the current extent and practicality of including best management practices (BMPs) already used across the agricultural landscape into the pesticide mitigation measures dialogue, (3) the role of existing, externally funded conservation programs in mitigating potential pesticide movement and protecting ESA-listed species, and (4) the importance of measuring outcomes of proposed mitigation measures.

The Intersection between Pesticide Use, Mitigation Measures, and ESA-listed Species

There is a long list of stakeholders across the United States including university agricultural extension, private crop consultants, local land and water protection agencies, commercial retailers, state departments of agriculture, professional organizations, agricultural industry, and numerous U.S. Department of Agriculture (USDA) entities, serving to educate, recommend, and enforce the implementation of smart pesticide use practices at the local level. Across entities, current efforts in support of the role pesticide stewardship plays in protecting humans, the environment, and wildlife are at an all-time high. For example, Georgia's flagship pesticide stewardship program, Using Pesticides Wisely, was created as a collaborative effort between the University of Georgia and state department of agriculture, as a way to share innovative research results on improving on-target pesticide applications with farmers and other pesticide applicators. Since its inception in 2014, more than 17,130 pesticide applicators have been trained on applying pesticides safely, while minimizing impacts to sensitive sites from pesticide movement (Culpepper et al. 2020). A similar example from the pesticide industry is the BeSure! Stewardship Program through the Growing Matters coalition, which is a coalition of numerous pesticide companies committed to science-based stewardship of neonicotinoid insecticides (Growing Matters 2020).

There has been, and continues to be, tremendous research and educational efforts across the United States to ensure pesticide applicators have access to science-based information on improved application practices, precision technology, and parameters directly influencing the ability of all products to remain in the field. While EPA's recent draft Vulnerable Species and Herbicide Strategy documents identify mitigation measures that are common conservation practices and actions for some growers, there is a lack of flexibility for complex production systems and the site-specific nature of conservation planning (EPA 2023a; EPA 2023b). In the Herbicide Strategy, the EPA outlined mitigations focused on reducing the potential for off-field pesticide movement into terrestrial and aquatic habitat through spray drift, aqueous runoff, and/or erosion to protect non-target species, specifically listed plants, obligates of plants, and generalist animals. However, in the Herbicide Strategy, the EPA did not identify specific types of terrestrial and aquatic habitat for listed species like they did in "Vulnerable Listed (Endangered and Threatened) Species Pilot Project: Proposed Mitigations, Implementation Plan, and Possible Expansion" (EPA 2023b) or in the recently released Endangered Species Protection Bulletins for malathion (EPA 2023c). By providing a general description of terrestrial and aquatic habitat, the proposed Herbicide Strategy does not consider the specific characteristics that constitute suitable habitat for individual species, therefore requiring growers to install and/or adopt mitigation measures around more generalized habitat than may be scientifically necessary or effective.

As the EPA focused on intentions to improve on-target pesticide applications with these documents, they strongly emphasized the use of spray drift buffers to reduce airborne pesticide particles blowing away from the intended target (spray drift) to terrestrial and aquatic habitat. Factors being considered to influence the size of the required buffers include the maximum single application use rate, application method, nozzle selection, and droplet size distribution, release height, use of a windbreak, and wind speeds. Although each of these factors influence on-target pesticide applications, current options to reduce required buffer distances neither do not encompass all the effective approaches pesticide applicators already implement nor are they given fair scientific credit as to how they can be used to reduce drift. While the Herbicide Strategy specifically expands upon previous definitions and defines the areas and structures that may be included as part of the buffered area (areas where the pesticide cannot be applied to offset airborne particle movement towards a sensitive site; typically, downwind of the application). However, the diverse landscape, field shapes, and cultural production practices across the country often lends to the inability to maintain this buffer outside of the crop field. It is likely that growers will have to include in-field areas in order to reach the required buffer width. The overly conservative approach of requiring growers to implement areas around and within the field where pesticides cannot be applied is an example of one mitigation measure that would severely limit the ability of growers to effectively manage pests while continuing to maintain production yields and profitability. Therefore, the EPA's proposed approach will likely lead to overly conservative and potentially large in-field buffers. In-field buffers (areas within the field where the pesticide cannot be applied to offset airborne particle movement towards a sensitive site; typically, downwind of the application), are an example of one mitigation measure that would severely limit the ability of growers to effectively manage pests while continuing to maintain production yields and profitability.

While some growers may be able to achieve the required buffer width without sacrificing productive areas of the field, it is important to understand the potential loss of production area and economic impact for those required to include cropland in the buffer. To gain a sense of the farm-level impacts from including in-field areas as part of the buffer, spatial data representing best- and worst-case scenarios were collected in Georgia. A best-case (least impactful) scenario was defined by selecting fields that were larger and covered a more

continuous area while a worst-case (most impactful) scenario was defined as smaller fields surrounded by trees. When considering a downwind in-field spray buffer of 110 ft, the loss of land in the field to be treated with a pesticide ranged from 10 to 15% while a 240 ft downwind buffer eliminated from 20% to 33% of the land to be treated within the field. For an expanded buffer of 310 ft downwind plus 57 ft omnidirectional, the loss in land ranged from 31 to 50%. Losing the ability to control pests within production agricultural fields can effectively eliminate the ability to harvest a crop within that area because of the impacts of competition from weeds, insects, or pathogens. Furthermore, increasing pressure from unmanaged weeds and other pests may begin to creep into the terrestrial habitat, placing ecological strain on the listed species the mitigation practice was intended to protect.

As the process of spray drift mitigation advances, providing science-based data to pesticide applicators is critical. In fact, education is a crucial and effective mitigation method for pesticide stewardship and has successfully been utilized to protect nontarget species and sensitive sites from pesticide exposure around the county. As many landowners and farmers are not aware of the listed species that are potentially in and around their operation, education can provide an opportunity to increase awareness and foster protection for species and their critical habitat. The FWS has identified lack of knowledge of the species occurrence across the landscape as one limitation for population improvements and includes public education as an action towards recovery/delisting of the species, while also listing education as part of individual species recovery plans. For example, in the 5-year review for the Georgia pigtoe, an endangered freshwater mussel in Alabama, Georgia, and Tennessee, the FWS stated: "Commercial applicators must also be tested and permitted on the proper application of pesticides, but applicators may not necessarily be aware of the presence of the Georgia pigtoe in the watersheds where pesticides are being applied. If applicators are aware of the presence of a rare species, they may be more likely to use proper application techniques" (FWS 2021). In the recovery plan for the Georgia pigtoe, the FWS identified voluntary stewardship and the development and implementation of programs and material to educate the public as actions that are needed to aid in recovery (FWS 2014). While farmers may not be aware of the listed species in their area, they are already making decisions to maintain productive farmland, protect natural resources such as water quality, and protect sensitive species and nontarget areas from the impacts of pesticide exposure, which are all components maintaining a healthy ecosystem and a thriving environment. By providing credit for education, growers could continue to seek up-to-date information on pesticide application techniques and practices, while learning more about the species in their areas and how to get involved in the development of stewardship plans and activities that benefit the species around them. As stewards of the land, farmers strive each day to protect the land that provides for their families, ensure the resources are available for generations to come, and, either directly or indirectly, benefit listed species.

In addition to spray drift, the proposed Herbicide Strategy focused heavily on mitigation practices to reduce movement of pesticides through surface runoff and/or erosion. The number of mitigation measures suggested by the agency for implementation by pesticide applicators depends on the location of the field, herbicide used, land characteristics, and production practices. First introduced in the 2022 Workplan Update and expanded upon in the Herbicide Strategy, the options available are referred to as the mitigation menu, with each option receiving a point value related to its effectiveness. As currently proposed, pesticide users will need to reach a specified number of points through implementing options from the menu to apply the herbicide. Options currently are summarized within five categories: (1) field characteristics, (2) application parameters, (3) in-field mitigation measures, (4) adjacent to field mitigation measures, and (5) other mitigation measures.

Points associated with field characteristics (one point for each) draw on the specific location and features of the application site, including geographic location, soil texture, and slope. As the characteristics of a field are not easily changed, mitigation measures in the remaining categories introduce options for growers to implement or adopt through changes in management or installation of physical measures. Application parameters include varying points for application rates, depending on the percent applied compared to the maximum labeled application rate, and two points for incorporating the product into the soil after application. In-field mitigation measures, such as contour farming, cover cropping, grassed waterways, in-field vegetative filter strips, irrigation water management, mulch amendments with natural materials, residue tillage management, and terrace farming, range in point values from one to three. These practices are centered around mitigating surface runoff within the field; however, these measures are not easily implemented in many cropping systems, installation can result in the loss of productive land, and a significant financial burden can be placed on the grower who is implementing the practice (Duzy et al. 2023). Adjacent to the field or other mitigation measures (one to three points) include maintaining riparian areas, vegetated ditches, vegetative filter strips (adjacent to the field), and water retention systems.

While the concept of preventing pesticide movement through the suggested mitigation measures is scientifically sound, it is important to recognize the tremendous challenges that come with requiring the diverse and dynamic agriculture production systems of the United States to adopt similar conservation practices irrespective of actual need of such practices and relevance to the species being protected. For example, while the use of cover crops is an excellent option for reducing erosion in one part of the country, this practice may not be feasible in other regions where there is limited moisture for establishment and maintenance. An additional challenge to national adoption is how each category is given a ranking (point value) by the EPA regarding the anticipated effectiveness of the respective mitigation measure around the country. For cover crops, the EPA determined the practice to have a minimal impact on pesticide residue runoff (EPA 2023a). However, as an example, field research conducted over four years by Potter and colleagues (2016) in Georgia observed that when a high biomass rye cover crop was used, a 98% reduction in fomesafen runoff was recorded. The fact that this practice was given a low effectiveness score and subsequent low point value on the draft Herbicide Strategy mitigation menu suggests a need for more scientific refinement through evaluating the practice in various production regions and cropping scenarios around the country. One suggestion is, working with the USDA, the EPA could develop criteria allowing growers the ability to produce cover crops through different management practices, which would enable them to achieve low, medium, or high pesticide

runoff reduction, thereby providing the pesticide applicator the opportunity to achieve flexibility in point options from the mitigation menu. Working with conservation practitioners, EPA could develop a system to tier efficiency points for any of the mitigation measures on the menu based on site-specific conditions, lifespan of the mitigation measure, and management of the measure, creating a system of tiered efficiency points to better represent site-specific conditions and farm-level management considerations, while providing improved flexibility to growers.

It is critical for the EPA to continue working closely with agricultural stakeholders to identify mitigation measures that work for various production systems across the country, especially specialty crop and permanent cropping systems, which face the greatest challenge in adopting proposed mitigation measures. Additionally, it will be critical for stakeholders, industry partners, regulators, and academics to generate scientifically sound data that defines exactly how effective proposed mitigation measures are in reducing pesticide movement from the field, but the conversation surrounding ESA compliance with pesticide use cannot end here. As a scientific community, we must understand direct pesticide interactions with listed species and their habitats, and how the proposed mitigation measures interact with these species. Are growers being asked to implement and adopt mitigation measures that are not necessary, protective of, or provide a benefit to listed species? If the ESA is driving the move to incorporate additional spray drift, sediment, and erosion mitigations into pesticide registration and use, what is the specific link to listed species and is more or less mitigation scientifically necessary?

Best Management Practices Being Used on the Agricultural Landscape

Identifying practices that support water quality protection, the conservation of soil resources, and prevention of pollutants from entering sensitive habitats has been a priority of numerous federal and state governmental agencies along with extension programs at land grant institutions for many years. Early concerns on the quality of watersheds because of nonpoint source pollution during the 1930s and 1940s led to the introduction of "better land-management practices," and the subsequent idea that our land management decisions had direct influence on environmental quality (Ice 2004). These practices served as the precursor to BMPs which are practiced in many industries around the country today.

Expanding industrialization and urbanization, along with growing agricultural and forest management entities have confirmed that human intersection and interaction with the environment is greater than ever (Costanza et al. 2007). As defined, BMPs are a combination of physical soundness and social actions developed to decrease the movement of pollutants into sensitive areas, such as watersheds or bodies of water, while considering overall environmental protection and stewardship (US EPA 2003; USDA ARS 2006). These practices generally take into consideration the regional geography and production practices that are already being implemented, to determine the best, most effective pollutant mitigation practices for a particular site. In Kansas for example, the city of Wichita has worked with farmers to provide incentives for implementing atrazine BMPs to reduce atrazine entering the Little Arkansas River. From inception in 2006 through 2022, more than 1,300 farmers implemented atrazine BMPs (92% participation rate) on nearly 300,000 acres, reducing runoff by approximately 50% (Graber 2023).

Because of the wide range of industries that use the land and its resources, tremendous work identifying and understanding BMPs has taken place through various entities around the United States. For decades, federal agencies such as the EPA, USDA (specifically the Agricultural Research Service (ARS), National Resource Conservation Service (NRCS), and U.S. Forest Service (USFS)), U.S. Department of the Interior (DOI), along with land grant universities, have generated methods to implement BMPs on farmland, forests, and natural landscapes to mitigate negative impacts of pollutants on the environment. The national, regional, state, and local approach offered by this diverse group of stakeholders representing various agricultural and environmental entities ensures that a broad variety of pollutant mitigation options are available to account for the diversity of production systems and land uses present across the United States.

Driven by those with a desire to pursue farm sustainability and protect the land and its resources for generations to come, conservation practices on agricultural lands have been adopted by farmers throughout the country (Prokopy et al. 2019). In most cases, the region, climate, topography, and specific characteristics of the land determine what conservation practices can be implemented on a site, and how effective these practices are in achieving the overall goal. For example, in various parts of the country, cover crops, conservation tillage, terrace and contour farming, vegetative filter strips, and grassed waterways are successfully used to promote water filtration, improve soil structure, provide wildlife habitat, and enhance other conservation efforts (Chow and Daigle 1999; Abu-Zreig et al. 2004; Nouri et al. 2018; Bergtold and Sailus 2020). Unlike the EPA's proposed options to address the ESA on a national level, these conservation actions have been developed locally for specific site needs, and vary greatly from farm to farm, based on the dynamic changes that occur even within a single cropping or ecological system.

Adoption data have demonstrated that producers are willing to implement creative solutions on-farm in order to conserve the land and mitigate the movement of pollutants. By combining the concepts behind BMPs with conservation practices that growers are currently using on the farm, this provides an opportunity to improve awareness and continue working towards the protection of listed species habitat and other sensitive sites without the need to incorporate these practices into the regulatory process. Throughout the country, production agriculture has coexisted with populations of listed plants and animals for decades, indicating that by ensuring access to the tools needed to effectively manage pests and maintain conservation practices (i.e., herbicides to burndown cover crops or control invasive weeds in a native plant filter strip), farmers can continue to voluntarily take personal responsibility in stewarding the land and protect sensitive species from urban encroachment and other habitat threats. Without demonstrating the need, using regulatory mechanisms to force farmers to adopt mitigation measures to address resource concerns that either do not exist on their operation or they have already addressed is unlikely to provide additional needed benefit to listed species. However, working within the current environment of voluntary conservation programs, locally and regionally led projects, and targeted conservation efforts provides

opportunities to engage farmers in new and innovative practices—which has always been the nature of agriculture.

The Role of Conservation Programs in Mitigating Pesticide Movement

The agriculture industry faces numerous daily threats to its ability to provide a continuous supply of safe and affordable food, feed, and fiber for our country and the world. With increasing input costs, fluctuating markets, and uncertainty surrounding the ability to effectively manage pests that threaten yield, an economic profit on the farm is more difficult than ever to achieve. Programs that promote and support endeavors to implement BMPs and conservation practices on farms are a critical component of overall farm sustainability but also these programs are essential in providing the infrastructure needed to mitigate the movement of pollutants. Existing programs through the USDA, specifically the NRCS and USDA Farm Service Agency (FSA), provide opportunities for farmers to receive financial assistance to establish costly BMPs and establish habitat on their farms, without which installation and maintenance may not be economically feasible (Hernandez et al. 2020). Programs such as these offer a unique opportunity to work with area experts at a local or regional level, who understand the unique characteristics of the local landscape, to design and implement conservation practices that have a greater chance at successful implementation, mitigating off-field pesticide movement, and overall listed species protection compared to making conservation practices part of the regulatory framework for pesticide use.

There are also commodity specific programs, as well as state and local programs, which highlight and reward farmers for maintaining or increasing conservation practices on the landscape. The Michigan Agriculture Environmental Assurance Program (MAEAP) is an example of a state verification program that assists farmers in voluntarily reducing or eliminating risk to the environment from agricultural pollution. They have verified more than 6,000 farms in Michigan (MAEAP 2023). Programs such as these can help growers overcome financial hurdles associated with starting BMPs and other mitigation measures, which can lead to a greater chance of successful implementation. Including participation in a commodity specific, state, or local conservation program as an endangered species mitigation option offers a local bridge to regulatory compliance.

According to the EPA, there are more than 182 different ecoregions in the United States, and with this level of diversity, a one-size-fits-all approach to mitigating pesticide spray drift and surface runoff and erosion across the landscape is extremely challenging (Omernik and Griffith 2014). Leveraging financial assistance programming opportunities, such as NRCS conservation assistance programs, coupled with effective science-based mitigation measures would provide a realistic opportunity of successful voluntary mitigation adoption on the farm. In fact, within the Herbicide Strategy, the EPA has included participation in a conservation program on land where the pesticide application would be made as an exemption and alternative to implementing practices from the mitigation menu. This is an excellent option for growers who participate in these programs, however for this effort to be successful, it is worth considering the barriers to continued participation or lack of participation in traditional conservation programs. With many farmers throughout the US implementing BMPs on their farms independently of conservation program participation, there must be opportunities for these farmers to continue to grow their conservation efforts and have the ability to participate in financial assistance programs, whether at the federal, regional, state, or local level.

Measurable Outcomes

Measurable outcomes are needed to scientifically document the need for and impacts from adopting endangered species mitigation efforts. With an overall goal of avoidance and minimization of impacts from pesticides to listed species, we must collectively as a scientific community continue to conduct research across the landscape that: (1) determines if additional mitigations are necessary, (2) identifies existing conservation practices that have been adopted by growers, and (3) understands the level of reduction in off-site movement of pesticides that already occurs from existing conservation programs. It is imperative to fully understand the baseline in order to clearly identify any need for additional mitigation measures to protect listed species and, if there is a need, understand which measures are most appropriate and effective.

As noted earlier, the proposed Herbicide Strategy addresses species at a general habitat level and is not specific to an individual species or habitat type. The lack of specificity outlined by the agency likely eliminates the scientific ability of identifying a measurable outcome since mitigation measures are applied to general habitat types instead of species-specific habitats.

Concluding Thoughts

Ensuring that the production of food, feed, and fiber remains economically and environmentally viable for the future is an enormous challenge. The use of pesticides to protect yields and maximize production forms the foundation of food production for sustaining the world's population, and parameters surrounding use of these products must be achievable by growers. As farmers work to overcome daily challenges, regulatory agencies must understand the implications of adding additional mitigation requirements for protection of listed species on pesticide labels that introduce a new level of complexity to pest management. It is unreasonable to expect farmers to produce enough food, feed, and fiber for a growing world population without the ability to use pesticides in a practical manner while also designing their on-farm stewardship practices to optimize environmental protection and production.

While protecting the nation's most sensitive plants and animals from pesticide stressors is critically important, incorporating conservation-focused mitigation measures as part of the regulatory framework changes the historical and current voluntary and site-specific nature of conservation planning on agricultural landscapes. Agricultural, environmental, and federal entities must all work together to understand, educate, and generate the information needed to reach the common goal of protecting the ability of our family farms to continue feeding the world while protecting listed species. With cooperation amongst all impacted parties, building mitigation practices on a foundation of sound science, and appropriate linkage of mitigation practices to species protection and health, it is possible to create regulatory actions to protect

listed species that improve the long-term outlook for family farms and long-term sustainability of species and their habitats as a result of reducing the potential for land-use changes.

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