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Pest Management in the Conservation Planning Process

Disclaimer and Intentions for Use

This document can be used in developing a mitigation approach to the potential loss of pesticides from their application area **for conservation planning purposes only**. While there has been research in conservation practice effectiveness regarding pesticide loss mitigation, the results tend to display a great variability. Thus, most of ratings that are provided in Tables 1 and 2 are derived from professional judgement based on the information found in *Aquatic Dialogue Group: Pesticide Risk Assessment and Mitigation* (Baker et. al., 1994). The values in these tables are a relative effectiveness guide for planners and should **not** be used to guarantee a specific level of pesticide loss reduction, nor are they designed to be used for regulatory purposes. The level of scrutiny for the items in the tables would need a regional approach and an extensive literature review for each entry to begin to approach regulatory use and that has not been provided in this document. The actual effectiveness of the planned activities and practices will depend on several factors that are within the control of the planner (e.g., design of the conservation practice, location of the conservation practice, establishment of the conservation practice, other conservation practices in the field, etc.) and several factors that are outside the control of the planner (e.g., pesticide selection, runoff-event size, runoff-event intensity, runoff-event duration, runoff-event timing relative to pesticide application, inherent field properties, etc.).

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Pest Management in the Conservation Planning Process

Introduction

This technical note is designed to help conservation planners apply the NRCS Conservation Practice Standard (CPS) Pest Management Conservation System (PMCS) (Code 595) and other NRCS conservation practices in the conservation planning process. Information provided here will help planners to understand potential for prevention, avoidance, monitoring, and suppression (PAMS) activities in addition to pesticide hazards and develop additional margins of precaution in preventing and mitigating pest management risks to natural resources.

Background

In 2019, the name of Code 595 was changed from “Integrated Pest Management” to “Pest Management Conservation System” to avoid confusion with the widely used term, “integrated pest management” (IPM). IPM commonly refers to anything from chemical recommendations to pesticide management techniques.

This technical note references IPM techniques, elements, strategies, guidelines, systems, and programs. Code 595 focuses on the components of IPM that are related to the conservation of natural resources in three broad categories:

- PAMS techniques
- Resistance management
- Mitigation of resource concerns arising from pest suppression activities

Code 595 is available at the Pest Management Conservation System Conservation Practice Standard. It addresses multiple resource concerns across soil, water, air, plants, and animals, including, but not limited to:

- Soil – Soil organism habitat loss or degradation
- Water – Pesticides transported to surface and groundwater
- Air – Emission of particulate matter and ozone precursors
- Plants – Plant pest pressure
- Animals – Terrestrial and aquatic habitat for wildlife and invertebrates

NRCS impacts on resource concerns related to pest management activities have not reached their full potential. Conservation partners and Farm Bill customers have praised NRCS for mitigating the adverse impacts of pesticide use but have asked for more vigorous support for adoption of pest management approaches with broad conservation value, namely PAMS activities.

Growers have their own strategy for producing crops, minimizing losses, and achieving profitability that is acceptable to them and their retailer. Many retailers have moved toward third- party verification of good farming practices driven by consumer demand to know more about the food they eat. What once was thought of as “pest control” is now viewed as “pest management” and depends on ecological and environmental aspects. Growers seek knowledge and resources to develop management strategies, whether through agricultural technologies, crop consultants, university extension specialists, or NRCS. Traditional production pest management controls include methods for monitoring pests and use of a control strategy. Integrated pest management has many opportunities to produce food through a balanced use of all available pest control options that combine to minimize the environmental risk of production and maximize conservation benefit.

Code 595

In the past, NRCS emphasized the evaluation and mitigation of environmental risks associated with pesticide use. This was the focus of the previous Code 595, which focused on pesticide hazard evaluation using the Windows Pesticide Screening Tool (WIN-PST) to predict hazards to water quality resulting from pesticide applications in specific scenarios.

In 2019, a team was assembled to update Code 595 to provide a more comprehensive standard governing all roles for NRCS in supporting conservation in pest management as defined in policy. This revised standard was published in May 2019, and accompanying payment schedules were prepared. This document provides specific guidance outlining PAMS conservation activities that can be undertaken by producers to support Code 595. Detailed guidance for NRCS assistance will be provided to states through the updated TN 190-AGR-5 and updated TN 190-AGR-9.

2018 Farm Bill

The 2018 Farm Bill provides an overall statement addressing conservation and production:

> “The purposes of the environmental quality incentives program…are to promote agricultural production, forest management, and environmental quality as compatible goals, and to optimize environmental benefits, by…assisting producers to make beneficial, cost-effective changes to production systems, including addressing identified, new, or expected resource concerns related to…pest management…or other practices on agricultural and forested land.”

Pesticide resistance incentivizes the adoption of alternate products to ensure continued efficacy, and this may lead to additional adverse impacts on the environment, so management to limit the development of pesticide resistance has conservation value. Combating pesticide resistance requires a multifaceted approach, including PAMS activities (Table A).

Partner Feedback

NRCS received feedback from many partners to broaden Code 595 beyond “end-of-pipe” risk mitigation of pesticide use and incorporate more PAMS activities that address natural resources. This includes promoting pest prevention, pesticide use reduction, biological approaches, and use of least hazardous pesticides. Incorporating these activities creates opportunities for greater risk reduction. There is often confusion and misuse of the terms hazard and risk.

- Hazard – The toxicity of the pesticide. The hazard posed by a pesticide depends on several factors, including the toxicity of the active ingredient, the amount of that active ingredient is in the pesticide, and the toxicity of the other ingredients.

- Risk – The possibility of loss or injury caused by the pesticide. Pesticides pose risks to people and other non-target living beings based on if, how, and how much exposure occurs combined with the hazard of that pesticide.

NRCS pesticide mitigation focuses on the hazards associated with pest management activities. It does not address risk. Risk includes consideration of both the potential for harm and the likelihood of it occurring. Evaluating and mitigating risk associated with pesticide use is outside the authority and capacity of NRCS and falls to other agencies (e.g., the U.S. Environmental Protection Agency) tasked with evaluating and labeling pesticides for use. Where such authorities have identified a higher risk, management objectives may include implementation of practices to exceed requirements of the pesticide label. All pesticide applicators must follow label requirements as “the label is the law.”

Unlike most other types of product labels, pesticide labels are legally enforceable, and all of them carry the statement: “It is a violation of Federal law to use this product in a manner inconsistent with its labeling.” In other words, the label is the law. For additional discussion, see section “Pesticide Registration Versus Pesticide Risk Analysis in Conservation Planning.”

NRCS Pest Management Policy

The NRCS pest management policy, 190 GM Part 404, states that conservation planners have five potential roles in pest management:

(1) Adopt PAMS activities that protect natural resources.

(2) Evaluate environmental hazards associated with a client’s probable pest management strategies.

(3) Mitigate the identified environmental hazards of pest management strategies through PAMS practices and activities.

(4) Inventory, assess, and suppress noxious and invasive weeds on non-cropland.

(5) Suppress weeds to ensure successful implementation and maintenance of permanent vegetative conservation practices.

Current NRCS pest management policy defines the agency role to assist clients to adopt IPM techniques that protect natural resources. These techniques are collectively categorized as PAMS activities. There is wide acceptance and promotion of these activities across farming, government, university, and non-government groups. Concern among some NRCS staff regarding involvement in PAMS activities has led to inconsistent implementation of the pest management conservation practice. Particularly, clarification is needed for when NRCS should be providing technical and financial assistance on PAMS activities, non-target organisms, and other resource concerns.

NRCS pest management policy defines IPM as a sustainable approach to manage pests that combines multiple PAMS conservation strategies to:

- maintain pest populations below economically damaging levels;
- minimize harmful effects of pest suppression on human health and environmental resources; and

- minimize development of pest resistance.

It further defines PAMS conservation practices and notes field employees’ responsibilities to provide technical assistance on PAMS conservation activities recognized by the local land grant university or regional IPM center as being viable IPM techniques. The planning and preparation for crop production afforded through IPM technical and financial assistance allows growers to improve their knowledge of pest management, recognize and address environmental risks of pest management activities, and incorporate advances in science and technology to optimize both production outcomes and conservation benefits.

Several resources have been revised and developed to support conservation planning:

- Revised and renamed national standard: Code 595 Pest Management Conservation System
- Updated payment scenarios to match revised standard
- Updated Code 595 Implementation Requirements
- Updated Agronomy Technical Notes 5 and 9
- Developed guidance to clarify policy regarding NRCS role in pest management

NRCS does not provide chemical pest control (i.e., pesticide) advice. However, this should not undermine NRCS engagement with producers when evaluating pest management strategies and mitigating adverse impacts on natural resources, including those caused by pesticide use. NRCS staff can still provide a conservation lens through which to evaluate and refine pest management activities.

This technical note outlines the role of PAMS conservation activities on cropland for conservation benefit to soil, water, air, plants, and animals. Further, it documents that such conservation activities align with the authorities of NRCS in Conservation Technical Assistance as well as in Farm Bill financial assistance conservation programs such as the Environmental Quality Incentives Program and the Conservation Stewardship Program.

Definitions

Avoidance – One of IPM’s four strategies: prevention, avoidance, monitoring, and suppression (PAMS). Avoidance is the "A" in the PAMS strategy for IPM. It is used when pest populations exist in a field or site but the impact of the pest on the crop may be avoided through cultural, mechanical, or biological processes (e.g., pest-resistant varieties, crop rotation, rotational grazing trap crops, delaying planting).

Biological Pest Suppression – The process of conserving, augmenting, managing, or introducing beneficial living organisms to reduce a pest population or its impacts. It includes the use of insects, nematodes, mites, plant pathogens, plants, vertebrates (including herbivores), and other living organisms. It may include targeted grazing and cover crops. Biological pest suppression is an activity in the PAMS approach to IPM.

Biological Pest Suppression Recommendation – A written or spoken instruction that includes specifics on approved suppression agents, methods of release, and management.

Brush Management – CPS Code 314. The management or removal of woody (non-herbaceous or succulent) plants, including those that are invasive and noxious. May be used alone or as part of a pest management conservation system.

Chemical Drift – The airborne movement of chemicals from an area of application to any unintended site.

Chemical Pest Suppression – The use of pesticides such as herbicides, insecticides, or fungicides to reduce a pest population or its impacts. Chemical pest suppression is an activity in the PAMS approach to IPM.

Chemical Pest Suppression Recommendation – A specific written or spoken instruction that includes pesticide formulation, application rate, form, timing, and method of application. At a minimum, a chemical pest suppression recommendation must follow the pesticide label instructions and any special label requirements pertaining to the location of application.

Cultural Pest Suppression – The use of practices other than chemical or biological suppressions to reduce a pest population or its impacts. It includes practices and activities such as narrow row spacing or optimized in-row populations, alternative tillage approaches such as no- till or strip-till, cover crops or mulches, and using crops with allelopathic potential.

Environmental Risk – The potential to negatively impact ecosystem values and functions.

Forest Stand Improvement – The manipulation of species composition, stand structure, or stand density by cutting or killing selected trees or understory vegetation to achieve desired forest conditions or obtain ecosystem services. May be used alone or as part of a pest management conservation system.

Genetic Pest Suppression – Use of pest-resistant plant varieties by classical plant breeding or through genetic modification. Pests may also be modified such as a sterile male insect release.

Herbaceous Weed Treatment – The removal or control of herbaceous weeds including invasive, noxious, prohibited, or undesirable plants. Code 315. May be used alone or as part of a pest management conservation system.

Integrated Pest Management (IPM) – IPM is a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks. (7 U.S.C. § 136r). IPM includes the use of PAMS strategies to manage pest populations.

Invasive Species – A species:

(1) Non-native (or alien) to the ecosystem under consideration; and

(2) Whose introduction causes or is likely to cause economic or environmental harm or harm to human health (Executive Order 13112).

Mechanical/Physical Pest Suppression – Pest suppression that uses physical methods to reduce a pest population or its impacts. Mechanical suppression methods include cultivation, hoeing, hand weeding, mowing, pruning, root plowing, roller chopping, vacuuming, and physical barriers. Mechanical pest suppression is an activity in the PAMS approach to IPM. Cultural and mechanical/physical suppression activities may overlap.

Mitigation – The process of minimizing the potential for harmful impacts of pest management activities on soil, water, air, plant, animals, and humans through the application PAMS activities, including conservation practices such as filter strip, conservation crop rotation, residue management, and irrigation water management, and management activities such as harvest timing, delayed planting, using resistant varieties, transgenic crops, pheromones, etc.

Monitoring – Proper identification of pests and beneficial organisms, the extent of their populations, and the probability of future populations. Examples includes scouting, soil testing, pest modeling, and weather forecasting. Records are kept of modeling results, pest incidence, and distribution for each field or site. These become the basis for crop rotation planning, economic threshold, and suppressive actions. Monitoring is conducted after suppression actions to determine the effectiveness of the treatment. Monitoring is the "M" in the PAMS strategy for IPM.

Organic Crop – An agricultural commodity that is produced consistent with section 2103 of the Organic Foods Production Act of 1990 (7 U.S.C. § 6052).

PAMS – An acronym of the four strategies in an IPM plan: prevention, avoidance, monitoring, and suppression.

PAMS Activities – Individual components within each PAMS strategy. Activities may include conservation practices.

Pest – A weed, invertebrate, disease, animal, or other organism (including invasive and non- invasive species) that directly or indirectly causes damage or annoyance by destroying or devaluing food and fiber products, causing structural damage, or creating a poor environment for other organisms.

Pest Management – A land manager's methods for managing disease, invertebrates, nematodes, and weeds. NRCS assistance to clients conducting pest management considers how to optimally apply PAMS activities to minimize adverse impacts to natural resources. It includes the evaluation of environmental hazards associated with a client's probable pest suppression strategies for a target pest management issue identified by the client. It includes assistance to clients to apply PAMS strategies and conservation practices to mitigate identified environmental hazards. On other land uses, pest management may facilitate the successful implementation of other conservation practices, such as herbaceous weed control and brush management.

Pest Management Conservation System (PMCS) – A system that combines an IPM decision- making process with natural resource conservation to address pest and environmental impacts. It may stand alone or include other practices, such as forest stand improvement, herbaceous weed treatment or brush management.

Pest Management Environmental Hazard Analysis – An evaluation of the client's potential pest management activities to impact the offsite and onsite ecosystems. This is accomplished using current agency tools, prediction models, and other approved tools as needed to evaluate impacts to natural resources.

Pest Suppression Reference – Written recommendations by the Extension Service, Agricultural Research Service, and other reputable sources that publish peer-reviewed documents which include, but are not limited to, bulletins, IPM guides, manuals, crop protection guides, brochures, fact sheets, computer software, and web-based materials.

Pesticide – A substance or mixture of substances intended for preventing, destroying, repelling, or mitigating pests; or a substance or mixture of substances intended for use as a plant growth regulator, defoliant, or desiccant. Pesticide applications are suppression activities in the PAMS approach to IPM.

Prevention – The practice of keeping a pest population from infesting a field or site. Prevention activities include, but are not limited to, using pest-free seeds and transplants, cleaning tillage harvesting and other equipment between fields and farms, feeding weed-free roughage to livestock, applying management activities that maintain or improve plant community resilience and resistance to pests, scheduling irrigation to avoid situations conducive to disease development, and eliminating alternate hosts or sites for insect pests or disease organism. Prevention is the "P" in the PAMS strategy for IPM.

Professionally Certified – Refers to individuals meeting local, state agency, and tribal certification or licensing requirements to make pesticide and pest management recommendations. This may include additional criteria established by the state conservationist. Professionally certified individuals demonstrate an understanding of pest identification and pest control alternatives through programs such as the Certified Crop Adviser, Pest Control Advisor, Certified Range Management Consultant, or other comparable programs.

Specialty Crop – Fruits and vegetables, tree nuts, dried fruits, and nursery crops (including floriculture), as per Specialty Crop Competitiveness Act of 2004, Public Law 108-465-December 21, 2004.

Suppression – Inhibiting a pest population or its impacts using cultural, biological, or chemical pest suppression. Suppression is the "S" in the PAMS strategy for IPM. Suppression activities can:

A. Directly suppress a pest through tillage or chemical applications and potentially negatively impact natural resources; or

B. Optimize a direct suppression activity through timing and precision to mitigate the impacts to natural resources.

Volatilization of Pesticides – The movement of pesticide vapors through the air.

Pest Management in Conservation Planning

Conservation planners start by identifying site-specific natural resource concerns in the conservation planning process. For concerns related to pest management, this can include the potential for pest management activities to impact soil, water, air, plants, animals, and humans. While EPA-approved pesticide labels account for numerous potential risks to all the above, users may wish to add an additional margin of precaution around such hazards and implement measures to address site-specific hazards of natural resource concerns. Once site-specific natural resource concerns are identified, conservation planners are authorized per policy (see above policy roles 1-3) to evaluate hazards associated with pest management activities, identify PAMS activities and site-specific conservation practices, including development and implementation of a CPMS, to prevent or mitigate hazards to identified natural resources.

Information on the pesticide label may require specific management; for example, pesticide applicators are required to prevent pesticide drift that may compromise water quality. Producers may wish to exceed the required protections and request assistance. For example, if a conservation planner identified an additional precautionary management objective regarding pesticide use near a surface water body, they would use the NRCS WIN–PST to evaluate potential pesticide hazards to water quality from pesticide losses in surface runoff. Based on site- specific WIN–PST results, Code 595 and other conservation practices may be applied as appropriate to provide an additional water quality protection. This may include implementation of PAMS strategies or implementation of other conservation practices.

Pest management risks may also be associated with the use of mechanical, biological, or cultural pest suppression techniques, but they must be evaluated with other tools, such as the Revised Universal Soil Loss Equation 2 (RUSLE2), or the professional judgment of the conservation planner.

Conservation planners may also address management of noxious and invasive weeds on non- cropland and weed management in permanent vegetative conservation practices (see policy roles 4-5 above) in the conservation planning process. This may include application of the NRCS CPS Brush Management (Code 314) and Herbaceous Weed Control (Code 315) and other supportive practices. Both conservation practices are used on non-cropland to address natural resource concerns related to plant pests, including invasive, noxious plants. Code 595 can be used in conjunction with Brush Management and Herbaceous Weed Control to prevent or mitigate pest management environmental risks associated with the application of these conservation practices.

Pesticide Registration Versus Pesticide Risk Analysis in Conservation Planning

The U.S. Environmental Protection Agency (EPA) regulates pesticides under two major Federal statutes: the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Federal Food, Drug, and Cosmetic Act (FFDCA), both amended by the Food Quality Protection Act (FQPA) of 1996.

Under FIFRA, pesticides intended for use in the United States must be registered by the EPA before they may be sold or distributed in commerce. The EPA would register a pesticide if scientific data provided by the applicant show that, when used according to labeling directions, it will not cause “unreasonable adverse effects on the environment.” FIFRA defines “unreasonable adverse effects on the environment” as: “any unreasonable risk to man or the environment, considering the economic, social, and environmental costs and benefits of the use of the pesticide.”

Under FFDCA, EPA is responsible for setting tolerances (i.e., maximum permissible residue levels) for any pesticide used on human food or animal feed.

FQPA mandated a single, health-based standard for setting tolerances for pesticides in foods, provided special protections for infants and children, expedited approval of safer pesticides, and required periodic reevaluation of pesticide registrations. FQPA also limited the consideration of benefits when setting tolerances. FQPA did not address the consideration of ecological risk.

The EPA pesticide registration process is based on a comprehensive risk assessment for a range of conditions under which the pesticide is proposed to be used. This risk assessment is designed to address many different risks to many distinct species that might be impacted by a particular pesticide use, and typically applies several “worst-case” assumptions about site susceptibility, pesticide usage, and weather conditions that affect environmental exposure. EPA assesses ecological risk with a screening-level approach that is designed to be highly protective.

However, even with screening-level inputs to ecological exposure models and ecological effects, no risk assessment can guarantee a zero-risk scenario. Furthermore, because the benefits of pesticide usage are weighed against identified risks, there may be situations where ecological risks remain because the benefits of some pesticides outweigh the ecological risk. This is particularly true for cases where alternatives to the pesticide in question present a worse risk outcome. Therefore, even when a pesticide is applied according to pesticide label instructions, there may be some site-specific conditions or scenarios where ecological risk may still be possible.

The EPA considers the benefits and the risks. On the label of each registered pesticide, EPA includes appropriate guidance for risk mitigation. However, there are obvious limitations on how well a pesticide label can address site-specific concerns that often vary widely across the landscape.

Pesticide impacts on aquatic life are common concerns, even with carefully written guidance on pesticide labels. The U.S. Geological Survey National Water-Quality Assessment Program found at least one pesticide in almost every water and fish sample collected from streams and in more than 50 percent of shallow wells, though the magnitude of these detections can vary widely and detection itself is not necessarily reflective of real-world risk. Furthermore, toxicity tests have not been conducted on the complex mixtures of pesticides that are sometimes found in samples. For example, a mixture of many pesticides at low concentrations throughout the year supplemented with higher pesticide concentration pulses soon after pesticide application may potentially pose concerns beyond those considered in any given chemical's individual risk profile.

Mitigating pesticide risks to natural resources is part of the NRCS's mission and the "label is the law," so conservation planners need to coordinate their conservation planning with pesticide label requirements. NRCS technical assistance and financial assistance programs must comply with FIFRA and all pesticide labels. Within the confines of laws and regulations related to pesticide use, conservation planners can help producers properly interpret the mitigation requirements on pesticide labels for a particular site and recommend ways to apply additional margins of precaution for sensitive natural resources.

Conservation planners can use WIN-PST to analyze pesticide hazard for water quality. The hazard analysis done with WIN-PST for drinking water and aquatic habitat is not as comprehensive as the EPA's risk assessment, but WIN-PST is sufficient to guide site-specific application of additional precautionary measures to address natural resource concerns identified in the conservation planning process. Conservation planners may also use WIN-PST to identify soil/pesticide combinations that may warrant additional precaution to protect site-specific natural resources.

Applying Code 595

Code 595 includes evaluation of pesticide use hazards and development of an IPM plan, including the application of PAMS activities and techniques to address site-specific natural resource concerns. Technical assistance includes working closely with the producers, the Cooperative Extension Service, and crop consultants to appropriately integrate all planned pest management activities into the IPM plan. The adoption of a comprehensive IPM system is always preferred, but Code 595 is not designed to prescribe what constitutes a comprehensive IPM system. Commodity-specific IPM elements, guidelines, and year-round IPM programs are often available at the state level from land-grant universities and the Cooperative Extension Service to describe and guide development of a comprehensive IPM system. These guidelines should be used to help document the application of Code 595 in a way that ensures resource protection and supports producers as they address pest management needs. Comprehensive IPM systems use a site-specific combination of pest PAMS strategies. For more information, see:

- Regional IPM Centers
- University of California's Pest Management Guidelines
- North Carolina State University IPM

Pest management efficacy is critical for viable crop production and remains a central guiding principle for any pest management plan. Code 595 does not focus on efficacy, though it recognizes that this is a critical element of evaluating any pest management approach. Rather, Code 595 focuses on documenting specific management approaches that provide additional precautions and mitigation benefits for resource protection.

A comprehensive IPM program guides pest management to prevent or avoid pests as much as possible, monitor pest activity for optimum timing of management activities, and minimize the need for pest suppression, including the use of hazardous pesticides. In addition, a comprehensive IPM program considers pesticide mode of action, precise timing, and other product characteristics to avoid development of pest resistance. Code 595 emphasizes prevention and avoidance techniques that address natural resource concerns.

When data is available, a comprehensive IPM system should also include setting economic pest thresholds. Such thresholds require careful monitoring of pest populations and detailed assessment of both losses from the pest damage and costs of management. Economic thresholds guide use of suppression techniques when the economic benefit is greater than the cost of applying a pest management control tactic. These thresholds are often developed by the Cooperative Extension Service and other IPM experts for each pest in each cropping system and are based on the biology of the crop and pest and the pest's natural enemies. The economic threshold is then dynamically adjusted based on the current cost of the pest suppression technique and projected value of the crop. However, in the absence of specific threshold data (particularly for non-insect pests), many pest management decisions may be guided by other factors, such as site history combined with in-season monitoring and disease- and pest-specific biological forecasting models.

A comprehensive IPM system also includes carefully managing the use of different pest management techniques to delay the onset of pest resistance to each suppression technique. Using a combination of different techniques, including pesticides with different modes of action, is critical to maintaining their efficacy.

Finally, a comprehensive IPM system can also address added measures of precaution for environmental hazards and minimize the risks to non-target species in the field. A comprehensive IPM plan can also reduce offsite movement of hazardous pesticides.

In some cropping systems and for some target pests, a comprehensive IPM system will not be feasible because appropriate IPM technology is impractical or has yet to be developed. In these cases, Code 595 can support the application of individual IPM techniques if they appropriately address potential site-specific hazards to humans and natural resources.

Note: Identified risks associated with planned pest suppression can also be addressed through other conservation practices or a system of conservation practices that also includes Code 595.

Prevention and Avoidance Activities and Conservation Practices

Prevention and avoidance techniques are key components of an effective integrated pest management (IPM) plan. These are the first line of defense against pests. The perfect time to review and select prevention or avoidance techniques is before the crop year begins. Techniques already in use can often be expanded or improved upon.

Below are a series of tables listing several techniques that producers can choose to implement as a component of their IPM plan. These tables only give a highlight of each technique. Your local land grant university extension or other local resources are a good place to gain knowledge of these procedures to fit your local conditions.

Techniques are listed alphabetically and may be covered by conservation practice standards Additional details on each technique are listed after the table.

Table A. Prevention, Avoidance, and Monitoring Practices to Reduce Need for Pesticides.

This series of tables list pest management techniques and conservation practices that have the potential to reduce the amount of pesticide applied, the number of applications made, or the application of the pesticide at all. Unlike mitigation techniques and practices in Tables 1 and 2, these techniques and practices do not always have a direct and quantifiable mitigation value. Their efficacy will depend on site-specific conditions.

Landuse Techniques

IPM Techniques [1,2]	Short Description
1. Avoid poor producing areas	Take poor performing areas out of production, consider replacing with beneficial habitat.
2. Banker plants	Banker plants supply an alternate habitat to support beneficial insects that are natural enemies of crop pests.
3. Beetle banks	Beetle banks provide habitat for insects that consume weed seed.
4. Conservation buffers	Conservation buffers are small strips of land in permanent vegetation that address specific conservation benefits.
5. Insectary strips	Insectary strips provide supplemental nectar, pollen, and habitat to improve the survival of natural enemies.
6. Refuge	A refuge is an area of non-Bt crop that has been planted to maintain a population of insects susceptible to *Bacillus thuringiensis*. Can be used for insect resistance management with chemical pesticides.
7. Trap crops	Growing plants to attract pests away from crops. Trap crops can sometimes be treated with pesticides (if economical) to reduce pest populations without spraying the primary crop.

[1] Additional information on pest management mitigation techniques can be obtained from Extension and other pest management publications including IPM Guidelines and Crop Profiles, pest management consultants, and pesticide labels.
[2] The pesticide label is the law. All pesticide label specifications must be carefully followed, including required mitigation. Additional mitigation may be needed to meet NRCS pest management requirements for identified resource concerns.

Before Planting Techniques

IPM Techniques [1,2]	Short Description
8. Air flow in the crop canopy	Impacts many pests and plant diseases. Balance with row spacing for weed control.
9. Allelopathic plants	Allelopathy is a biological phenomenon where one plant inhibits the growth of another. Can suppress certain weeds.
10. Alternate host reduction	Locate and manage alternate hosts for pests and pathogens to control populations across crop cycles.
11. Cultivars locally adapted	Using crop varieties with genetic resistance to specific diseases or pests.
12. Polyculture	More than one plant species is grown at the same time on the same field to mimic the diversity of natural ecosystems.
13. Seed varieties pest tolerance	By selecting a variety of seeds with strong traits against the major disease or pest of concern in crop, reduces the chance that disease or pest will be problematic.
14. Sequence crops	Growing crops one after the other within the same crop year, one crop being sown after the harvest of the other.
15. Soil health management	Optimize soil conditions for moisture and nutrient availability, soilborne pest/disease resilience, and overall crop health by following core management principles of soil health: 1) minimize disturbance, 2) maximize soil cover, 3) maximize biodiversity, and 4) maximize presence of living roots.

Growing Season Techniques

IPM Techniques [3,4]	Short Description
16. Soil occultation	Uses opaque coverings (e.g., plastic) to trap heat and moisture, which encourages weed seed germination and plant growth but then, by blocking access to water and heating up the soil, eventually kills the weeds underneath.
17. Soil solarization	Uses clear coverings. A method of covering the ground and using the sun's power to heat the soil and reduce soilborne disease or weed growth.
18. Stale seedbed	Allowing weed seeds just below the soil surface to germinate so they can be killed prior to planting the cash crop. May be used in conjunction with soil occultation.
19. Timing of planting or harvest	Adjusting your planting/harvest date to avoid pest/disease pressure.
20. Barrier exclusion	Providing a physical barrier between crop and pest (e.g., floating row covers, sized netting/screens, fruit bagging, kaolin clay dust).

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[3] Additional information on pest management mitigation techniques can be obtained from Extension and other pest management publications including IPM Guidelines and Crop Profiles, pest management consultants, and pesticide labels
[4] The pesticide label is the law. All pesticide label specifications must be carefully followed, including required mitigation. Additional mitigation may be needed to meet NRCS pest management requirements for identified resource concerns.

IPM Techniques [3,4]	Short Description
21. Equipment sanitation	Removing all soil and debris from field equipment before problem pests can leave one field and enter another.
22. Field sanitation	Avoid providing harborage for pests to bridge to next crop. May include management of residue, cover crop biomass, unharvested crop (e.g., mummy nuts in nut orchards, culled fruit, or fruit drop).
23. Mating disruption	Artificial sources of pheromone are placed in an area so that male pests are prevented from effective mating activity and the volume of viable eggs is reduced.
24. Natural enemies	Insects that kill, decrease the reproductive potential of, or otherwise reduce the numbers of another insect or pest. Can include conservation of existing beneficial/natural enemy populations or intentional/inundative releases of natural enemies.
25. Nurse crops	A nurse crop is usually an annual crop planted together with a slow-establishing crop (often a perennial) to assist in establishing the slower-to-establish crop.
26. Shallow cultivation	Minimizing depth of soil disturbance to maintain soil health benefits.
27. Weed seed bank reduction	Prevent weeds from producing seed. Weed seed bank will be depleted in about 5 years if no additional seeds are added.
28. Dust management	Controlling or minimizing dust on crops to reduce diseases and pest issues.

Conservation Practices

IPM and NRCS Conservation Practices	Short Description
29. Conservation Crop Rotation (328)	Including non-host crop or pest/disease-suppressive crop in rotation may reduce pest/disease pressure and need for suppression strategies. Where pesticides are used, this may also increase ability to rotate pesticide modes of action to manage for pesticide resistance.
30. Cover Crop (340)	Plants established for seasonal vegetative cover. May help break disease/pest cycles, reduce weed growth, and enhance nutrient/soil moisture management for overall crop health and resilience.
31. Field Border (386)	Strips of permanent vegetation established on one or more sides of a field. May support beneficial insects.
32. Forage Harvest Management (511)	Timely harvesting reduces the need for pesticides by harvesting the forage before pest populations exceed a threshold value. Early harvesting may only delay the application of the pesticide rather than avoiding it.
33. Irrigation Water Management (449)	Irrigation scheduling optimizes plant health and soil moisture management, both of which can help reduce the chances of disease development in crops.
34. Nutrient Management (590)	Healthy, vigorous plants that grow quickly are better able to withstand some pest injury.
35. Mulching (484)	Placing (or planting) a protective layer of material on top of the soil. Increases infiltration, reduces soil erosion, and may reduce pesticide use.

IPM and NRCS Conservation Practices	Short Description
36. Prescribed Grazing (528)	Managing the pasture for even grazing activity and maintenance of adequate residual dry matter to maintain desired plant community without need for chemical suppression.
37. Strip Cropping (585)	Partitioning a field into strips which are alternated in a crop rotation system.

Prevention or Avoidance Techniques

Landuse

1. Avoid poor producing areas; change land use in areas where pathogen or other pests are likely to cause crop failure

Plant growth and geographic distribution are affected by the environment. If any environmental factor is less than ideal, it limits a plant's ability to be healthy. When plants are seeded in areas historically prone to poor growth, they are more susceptible to disease or insect attack. One example of an environmental factor is water stress; poorly drained soils and areas that do not hold enough water to promote growth leave plants vulnerable to pests.

Taking areas that perform poorly out of production can make treatment of pests unnecessary. These areas can still be managed for other beneficial uses, such as conservation plantings, permanent grasslands, and other options.

2. Banker plants may be particularly useful in greenhouse and high tunnel culture

Banker plants provide alternative food sources to beneficial insects during times their prey become limited. Banker plants are used in production settings that supply a non-pest prey species (i.e., beneficial insects) to provide a continual source of natural enemies to pests.

3. Beetle banks

Beetle banks are raised or bermed strips 2 to 6 feet wide that provides overwintering habitat for ground beetles. They often include plants such as bunch grasses, sunflower or buckwheat. Beetle banks promote insects that consume weed seed and thus reduce or replace the use of insecticides. Beetle banks can also provide excellent habitat for birds and beneficial insects.

4. Conservation buffer plantings (see CPS list for beneficial habitat)

Conservation buffers are small strips of land in permanent vegetation, such as grasses, shrubs, or trees. These strips are strategically designed and placed on the landscape to address specific conservation benefits. A buffer can be used to trap sediment, nutrients, and pesticides before they enter a water system. They can also provide excellent wildlife benefits, as specific plant species provide habitat for monarch butterflies, bees, birds, and small mammals.

5. Insectary strips, including strips of cover crops left standing to flower

Insectary strips provide supplemental nectar, pollen, and habitat to support the survival of natural enemies. Planting strips or hedge rows can be incorporated along the perimeter of a nursery or crop. Either annual or perennial species can be used depending on the objective. Species included typically bloom quickly and have staggered bloom dates to provide longer lasting benefit. Insectary plantings can also involve using a cover crop between or throughout rows of plants.

6. Refuge management to avoid development of pest resistance to Bt crops

Bt hybrid crops are genetically engineered to contain a gene from the soil bacterium *Bacillus thuringiensis* (Bt). Different strains of Bt have been identified to target distinct groups of insects. As Bt acres will not eliminate any insects emerging from the Bt portion of the field, the possibility for these surviving insects to become resistant is high.

A refuge is an area of non-Bt crop that has been planted to maintain a population of insects susceptible to Bt. The goal is to have these susceptible insects far outnumber any potentially Bt-resistant insects so that the resistant insects are more likely to mate with susceptible insects that were produced by the refuge. There are several configurations of refuge layouts, which are more effective depending on the crop and which Bt gene is used. The most common methods are either planted in a block or a strip or integrated with a mix of both Bt and non Bt seeds (i.e., refuge-in-a-bag). Refuge management is most common in production of Bt crops as described above. But the same concept can also be used to conserve susceptible insects with conventional insecticides in some instances.

7. Trap crops to divert pests from production crops

Trap cropping is the practice of growing plants to attract pests away from the cash crop. Pests congregating on the trap crop can then be more easily treated. Using trap crops can reduce or eliminate the use of pesticide on the cash crop. The trap crop can be a different plant species, variety, or just a different growth stage of the same species as the main crop, if it is more attractive to the pests when they are present.

Examples:

- In Florida, planting collards around the perimeter of cabbage fields to trap the diamondback moth.
- In Connecticut, planting hot cherry peppers to trap pepper maggots from bell peppers.
- In California, planting strips of alfalfa among strawberry plants and using a vacuum to remove lygus bugs.[5]

Transplanting the trap crops while simultaneously sowing the seeds of the cash crops draws the pests to the older trap crops, where they can be managed, and avoids damage to the younger cash crops. Trap crops are best transplanted as 2-week-old seedlings.

Before Planting

8. Air flow (e.g., row or plant spacing, row orientation, canopy management, pruning)

Air flow helps to deliver carbon dioxide to plant leaves while removing water vapor produced by

[5] Management of Alfalfa Trap Crops to Prevent First Generation Lygus Bug (Lygus Hesperus Knight) Damage in California Strawberries | National Agricultural Library (usda.gov)

evapotranspiration. Air flow also enhances photosynthesis and nutrient delivery within plants. Planting sites in a way that will allow air flow helps to prevent the growth of certain fungus, bacteria, and molds.

Row spacing can be an effective method for using air flow to prevent a variety of pest problems. For example, pathogens such as *Sclerotinia sclerotium* (white mold) are a concern for soybeans. Wider row spacing (30 inches) can reduce the survival of the spores of white mold by increasing air flow between rows. However, row spacing can also affect the cover crop canopy, which may negatively impact weed management.

The effect of row orientation varies with latitude and with the seasonal tilt of the earth in relation to the sun. It is possible that, due to the direction of its orientation, crops could shade weeds in the interrow space.

Managing plant canopies to suppress disease can be achieved through a variety of approaches. Various degrees and types of canopy management, including genetic, mechanical, and cultural, have been studied and adopted for disease management in many crops. Mechanical modification of plant canopies to reduce disease is routinely used in the production of only a few high-value crops, such as pruning of grapes to manage botrytis bunch rot (R'Houma and Boubakker 1998) and pruning coffee to reduce the severity of coffee rust (Arneson 2011).

In field crops, plant genotypes with upright and compact growth habits allow for disease avoidance based on plant architecture. Soybean cultivars with certain traits, such as reduced height and lodging and early maturity, typically have a reduction in white mold within the crop and in disease incidence at harvest.

9. Allelopathic or competitive crops

Allelopathy is a biological phenomenon where one plant inhibits the growth of another. A specifically chosen allelopathic plant can suppress certain weeds and without disturbing the growth of the cash crop. Some examples of plants that offer some level of allelopathic tendencies to other plants include cereal rye, perennial rye, garlic mustard, goldenrod, tall fescue, Kentucky bluegrass, some sorghum species, elderberry, sumac, bearberry and English laurel.

There are a few different pathways for which plants can offer this competitive nature. First, some allelopathic plants release chemical compounds from their roots, similar to how they release soluble carbon and sugars. These chemicals will then suppress or even kill the neighboring plants. Allelopathy may also result from release of gases from small pores in the stomata of plant leaves.

A third method is through byproducts of the decomposition of fallen leaves. As the leaves decompose, they release a noxious chemical into the soil, which inhibits growth of some neighboring plants. The length of time these compounds remain in the soil varies among species and can be as short as a few days but can be as long as multiple growing seasons.

With increasing emphasis on environmental protection, more attention has been paid to allelopathy research to better understand the mechanisms of allelopathy.

10. Alternate hosts reduction for insect pests and disease

The term "alternative host" may be used when a pest or pathogen has several different hosts. When an alternative host is present in the production environment, it creates a "bridge" for a pest to potentially carry over to a following cropping cycle. Once a pest of concern has been identified, controlling alternate hosts for that pest can be an important way of pest reduction. This includes controlling weed hosts in field borders. Selection of cover crop species should consider whether the species is a known host for diseases and pests for the following cash crop.

11. Cultivars locally adapted with genetic resistance to specific diseases or pests

Cultivars are plant varieties that have undergone selective breeding to produce desired genetic traits. For example, several crop varieties have been bred with genetic resistance. Other desired traits include insect resistance, herbicide tolerance, drought tolerance, disease resistance, enhanced nutritional content, and improved properties for processing post-harvest.

Different crops are modified for different traits; some may have multiple traits engineered into them.

12. Polyculture consisting of multiple crops grown together

Polycultures mimic the diversity of natural ecosystems by growing more than one plant species at the same time on the same field. A well-known polyculture is the historic three sisters of corn, beans, and squash.

When complementary plants are grown near each other, they tend to be more immune to pests or have higher resistance to insects and disease. There are many ways to set up a polyculture. Here are a few examples:

- Planting multiple species of grain that mature at a similar time. The grains are harvested together, and the seeds are separated after harvest.
- Planting multiple cover crop species together to complement each other.
- Planting a cash crop between young orchard trees before the canopy closes.

Polyculture may include intercropping, permaculture, and integrated aquaculture. Some producers inter-seed cereals (e.g., oats, spring wheat, winter wheat, or rye) with soybeans. The early-emerging cereals limit wind erosion and can function as weed control for spring weeds.

Harvesting a taller crop while leaving a shorter crop to grow causes its own logistical complications. Some producers have overcome this by installing a piece of plastic over the cutter bar directly over the soybean rows, allowing them to stay growing while the small grain is harvested.

13. Seed varieties pest tolerance

When selecting seed varieties and hybrids, consult characteristic charts to select those with the highest tolerance for the pests of greatest concern. Seed companies and land-grant university (LGU) extensions offer local characteristic charts that rate for several common concerns. This can be particularly useful in managing for early emergence vigor, various disease possibilities, and placement on soil types that promote growth. Selecting a variety with strong traits against the major pests of concern reduces the chance of pest and disease damage to the crop.

14. Sequence cropping

Sequence cropping refers to growing crops one after the other within the same crop year (i.e., one crop being harvested before the other is planted). When two or more crops are grown in a year on the same land, this system can also be referred to double cropping. Herbicides used in this system, must be carefully assessed to make sure there are no residual effects on the second crop. A good crop rotation must be planned and includes not only the crop-to-crop sequences but also how the crops will be laid out on the farm over the entire season. Growing the same crop, or one with similar pest concerns, the same year within a field can increase pest populations.

15. Soil health management – cover crops, crop rotation, no till or strip till, organic matter, soil structure, and soil biotic diversity and capacity

A well-planned and -managed system optimizes soil function and supports plant vigor. Soil health management promotes active and diverse microbial communities in the soil, which provides benefits for nutrient cycling, available water holding capacity, soil physical properties, and suppression of soilborne pathogens and pests. The core soil health management principles are: 1) minimize disturbance, 2) maximize soil cover, 3) maximize biodiversity, and 4) maximize presence of living roots.

Minimizing disturbance reduces new flushes of emerging weeds, avoids destroying fungal mycelia, and slows oxidation of soil organic matter.

Maximizing soil cover can reduce weed emergence, support diverse and active soil biological activity, and reduce splash transfer of soilborne disease transfer from raindrops or overhead irrigation. Keeping the soil covered also creates improved soil habitat for organisms that produce organic materials.

Maximizing biodiversity provides a diverse aboveground plant structure and belowground roots with variable carbon composition and exudates. The aboveground plant structure provides better protection while the belowground roots feeds many types of micro- and macrofauna.

Maximizing living roots provides more root exudates and biomass as well as feeds organisms that produce biotic glues. Biotic glues are important for building protected pools of organic matter.

16. Soil occultation

Tarping, or occultation, involves the use of durable black plastic, often sold as silage covers, that is applied to the soil surface between crops and removed before planting. Tarps are reusable over multiple years and adaptable to different applications and planting times over the season. They function as a soil health and weed management tool and serve as a valuable "placeholder" on the farm to hold beds weed-free between plantings. Tarps are working to do many different things - create a stale seed bed for the following crop, kill crops and weeds after harvest, terminate cover crops, and control soil moisture to improve field access in spring. Many of the challenges associated with tarping are logistical, including applying and securing them, moving them across fields, water ponding, and finding time in the rotation to fit them, especially in the middle of the season.

17. Soil solarization

Soil solarization is a method of covering the ground and using the sun's heat to kill weeds. Products that work best to trap heat are materials that allow solar radiation through to the soil but trap the heat from escaping through to the atmosphere (e.g., transparent plastic rather than opaque). Soil solarization can take around 4–6 weeks longer if not done in the heat of the summer. If the soil is too dry or excessively wet, solarization takes longer. Moist soil just after a rain or proper irrigation seems to work best. If the coverings are obscured (gets muddy), it also slows the heating process. Note that use of soil solarization may reduce soil biota and negatively impact soil health.

18. Stale seedbed

The stale seedbed technique is a weed management practice in which weed seeds that are just below the soil surface are allowed to germinate and then are killed prior to planting the cash crop. Small-seeded and quick-germinating weeds are the best target for this strategy. Shallow tillage is usually a good method to get nondormant seeds to germinate. Once the weeds are growing, they can be terminated by either herbicide, flamer, solarization, or tillage.

When using tillage, it is important to keep soil disturbance very shallow so that weeds from deeper in the soil do not replenish the surface seedbank. When planting in the stale seedbed, keep soil disturbance to a minimum for the same reason. This process takes a few weeks to get the weeds to grow and then be terminated, especially if the process needs to be repeated due to a heavy weed seed bank.

19. Timing of planting or harvest to avoid pest damage (including choice of crop maturity date)

Certain insect infestations can be avoided by strategically adjusting the planting date. This prevention technique can be challenging as moving planting dates can avoid one pest of concern but leave the crop vulnerable to another. Routine scouting can help determine if unexpected pests become a concern.

For some insects, planting a crop early and getting ahead of the problem (crop gets to a less or unsusceptible physiological stage) can be a practical solution. For example, corn earworm on sweet corn is less of a problem in crops planted early. On the other hand, squash bugs tend to be less of a problem if planting is delayed until the overwintering bugs have died off. Planting winter wheat after the hessian fly-free date has been recommended by LGUs. Thrips, for example, often infest early planted crops in high numbers but are less of a problem for crops planted later.

Harvesting earlier can have effects on pests, particularly weeds and diseases. For some vegetable crops, early harvest decreases the time that the crop is exposed to a pathogen. Harvests can also be timed to mitigate insect infestations. Alfalfa stands commonly harvest a little early to avoid the need to treat for potato leafhoppers.

Growing Season

20. Barrier exclusion

Barrier exclusion is the practice of laying a physical barrier between crops and pests. There are several methods of barrier exclusion, including floating row covers, kaolin clay, fruit bagging, and properly sized netting or screens.

Floating row covers, also referred to as garden fabrics, are a white, thin, light piece of material used to shelter crops for several reasons. When the correct cover is chosen it can reduce insect pressure and reduce feeding of rabbits or deer. When used a part of an IPM system, be mindful of previous pests that may have overwintered in the soil under the cover.

Kaolin clay is used in manufacturing of porcelain and fine china. It is also instrumental in the production of paper, paint, rubber, and heat-resistant materials. Kaolin clay can attract heavy metals onto the clay particle, neutralizing particulates and pathogens. When mixed and applied properly, it can be used as insect control by creating a barrier film to cover the leaves and fruit. The white, powdery film irritates insects, thereby reducing their feeding on fruit or leaves.

Fruit bagging means covering young fruit with plastic bags while they are young. The bags provide a layer of protection between the fruit and the outside world. Growing fruit in bags can avoid most of the spraying that would otherwise be needed. It is often used for apples and pears but can be used on other fruit as well.

Garden netting can prevent birds from fruits, vegetables, and other crops. There is a wide variety of material options available, such as polyethylene, metal wire, or plastic.

21. Equipment sanitation

The spread of many problem pests can be effectively managed by removing all soil and debris from clothing and field equipment before they leave one field and enter another. Regardless of what type of equipment (sprayer, tillage, planter, drill, etc.), taking a few minutes to thoroughly clean them can be effective. For instance, following harvest of an individual field, combines retain as much as 150 pounds of biomaterial, including chaff, grain, and weed seed. This material may remain in tight spaces within the machine or in obvious places, such as the gathering head and grain tank.

While it is impossible to remove all material from clothing and equipment, any effort following the harvest of fields can reduce movement of weed seed and other material from one field to another. Most farmers can point to fields with specific problems that other fields do not have, such as bur-cucumber, palmer amaranth, or other difficult-to-manage issues like herbicide-resistant weeds. Similarly, soilborne disease may be transferred on wheels, boots and tillage implements. Sanitation and appropriate combine clean-out when working with these fields should be a top priority to prevent spread of these issues.

22. Field sanitation procedures

Crops can become contaminated with pathogens before, during, and after harvest. It is important to consider all potential sources of pest and disease hazards to reduce contamination. Avoiding residue that may harbor rot disease or slugs in new plantings, removing mummy nuts in which navel orangeworm may overwinter in nut orchards, and avoiding weed growth that harbors pests and diseases are all examples of field sanitation management.

As noted previously, equipment may transfer diseases and pests. Also consider how water moving across the landscape, as well as animals and workers moving among fields, may affect contamination. Careful attention to all ways that pests and diseases may move or persist in crop fields, as well as routine cleaning and equipment maintenance, is critical for preventing the movement of plant pathogens or pests between fields.

23. Mating disruption

Many insects communicate using pheromones, which are scents released by one insect to communicate with another insect of the same species. Mating disruption by pheromones takes place when enough artificial sources of pheromone are placed in an area that the probability of a female being found by a male, mating, and laying viable eggs is reduced below the point where economically considerable damage occurs. Mating disruption is a very focused approach to target a specific species without harming beneficial insects.

Scientists have identified and are able to manufacture many pheromones that can be applied to fields. Many pheromones are labeled as pesticides by the EPA, but they do not work in the same way as a traditional pesticide. The effectiveness of this technique relies on the ability to dispense these pheromones. It is important to release the scent at the correct location and length of time.

Mating disruption pheromone systems are available for pests such as the navel orange worm, vine mealybug, codling moth, oriental fruit moth, dogwood borer, peach tree borer, and lesser peach tree borer, as well as other leafroller species.

24. Natural enemies

Often referred to as “biological control,” this IPM option can be highly effective when applied in a targeted manner. Natural enemies are insects that kill, decrease the reproductive potential of, or otherwise reduce the numbers of another insect or pest. Typical natural enemies of insects include predators, parasites, and pathogens. Purchasing and releasing natural enemies is a little different than protecting or promoting beneficial organisms. NRCS has a limited role in pest management strategies that involve biological control and will not make recommendations on introducing natural enemies (see 190 GM § 404.10). It is important to do research before purchasing and releasing natural enemies, as some natural enemies on the market have never been demonstrated to effectively control any agricultural pests.

Natural enemies may be managed by inoculation, in which a few natural enemies are released. Inoculation relies on the offspring of these natural enemies to provide biological control, not the individuals released. Natural enemies may also be managed as an inundation, in which large numbers of natural enemies are released. Both the natural enemies released, and their offspring provide the biological control.

In North Dakota, flea beetles have successfully been used as biological control of leafy spurge. Green lacewings are commonly sold for aphid control. Other popular natural enemies are Trichogramma wasps (to control cabbageworms, cabbage loopers, tomato hornworms, and other caterpillars) and beneficial nematodes (to control a wide variety of garden pests). Predatory mites of several species are commonly released in strawberry production systems in California to control spider mites. These natural enemies can be purchased and released early in the growing season for earlier and more effective control.

The release of natural enemies (predators, parasites, and pathogens) to control pests is a type of biological control called augmentation. This approach uses commercially available species that are applied in a timely manner to prevent population increases or suppress a pest population. Successful augmentation requires advanced planning, biological expertise, careful monitoring, optimal release timing, and patience, and may require tolerating certain levels of pests and damage. Situations where pests or damage are already abundant are not good opportunities for augmentation.

25. Nurse crops

A nurse crop is typically an annual crop used to assist in establishing a new seeded perennial crop. The widest use of nurse crops is for establishing legume crops, such as alfalfa, clover, or trefoil. Nurse crops are also often used for establishing perennial grasses in range plantings. Nurse crops can effectively reduce early season weed populations due to their ability to establish quicker than the main crop. Often, nurse crops can be either harvested for hay or grain or otherwise terminated. However, allowing the nurse crop to be taken as forage or grain may increase the stress on the perennial under seeding, which may reduce density or tonnage.

26. Shallow cultivation

Shallow cultivation can be done using hand tools or mechanical equipment. Shallow cultivation can be used to eliminate small weeds that have recently emerged. It can also be used to break up a crust that has formed on the soil surface due to low residue amounts (an indicator of poor soil health); however, alternative practices should be considered.

It is important to only disturb the soil surface by less than 2 inches. Minimizing the depth of soil disturbance will maintain soil health benefits. Going too deep tends to dry out the soil. It is also important to only cultivate when the soil profile is not excessively wet as this may lead to compaction and crusting. Ultra-shallow tillage is a tillage practice that fully cuts through residue at 1 inch (or less) working depth. This can eliminate small weeds while reducing the chance that new weeds will emerge due to limited soil disturbance.

27. Weed seed bank reduction

Reducing the weed seed bank may prevent weeds from producing seed. The seed bank is the resting place of weed seeds and forms an important component of the life cycle of weeds. Weed seed banks are a source of future weed populations of annual and some perennial weed species that reproduce by seed only. On average, the bulk of a weed seed bank depletes in about 5 years if no additional seeds are added. Multiple passes of mowing, tillage, herbicide, or any combination of the three can prevent weeds from setting reproducing seed.

When using herbicides as the primary treatment option, there are a few things to consider. Weeds larger than 2 inches are more likely to survive herbicide applications, especially if less than ideal conditions occur during application (e.g., issues with rate, coverage, temperature, time of day). Larger weeds have more growing points than smaller seedlings, which helps them tolerate and escape an herbicide application. Larger weeds also can reduce herbicide coverage and uptake. Density of the crop canopy may also affect coverage of application.

If only a few weed escape, hand pulling and removing them prior to harvest is a great option. If larger patches of weeds produce seed, combine around these areas to reduce the spread of seed.

28. Dust management

Several mite pests that affect crop plants can be effectively reduced by controlling dust in the production environment. Dust may occur from vehicle traffic, cultivation or harvest operations, or wind. Planting windbreaks, applying water or oil to unpaved roads, and minimizing speed on unpaved farm roads are all effective dust reduction approaches.

Conservation Practices

29. Conservation crop rotation (328)

Design to break pest and disease cycles by including non-host plants or disease- and pest-suppressive plants. Crop rotation is the art of growing a sequence of crops specifically planned to either provide benefit (e.g., legume cover crops to build soil nitrogen), break pest cycles (e.g., suppress a soilborne pest), or optimize resource protection (e.g., including deep- rooted plants to break compaction) on the same footprint each year. This practice has the greatest potential to impact pests and improve soil health consistently when used to its fullest capacity. Increasing diversity in a crop rotation (e.g., including both broadleaf and cereal crops, vegetables of different families) can maximize IPM benefit. Changing crop types (e.g., mixing cool and warm season crops, grasses, and broadleafs) will also improve the effectiveness. Rotating between annual and perennial species is also highly effective.

The efficacy of crop rotation is related to the variation in the rotation, including variation in the sequence of the crops. The longer the period before the sequence repeats, the more effective the rotation is against pests. Rotating through crops with different vegetative characteristics is also important. For example, rotating leaf vegetables (e.g., celery, cabbage, spinach, lettuce, or parsley) with root vegetables (e.g., carrots, garlic, onions, potatoes, or radishes) or with fruits and flowers (e.g., tomato, cauliflower, eggplant, or strawberries). In coastal California, a common rotation includes strawberries, lettuce and broccoli for nutrient management and pest management benefit.

30. Cover Crop (340) to interrupt pest, pathogen, and weed life cycles

Planting a cover crop can be an effective IPM strategy. Cover crops can be planted after harvesting a crop or inter-seeded between rows of a growing crop. Depending on their characteristics, certain cover crop species can interrupt weeds and insects or lessen disease pressure.

The rate that cover crops are planted can play a key role when weed control is the objective. Planting an overwintering cereal grain in the fall provides an opportunity to reduce weed populations the following spring. Species such as cereal rye have good weed suppression tendencies due to their allelopathic properties. Moreover, the residue left after their termination provides a mulch to minimize weed seeds from germinating.

Other species can help suppress weeds when planted in a blend that establishes quick and provides ample biomass. Pacific gold oriental mustards can reduce damage of herbivore nematodes in orchards and potatoes.

No-till drilling a cover crop can produce a uniform stand across the field with less chance for skips when compared to broadcast or aerial applications. Always be sure to research potential unintended outcomes, such as providing a green bridge for pests or competition for resources (e.g., nutrients, water), that may reduce in crop performance.

31. Field borders (386) (includes prairie strips)

Field borders may provide habitat for beneficial insects, thereby providing excellent support for pest management. For example, prairie strips planted in strategic locations within a crop field provide numerous benefits. Because prairie strips are planted with many different native grass and wildflower species, they offer higher quality habitat than exotic grasses or single-species plantings. Prairie strips also provide year-round habitat and food for pollinators and other beneficial insects, such as those that prey upon crop pests. With careful management, insect diversity in cropland with prairie strips equals that of prairie restorations. Low-yielding acres may be used to integrate prairie strips, reducing the cost of inputs otherwise spent on those acres.

32. Forage harvest management (511)

The timely cutting and removal of forages as hay, green-chop, or ensilage is an effective IPM support strategy. Harvest frequency or scheduling can have major effects on pests, particularly weeds and diseases, but can also be used to avoid insect damage. Generally, harvest schedules are dictated by the desire to maximize yield and quality and by practical considerations such as irrigation scheduling, labor, and available machinery.

33. Irrigation management (449)

Except for members of the Erysiphales (Ascomycota) family, fungi and bacteria need free water on the leaf surface to initiate infectious processes. As such, irrigation scheduling can help reduce the chances of disease development in crops.

Irrigation water applied in excess (or deficit) may result in the development of many fungal and bacterial plant diseases, or plant stress and vulnerability to a range of pest and disease issues. Leaf wetness duration, soil water tension, and related water variables impact several aspects of different plant disease cycle. Sporulation, survival of pathogen propagules, their dispersal to new hosts, germination, and infection can all be managed by targeted irrigation scheduling.

34. Nutrient management (590) to favor crops over weeds, pests, or pathogens

Healthy, vigorous plants that grow quickly are better able to withstand some pest injury. However, overfertilizing crops can increase pest problems. Beginning with a quality soil test and accurately calculating rates based on LGU rate recommendations help reduce the chance for over application.

Increasing soluble nitrogen levels in plants can decrease their resistance to pests. Some crops that require nitrogen have been found to be less prone to insect pests and diseases when organic soil amendments are used (if applied at a calculated correct rate) due to lower nitrogen content in the leaf tissue. Under fertilization of nitrogen can lead to increased early blight *(Alternaria solani)* on potato (MacKenzie 1982) and fusarium wilt *(Fusarium oxysporum)* on melons (Egel and Martyn 2013). Overfertilization can lead to greater disease severity, such as *Rhizoctonia solani* on rice (Datnoff, 1994).

35. Mulching (484) for weed suppression

Mulching has long been an effective IPM method. It involves simply putting a protective layer of material, such as woodchips, compost, straw, or black plastic, on top of the soil. Certain factors impact the choice of material; cost and availability are typically the first considerations.

Mulch improves pest resistance by improving soil microbial activity and soil nutrient balance and content. The presence of mulch can balance soil humidity, temperature, and soil structure. Mulch can smother weeds before they can become a pest of concern. Also, mulch made of organic materials (e.g., crop residue, rolled cover crop, installed mulch) can contribute to the carbon content in the soil.

Organic mulch can benefit crops through means other than improving soil, which includes reducing soil splash onto plants and providing habitats for natural enemies.

Natural enemies require more than just food (pests to eat) to complete their life cycles. They may need an overwintering site, protection from heat and desiccation, and alternative food sources (such as plants and early season prey) when pests are not present. Mulch can provide the habitat to meet the needs of many beneficial insects. Also, the mulch may make it harder for flying insects, such as aphids and leafhoppers, to see the crop by reducing the visual contrast between the foliage and the soil surface.

Soil splash occurs when falling water (rain or irrigation) impacts soil with such force that the soil splashes onto the crops. Because soil can carry bacterial pests, reducing soil splash is important for crop health. For example, fruit rot resulting from soilborne pathogens (bacteria, yeast, and molds) occurs less in a mulched garden because the fruit do not touch the soil and soil is not splashed up on the fruit by water (rain or irrigation).

Mulches that use reflective materials can repel invading insects and keep pest populations below thresholds. Reflective mulch delays or prevents certain flying insects from infesting plants by reflecting ultraviolet light in an unexpected direction, which confuses pests—specifically aphids, whiteflies, and leafhoppers—and decreases the chances that they land and feed on the plants growing over the mulch.

Reflective mulches are generally available in rolls from gardening supply outlets. Colors range from silver, white, black, yellow, orange and red. While some of the colored reflective films have been reported as more effective than white or black plastic mulches for managing certain pests, they are not equally effective on all pests. Certain colors are better at repelling certain pests while others have instead attracted certain pests.

When following the basic principles of soil health, do not leave any soil bare. Use living mulches (cover or companion crops) as much as possible. When adding mulch to a system, monitor for pests that may use the mulch as a habitat or food source. For example, rodents frequently use deep wood chip mulch to nest.

36. Prescribed grazing (528)

Using livestock to graze on grasslands can be an effective weed management technique. Grazing can also provide nutritional benefits to the livestock. In the early vegetative stage of growth, many weeds have nutrition values equal to or greater than the desired forages. However, the forage quality of weeds declines rapidly as the plants mature.

There are a few different strategies for grazing management, such as ultra-high stock density, mob grazing, or management-intensive grazing. Most rely on short duration, high density grazing with a longer than usual grass recovery period. Each has its advantages and disadvantages but, when performed appropriately, can have a dramatic impact on grasslands. Weeds that are not eaten will likely be trampled, causing a mulch effect that allows favorable grass recovery.

Weed control in any grazing system can be management intensive, as it requires a pasture to be grazed evenly. Under grazed pastures may become weed-infested, while overgrazed pastures provide an opportunity for less palatable weeds to grow. Lax management allows the livestock to be selective and often results in overgrazing. A rotational grazing program, where pastures are permanently or temporary subdivided, can adjust the size of the grazing area. Using a rotational grazing program in conjunction with correct animal-to-pasture ratios helps decrease the risk of overgrazing.

37. Strip cropping (585)

Strip cropping is a method of farming which involves partitioning a field into long, narrow strips which are alternated in a crop rotation system. Trap crops can be used within a strip cropping field layout.

These alternating crops can make excellent trap crops, catching incoming pests from neighboring strips. Some research has found a 50 percent reduction in soybean aphid populations where trap crops are used. Beneficial insects can also thrive having different crop types grown in proximity.

This technique is often seen on slopes where erosion is a concern. The fields are usually farmed on the contour. When planting, extreme care must be taken to reduce any spaces between the crops as this will be a place for weeds to grow. The width of the crop strips can vary depending on secondary purposes. Strip cropping can also be done on a smaller scale, if the strips are wide enough to accommodate equipment (either tillage tools or harvest equipment) but narrow enough for the crops to interact with each other.

Monitoring Activities

Crop Scouting Basics

Routine scouting of the fields helps to correctly identify pests and diseases and monitor environmental conditions (e.g., temperature, moisture) and pest presence and life stage, which is important for managing crops. In today’s busy world, producers, agronomists, and retail centers are often short on time and staff to devote to a routine scouting program. While many growers employ pest management services to monitor and manage pests, for those who do so themselves, prioritizing scouting with other activities can be difficult. Regardless of who does the work, taking the time to scout fields is an essential element to an IPM plan. This technical note provides information about when and how often to monitor, tools to use, and other advice.

When to begin scouting? As the growing season begins, weeds must be evaluated early on. Determining which weeds are present and their size will affect what control measures to take and when. Options typically include a burndown herbicide application, a tillage pass, or flaming, among others. Scouting should also check on field sanitation and insect presence.

Once the crop has been planted, it will need a more routine scouting program. A weekly program early in the growing season is often adequate, though it depends on the crop. As the season progresses and the crop has canopied, scouting can often be extended to less frequent observations. If an insect or disease becomes present on a specific crop, you may choose to closely monitor that pest of concern with a short scouting interval of a few days until the pest reaches economic threshold or populations decline.

Check with a local LGU for information on when locally relevant pests tend to emerge and resources for tracking degree days and flight dates of specific pests.

Notes, Tools, and Supplies

Common tools used for scouting include pocket size reports (Figure 1). There are several digital reports available when using computer applications, and reports can be customized with a list of pests common to the area. Important items to document in a scouting report include the date, field name, portion, or location of the field you were in that week, stage of the crop, crop condition, population or stand count, soil moisture, and types of pests. Monitoring records should include, at the minimum, dates done and key findings. When a finding includes a pest of concern, record detailed observations.

Pests of concern should be the focus from week to week, including:

- ***Weeds:*** Correct identification is important. Record the size and amount present. The earlier you can identify weeds, the more effective and diverse your management options will be. You may want to enroll in a class to become proficient in naming weeds at the cotyledon stage.
- ***Insects:*** Include both pests and beneficial insects, as well as the name of the insect and estimated population per plant or the percent defoliation of the crop. Note the life stage of the pest where relevant. Each insect pest usually has an economic threshold that is dependent on either population or defoliation and can typically be found in the local LGU extension references.
- ***Disease*****:** Early disease pressure can be difficult to notice. Check for plants that show signs of stunting, lesions, discoloration, yellowing, and senescence. Get a laboratory diagnosis if you are unsure of the correct identification of the disease.

Laboratories can provide information on, and identification of, pests, but may need a sample to analyze. To collect a weed sample, take a leaf of the plant. When collecting samples of weeds and plants, a pocketknife may come in handy for splitting stalks or roots. Before sending the sample to the laboratory, take two pieces of cardboard, lay the sample flat on one piece, and press and hold the second piece on top. This will reduce the chances of the sample drying out and becoming unrecognizable.

Insect samples can be the insect itself or, if it cannot be caught, a clear photo of the insect. The insect can be sent to the laboratory in a simple jar with a tight lid. The insect sample should also come with a population count. Sweep nets are commonly used to collect and count some species of insects. The local LGU extension can provide nets (or information on where to get them) and instructions for using them. When counting insects, you may need to count how many sweeps of the net you make to accurately determine the pest population. This information will be used when evaluating economic thresholds.

A tape measure is also important as you may need to count insects per foot of row. A tape measure can also be used to confirm the size of weeds.

How Often to Scout

Deciding how often to scout fields will depend on the crop you are monitoring. For example, row crops, once planted, are typically scouted every 7 days until crop reaches canopy. Scouting frequency also depends on the crop stage and weather conditions. For example, if a field was just sprayed with a pesticide a day or two before, scouting of that field can be skipped for a week.

Once the crop reaches canopy, scouting can occur less frequently or on an as-needed basis. Local reports can help to inform you when increased scouting may be needed. For instance, if a particular insect has been reported from the local extension office to be in your region, scouting more frequently may be warranted. When the pest has reached economic threshold and is treated, scouting can return to the prior frequency.

Other factors that influence scouting frequency include severity of the pest impact. Economic thresholds will also need to be researched and documented. These are available for most insect pests common to your area through your local LGU. When economic thresholds are very low, frequent monitoring may be essential to catch a problem early. In instances where a problem is likely, but management options are limited, monitoring may be less frequent. Following a scouting calendar can offer helpful reminders of what to look for within the growing season the first few years of scouting fields.

For more intense crops that are grown in a high tunnel or a community-supported agriculture (CSA) garden, these may need to be looked at daily. The condition of the crop and identified pest of concern will affect what notes to take on the scouting report. Plan to complete a scouting report on a weekly basis.

Utilize Regional Information

A lot of information is available in extension office blogs, publications, and regional agriculture industry reports, often shared in local press or radio programs. Many LGU extension offices provide weekly newsletters with valuable information during the peak scouting season. Newsletters typically will provide updates on the local pests of concern, including weeds, insects, and disease. Newsletters also often offer weather-related trends that may help predict disease possibility and whether proactive treatment is needed. In some cases, they may offer a “biofix date” (i.e., a date that signals the start of growing degree day accumulations), which guides placement of mating disruption products and some suppression activities. Local agronomy centers and other professionals may also send information through text alerts. This information should be used to help optimize your monitoring efficiency, not to replace site-specific pest monitoring for making any specific management decisions in your fields.

Apps Can Be Useful

Using smartphone or tablet apps to organize and track your scouting history can be helpful. There are already many easy-to-use apps on the market today that are ideal for everyday field scouting tasks, with new ones coming out all the time. Some offer insect-only options, such as soybean aphid speed scouting from the University of Nebraska – Lincoln Extension. Others offer pest identification, in-season imagery, options to record notes by GPS location, a record of what variety was planted, cause of crop damage identification, and more. Some are free, others have a small fee, and most of them will ask for a registration login.

Keeping your data safe should always be a priority, so before you begin using an app, research who can have access to your records and choose an app that you feel comfortable with. If you plan to share data from an app with your agronomist, custom applicator, or other professional, discuss app options with them beforehand to select one that is compatible with everybody’s phone or tablets.

Review Your Results

Once a season of scouting ends, it can be difficult to organize reports for future reference. Creating a summary report of the significant issues or pests of greatest concern of the season will help to organize the information and plan prevention and avoidance strategies for the next season. A summary report should include information that shows what worked well during the season and what did not, such as an accurate measurement of pest populations and assessment of damage levels. Many digital programs that can merge notes from multiple people into one report can also generate summary reports.

Summary reports can be either shared with your agronomy center or used in planning with your retail agronomist, who can then compare them to reports of previous crop seasons and identify trends. Having this information as well as knowledge of available strategies helps to make informed IPM decisions. This review is often done in the winter months during the planning stages for next year’s crop.

Resistance Management

Pesticide resistance is when a pest population becomes less susceptible to a pesticide that was previously effective at controlling it. This can happen when pesticides are repeatedly applied in the same area and target the same pests, especially if they have the same mode of action (MOA). This series of tables list pest management techniques that have the potential to slow the rate of pesticides developing resistance. Unlike mitigation techniques and practices in Tables 1 and 2, these techniques and practices do not always have a direct and quantifiable mitigation value. Their efficacy will depend on site-specific conditions.

Table B. Strategies to Reduce Pesticide Resistance.

Pre-Season Strategies
1. Acquisition of knowledge and skills to manage pesticide resistance by: o Attending educational meetings to obtain the latest information in development of sound pest management programs. OR o Promote communication regarding pesticide resistance, by hosting a field day or community meeting to discuss pesticide resistance issues in their community.
2. Diversify the current crop rotation to add different crop types to disrupt the host plant/pest cycle and reduce use of the same pesticide MOA season after season.
3. Add cover crops to the crop rotation or consider use of nurse crops and intercropping of crops to be competitive with weeds thereby reducing weed pressure in the cash cropland weed seed development or as host crops for beneficial insects.
4. Use grazing and/or browsing animals when applicable, to reduce weed populations.

Planting Strategies
5. Plant certified (or tested by a certified lab) weed-free crop, cover crop, or pollinator habitat seed to reduce introduction of new weed pests.
6. Use pre-emergence herbicides with soil residual activity, with different mechanisms of activity MOA on target weed species.
7. Plant crops with stacked traits to maximize the diversity of available pest management tools a crop with Bt (bacillus thuringiensis) and herbicide resistance traits.

Growing Season Strategies
8. Managing the crop according to recommendations from local extension experts or crop consultants (i.e., Certified Crop Advisors) to promote overall crop vigor, resilience, and competitiveness.
9. Scouting prior to pesticide application to correctly identify the target pest and to determine if economic thresholds or estimates of crop damage are met before applying pesticides.
10. Time pesticide applications treatment or other PAMS activity when the most susceptible life cycle stage of the target pest(s) is present to maximize the efficacy for the treatment selected.
11. Methods of monitoring include use of monitoring traps to indicate adult emergence, real time data feeds from monitoring systems, or using weather or vegetation growth models that predict conditions conducive to pest development.
12. Perform in-field follow-up after pesticide application determine and document whether the applied pesticide provided effective control of the target pests.
13. Use of cultural, mechanical or biological pest management strategies such as, tillage, mowing, flaming, roller crimping, etc.

Harvesting Strategies
14. Manage the soil seedbank by reducing weed seed inputs through use of harvest weed seed destruction equipment i.e., combine weed seed grinding.
15. Manage the field environment (including soils) to lessen the probability of weed establishment, enhance weed seed decay, and promote weed seed predation (e.g., maintaining habitat refuges, delaying postharvest tillage etc.).

Using WIN–PST

The Windows Pesticide Screening Tool (WIN-PST) should be used when addressing the additional criteria of the Code 595. WIN-PST is the NRCS-supported technical tool that assesses relative pesticide leaching, solution runoff, and adsorbed runoff risks to water quality. WIN-PST analysis is based on—

- Soil properties
- Pesticide physical properties
- Pesticide toxicity data
- Method of application – extent (broadcast, banded, or spot treatment)
- Method of application – location (surface-applied, incorporated, or foliar)
- Application rate (standard, low rate, or ultra-low rate, based on label)
- Moisture conditions (humid or dry (no irrigation))

The major components of the NRCS nonpoint source water quality pesticide risk analysis are—

- The potential for pesticide loss in—
    - Water that percolates below the root zone
    - Water that runs off the edge of the field
    - Sediment that leaves the field in runoff
- Long-term pesticide toxicity to humans in drinking water and fish in aquatic habitat

These two components are then combined to create site-specific ratings for offsite pesticide hazards in leaching, solution runoff, and sediment-adsorbed runoff. The final ratings are called WIN-PST Soil/Pesticide Interaction Hazard Ratings. The term "hazard" is used even though these ratings include both pesticide toxicity and a partial exposure analysis based on field conditions, as it reminds users that the WIN-PST only serves to guide conservation planning. It does not fully analyze risk to human drinking water and aquatic habitat and cannot provide the same level of certainty as EPA's methodology does. To apply these hazard ratings into the proper context, additional information is required.

The conservation planner is responsible for putting these hazard ratings into proper context by using professional judgment to assess the potential for pesticide movement below the root zone and beyond the field's edge to identified ground or surface water resources, as well as the potential for that pesticide contamination to impact the water resources based on watershed and water body characteristics.

WIN–PST has five distinct categories of resource concerns:

- Human Hazard Leaching. —For leaching risk to drinking water
- Fish Hazard Leaching. —For leaching risk to aquatic habitat (lateral flow to streams)
- Human Hazard Solution. —For solution runoff risk to drinking water
- Fish Hazard Solution. —For solution runoff risk to aquatic habitat
- Fish Hazard Adsorbed. —For pesticides adsorbed to sediment and accompanying runoff risk to aquatic habitat, including the benthic zone

There is no WIN–PST category for Human Hazard Adsorbed because human exposure to sediment is minimal.

The WIN–PST hazard rating levels are very low, low, intermediate, high, or extra high.

To fully evaluate the potential risk of a pesticide to a human drinking water supply or aquatic habitat beyond the mitigations already applied by following label requirements, the conservation planner must consider the impact of flow path characteristics between the field and the water body of concern (i.e., through the vadose zone to groundwater or overland flow to surface water) and the characteristics of the watershed and water body.

Examples of risks on the high end of the overall risk spectrum include:

- The flow path from the field to the water body is shorter and more direct to the water source, creating little opportunity for pesticide degradation or assimilation.
- The watershed has significant pesticide loading potential due to numerous fields being managed

in a similar fashion as the field being analyzed.

- The water body is sensitive to pesticide contamination due to limited flushing and dilution.

Examples of risks on the low end of the overall risk spectrum include:

- The flow path to the water body is longer and more arduous with lots of opportunity for pesticide degradation and assimilation.
- The watershed has only a few fields managed in a similar fashion, so there will be limited loading potential for the pesticide in question.
- The water body is not very sensitive to pesticide contamination due to lots of flushing and dilution.

Code 595 has mitigation requirements for water quality that are based on an average situation in between the high and low extremes described. Although these mitigation requirements for water quality will serve most situations, the conservation planner may use professional judgment to determine that alternative mitigation may be more appropriate for a specific site. In some cases, a suite of conservation practices may be required to provide sufficient mitigation to meet the quality criteria of the NRCS Field Office Technical Guide.

Appropriate mitigation for water quality should be chosen based on final WIN–PST hazard ratings of all applicable pesticide loss pathways to all identified water resource concerns, with a focus on the most likely pathways. This ensures that sufficient mitigation will be applied for the highest potential risks scenarios identified for a given planning area.

Conducting a WIN–PST Analysis

Step 1 – Choose all the major soil types for the field or planning area (i.e., soils that cover 10 percent or more of the area). Enter appropriate information regarding site-specific soil properties (e.g., presence of large cracks, shallow groundwater table).

Step 2 – Choose all the pesticides that the client is planning to use. Enter appropriate information regarding methods of application, rate of application, and conditions in which applied.

Note: Each pesticide can be chosen by product name, EPA registration number, or active ingredient name, but the final ratings are specific to each active ingredient.

Step 3 – Analyze the results for each soil/pesticide interaction.

Step 4 – Select the highest hazard soil/pesticide combination for the identified natural resource concerns to plan appropriate mitigation.

In the example below, there is a solution runoff concern to aquatic habitat. Pesticides X and Y are planned for a field that contains soils A, B, and C. Due to its high rating, the combination of soil C with pesticide Y would be selected to plan an appropriate level of mitigation to protect the aquatic habitat.

Soil and Pesticide Combination	WIN–PST Fish Hazard Solution rating
Soil A – Pesticide X (20% of the area)	Very low
Soil B – Pesticide X (50% of the area)	Low
Soil C – Pesticide X (25% of the area)	Intermediate
Soil A – Pesticide Y (20% of the area)	Low
Soil B – Pesticide Y (50% of the area)	Intermediate
Soil C – Pesticide Y (25% of the area)	High

Mitigation Requirements Pest Management Conservation System Practice

Code 595 address natural resource concerns related to pest management activities by creating additional margins of precaution. These practices have specific mitigation targets for identified natural resource concerns, which should be reached.

For water quality concerns related to pesticide leaching, solution runoff, and adsorbed runoff, producers should use WIN–PST to evaluate potential hazards to humans and fish as appropriate for each pesticide to be used. Human hazard is represented by the potential for chronic impacts to drinking water, and aquatic habitat hazard is represented by the potential for chronic impacts to fish. Scores reflect targets for applying additional margins of precaution. The minimum mitigation target for each resource concern is based on the final WIN–PST Soil/Pesticide Interaction Hazard ratings:

WIN–PST identified final hazard rating	Minimum mitigation index score level needed
Low or very low	None
Intermediate	20
High	40
Extra High	60

Suggested mitigation targets can be met through other conservation practices as well as IPM techniques applied with Code 595. See Table 1 at the end of this technical note for mitigation index values for IPM techniques and Table 2 for mitigation index values for conservation practices. The index values from Table 1 can be added to the index values from Table 2 to calculate the total index score for the planned conservation system.

For example, if “Fish Hazard Solution” is identified as a pathway of concern for an identified water resource and WIN–PST reports an intermediate rating, IPM techniques from Table 1 and conservation practices from Table 2 that address the concern can be applied such that the sum of the index values from either table for the selected techniques and practices is 20 or more.

As identified hazard level increases, so should the target mitigation score to guide conservation planning. For example, the target sum for a high rating is forty or more, while for an extra high rating, it is sixty or more. This will be the case for all natural resource concerns and all applicable pesticide loss pathways identified with the aid of WIN–PST. In some cases, mitigation requirements may be met without applying any IPM techniques, so Code 595 is technically not required. If the practice is planned, successful implementation and certification must meet the planning criteria as outlined in the standard.

As an alternative to mitigation, the conservation planner can also work with Cooperative Extension Service personnel, published Cooperative Extension Service recommendations, the producer, or the crop consultant to see if there are lower risk pesticide alternatives that still meet the producer's objectives. A producer may choose to use a pesticide that has risk (if appropriate mitigation is also applied) or choose a lower risk pesticide that needs less or no mitigation—pesticide choice is the producer's decision.

Pesticide spray drift has also been identified as a major pesticide loss pathway. Predicting drift is difficult because it is influenced by many rapidly changing site-specific factors, including wind speed, relative humidity, temperature, spray release height, and the presence of temperature inversions. Spray droplet size as determined by nozzle configuration and pressure also plays a significant role in drift, though it should be noted that this relationship is complex and not always intuitive.

Drift that leaves the application area may impact nearby sensitive crops, organically grown crops, and wildlife, including pollinators and beneficial insects, as well as human bystanders.

Drift can also be a major pesticide loss pathway to surface water in some cases, so appropriate mitigation for drift may be required in addition to mitigation for pesticide leaching, solution runoff, and adsorbed runoff to adequately protect a surface water resource.

If the conservation planner identifies a natural resource concern related to pesticide spray drift, the target level of mitigation is an index score of 20. The index values from Table 1 can be added to the index values from Table 2 to calculate the total index score for the planned conservation system.

Pesticide volatilization has been identified as a contributor to air quality concerns through volatile organic compound (VOC) emissions that are a key precursor to ground-level ozone. The State of California has local air shed rules and regulations in place for nonattainment areas, and other states may follow.

Pesticide-related VOC emissions are influenced by the vapor pressure of the active ingredients and the way pesticide products are formulated. Emulsifiable concentrates have higher VOC emissions than other formulations. If the conservation planner identifies a VOC-related natural resource concern and Code 595 is planned, one or more of the following VOC mitigation techniques must be applied:

- Use lower VOC-emitting pesticide formulations and eliminate the use of emulsifiable concentrates when other formulations are available
- Use precision pesticide application or smart sprayer technology, including:
    - near-infrared-based or AI-enhanced weed sensing systems (e.g., John Deere's See and Spray Technology and Farmwise precision weeding, etc.)
    - map/GPS-based variable rate application
    - sonar-based vegetation sensors
    - computer-controlled spray nozzles
    - hoods and shields to direct applications

    - wicks
    - backpacks
    - remote sensing, GIS, or other spatial information system
    - fumigant delivery with precision application
    - fumigant delivery with drip irrigation
    - fumigant soil retention using precision water application
- Use impermeable tarps to cover fumigated areas
- Shift dates of fumigant application to outside the May–October period to move VOC emissions out of the nonattainment period
- Use solarization (e.g., irrigate and tarp during summer fallow) to kill pests without fumigation
- Use biofumigants or other soil treatments (e.g., thiosulfate) instead of pesticides
- Use steam fumigation instead of pesticides
- Fallow fields (weed-free) for several years before replanting an orchard crop, or inoculate young trees (e.g., with yeast) to reduce fumigant use

Direct contact with pesticides can affect pollinators and other beneficial species in the application area while pesticides are being applied and later when pollinators and other beneficial species re-enter the treated area. Planners can use the steps detailed in Technical Note 190-AGR-9, “Preventing or Mitigating Potential Negative Impacts of Pesticides on Pollinators Using Integrated Pest Management and Other Conservation Practices,” to determine if pollinators and beneficial species are potentially being impacted by the pesticides used by the client. Planners should use the same document in collaborating with the client and pest management professional in determining the minimum amount of mitigation needed for the identified risk.

IPM Plans

What constitutes an IPM plan can range from an effective pesticide recommendation based on site history all the way to a detailed year-round plan that addresses all facets of pest prevention, pest avoidance, pest monitoring, and pest suppression for an entire farm or even on an areawide basis. Conservation planners do not develop IPM plans but must carefully coordinate the conservation plan with the IPM plan. Many LGU programs offer information to develop an IPM plan for major crops in their service area. If the IPM plan or the application of individual IPM techniques appropriately mitigates site-specific pest suppression risks to natural resources and humans, then it meets Code 595 requirements. Follow Code 595 to ensure that all required elements are included in implementation.

Conservation planners can work with existing IPM plans or work with Cooperative Extension Service producers or their crop consultants to develop new IPM plans. IPM elements and guidelines from the Cooperative Extension Service or the LGU should be used where available. A national listing is available at https://www.ipmcenters.org.

The goal is to develop an efficient IPM system that uses prevention, avoidance, monitoring, and judicious suppression when a pest population exceeds an economic threshold (for insects only) or based upon site history (i.e., for insecticides, fungicides, and herbicides). IPM helps ensure that precautions are applied where feasible and environmental risks are avoided where practicable. A good IPM system considers economics, efficacy, and environmental risk of pest management tools and tactics.

IPM plans have traditionally been developed for efficient pest control, considering economics, efficacy, and resistance management. Environmental risk reduction was initially an indirect benefit of an efficient IPM system, but with the advent of the National Road Map for Integrated Pest Management in 2004, environmental risk reduction became a core principle of IPM and is now just as important as economics and efficacy. The 2018 National Road Map for Integrated Pest Management can be viewed at https://www.ars.usda.gov/arsuserfiles/opmp/ipm%20road%20map%20final.pdf.

It may take several passes through the Code 595 planning process to achieve all the producer's goals. The first pass may result in an efficient IPM system, but there may still be risks to site-specific natural resources. If a high-risk suppression alternative is important to the overall IPM system, a second pass through the IPM planning process may reveal additional IPM techniques that can help to mitigate risks to site-specific natural resources.

It is important to note that other NRCS conservation practices, such as conservation crop rotations, cover crops, and field borders, can be used to help develop an efficient IPM system. The IPM techniques described in Table 1 can be used together with the NRCS conservation practices described in Table 2 to develop an appropriate IPM system that provides adequate mitigation for the identified resource concerns. A collaborative effort between an IPM professional and the conservation planner to coordinate the IPM system with the conservation system will provide the best overall results for the producer.

The IPM mitigation techniques in Table 1 are included in most LGU IPM programs, but NRCS conservation planners should be certain that the techniques are appropriate for the specific conditions, the cropping system, and the capacity of the producer. Consult the Cooperative Extension Service or an appropriately certified farm advisor for assistance in evaluating the appropriateness of site-specific techniques when warranted.

The NRCS pest management policy does not support NRCS conservation planners changing the way a pesticide is applied or substituting a different pesticide; such guidance must be offered by a qualified pest control professional.

Using Tables 1 and 2

Table 1 identifies IPM techniques and Table 2 identifies NRCS conservation practices that have the potential to prevent or mitigate pesticide impacts on water and air quality. Pesticide impacts on water quality are divided into four separate pesticide loss pathways: leaching, solution runoff, adsorbed runoff, and wind born losses. The pesticide wind borne loss pathway may apply to pesticide impacts on air quality, water quality, or sensitive nearby habitat (read associated footnotes for what the points in the wind born loss column apply).

Not all IPM techniques and NRCS conservation practices will be applicable to a given situation. Relative effectiveness ratings by pesticide loss pathway are indicated with index values of 5, 10, or 15. The tables also identify how the IPM techniques and NRCS conservation practice's function and the performance criteria on which the index values are based. Effectiveness of any IPM technique or NRCS conservation practice can be highly variable based on-site conditions and how the technique or conservation practice is designed, implemented, and maintained. The professional judgment of the conservation planner is essential to fully estimate the effectiveness of a particular IPM technique or NRCS conservation practice for a particular field or planning area.

Tables 1 and 2 are based on available research specific to that IPM technique or NRCS conservation practice, related research, and the best professional judgment of NRCS technical specialists. The ratings are relative index values as opposed to absolute values, much like the Conservation Practice Physical Effects (CPPE) matrix ratings. The index values are intended to help conservation planners choose the best combination of IPM techniques and NRCS conservation practices for identified resource concerns. Notice that Table 1 entries for Pesticide Application Reduction have similar techniques listed. It is up to the pest management professional to determine the effectiveness of the implemented technique to achieve the listed reduction for each field being evaluated and mitigated.

The ratings are based on the relative potential for IPM techniques or NRCS conservation practices to provide mitigation. The IPM techniques or NRCS conservation practices need to be specifically designed, implemented, and maintained for the mitigation potential to be realized. Varying site conditions can influence mitigation effectiveness, but the relative index values indicate which IPM mitigation techniques or NRCS conservation practices will provide mitigation under a given set of conditions.

A general rule of thumb for IPM techniques or NRCS conservation practices having an index value of 5 is that they have the potential to reduce losses by 10 to 5 percent. IPM techniques or NRCS conservation practices with an index value of 10 have the potential to reduce losses by about 25 percent, and IPM techniques or NRCS conservation practices having an index value 15 have the potential to reduce losses by 50 percent or more.

States may request adjustments to values in Tables 1 and 2, but any adjustments should be discussed with NRCS regional agronomists to ensure consistent understanding across states.

For questions about the information in this publication, contact the NRCS state agronomist, NRCS regional agronomist, or NRCS national pest management specialist.

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Table 1 Suppression IPM Techniques for Reducing Pesticide Environmental Risk by Mitigation Index Value (by pesticide loss pathway).

IPM techniques [1]	Leaching	Solution runoff	Adsorbed runoff	Wind Born Loss-Drift	Function and performance criteria
Pesticide Application Reduction—**Significant Reduction**	15	15	15		Assumes a **50% reduction or more** in the amount of active ingredient of an otherwise full rate application is applied to the field in question. Reduction of pesticide application can be achieved through many possible ways including but not limited to: • Partial or spot treatment, banding, electrostatic spraying, directed spraying, or using precision sprayer technology (i.e., green sensors, sonar-based sensors, GPS-based variable rate application, computer-controlled spray nozzles, etc.). Implementation of other techniques not listed here but demonstrating a reduction of pesticide application of at least 50%.
Pesticide Application Reduction—**Moderate Reduction**	10	10	10		Assumes **at least a 25% reduction** in the amount of active ingredient of an otherwise full rate application is applied to the field in question. Reduction of pesticide application can be achieved through many possible ways including but not limited to: • Application timing (rain): Reduces exposure—delaying application when significant rainfall events are forecast that could produce substantial leaching or runoff can reduce pesticide transport to ground and surface water. • Partial or spot treatment, banding, electrostatic spraying, directed spraying, or using precision sprayer technology (i.e., green sensors, sonar-based sensors, GPS-based variable rate application, computer-controlled spray nozzles, etc.). Implementation of other techniques not listed here but demonstrating a reduction of pesticide application of at least 25%.
Pesticide Application Reduction—**Slight Reduction**	5	5	5		Assumes **at least a 10% reduction** in the amount of active ingredient of an otherwise full rate application is applied to the field in question. Reduction of pesticide application can be achieved through many possible ways including but not limited to: • Electrostatic spraying, directed spraying, or using precision sprayer technology (i.e., green sensors, sonar-based sensors, GPS-based variable rate application, computer-controlled spray nozzles, etc.). Implementation of other techniques not listed here but demonstrating a reduction of pesticide application of at least 10%.
Pesticide Drift Reduction—**Significant Reduction**				15	Assumes a **50% reduction or more** in the amount of expected drift losses at the edge of the field from the adoption of technologies listed below. Reduction of drift can be achieved through many possible ways including but not limited to: • Application parameter (wind direction): Spray when wind is blowing away from a sensitive area. • Setbacks – Drift – 100 feet (ground rig or manual application): Assumes that the setbacks with no application are at least one hundred feet wide or label specified width, whichever is greater.

IPM techniques [1]	Leaching	Solution runoff	Adsorbed runoff	Wind Born Loss-Drift	Function and performance criteria
					• Implementation of other techniques not listed here but demonstrating a reduction in drift of at least 50%. Some of those techniques could be shielded booms, canopy-targeted nozzles, electrostatic sprayers, alternative nozzles and pressures, using precision sprayer technology (i.e., green sensors, sonar-based sensors, GPS-based variable rate application, computer-controlled spray nozzles, etc.), etc.
Pesticide Drift Reduction—**Moderate Reduction**				10	Assumes **at least a 25% reduction** in the amount of expected drift losses at the edge of the field from the adoption of technologies listed below. Reduction of drift can be achieved through many possible ways including but not limited to: • Application parameter (lower nozzle height): Reducing nozzle height can reduce pesticide drift. Nozzle height must be reduced by at least 20cm and be no higher than 50 cm. This may be most important to implement around the edges of the field that are most prone to drift losses impacting offsite resources. • Application timing (wind speed): Delaying application when wind speed is not optimal can reduce pesticide drift. Optimal spray conditions for reducing drift occur when the air is slightly unstable with a very mild, steady wind between 2 and 9 miles per hour or label specific range. The lower the speed in this range, the lesser the drift losses. • Setbacks – Drift – 30 feet (ground rig or manual application): Assumes that the setbacks with no application are at least thirty feet wide or label specified width, whichever is greater. • Setbacks – Drift – 100 feet (aerial application): Assumes that the setbacks with no application are at least one hundred feet wide or label specified width, whichever is greater. • Sprayer nozzle selection, maintenance and operation including calibration for herbicides: Selecting appropriate nozzle and pressure for herbicide application, with an emphasis on higher volume spray nozzles run at lower pressures, will produce larger droplets and a narrower droplet size distribution, which reduces spray drift. • Implementation of other techniques not listed here but demonstrating a reduction in drift of at least 25%. Some of those techniques could be shielded booms, canopy-targeted nozzles, electrostatic sprayers, alternative nozzles and pressures, using precision sprayer technology (i.e., green sensors, sonar-based sensors, GPS-based variable rate application, computer-controlled spray nozzles, etc.), etc.
Pesticide Drift Reduction—**Slight Reduction**				5	Assumes **at least a 10% reduction** in the amount of expected drift losses at the edge of the field from the adoption of technologies listed below. Reduction of drift can be achieved through many possible ways including but not limited to: • Application parameter (sprayer speed): Reducing traveling speed by half can significantly reduce pesticide drift. This may be most important to implement around the edges of the field that are most prone to drift losses impacting offsite resources.

IPM techniques [1]	Leaching	Solution runoff	Adsorbed runoff	Wind Born Loss-Drift	Function and performance criteria
					• Application timing (ambient temperature): spraying during cooler temperatures (e.g., early morning, late evening or at night) can help reduce drift losses. Avoid spraying in temperatures above 90 °F or label-specific temperatures. • Application timing (relative humidity): spraying when there is higher relative humidity reduces evaporation of water from spray droplets thus reducing drift losses. • Drift retardant adjuvants can reduce pesticide spray drift.[2,3] • Setbacks – Drift – 30 feet (aerial application): Assumes that the setbacks with no application are at least thirty feet wide or label specified width, whichever is greater. • Implementation of other techniques not listed here but demonstrating a reduction in drift of at least 10%. Some of those techniques could be canopy-targeted nozzles, electrostatic sprayers, alternative nozzles and pressures, using precision sprayer technology (i.e., green sensors, sonar-based sensors, GPS-based variable rate application, computer-controlled spray nozzles, etc.), etc.
Setbacks – Water Quality		5	5		Reduces exposure—reduces overall amount of pesticide applied; reduces pesticide lost from edge of field. Assumes that the setbacks with no application are at least thirty feet wide or label specified width, whichever is greater.
Soil incorporation [2, 3]		15	15		Reduces exposure—reduces solution and adsorbed runoff losses, but potentially increases leaching losses, especially for low K_{OC} pesticides. Only applicable to pesticides (typically, but not exclusively herbicides) that are labeled for this type of shallow mechanical incorporation or incorporation with water. This technique should not be used if pesticide leaching to groundwater is an identified natural resource concern and the pesticide and soil conditions are conducive to leaching or if soil erosion is not adequately managed.
Pesticide Application Reduction—**Significant Reduction**	15	15	15		Assumes a **50% reduction or more** in the amount of active ingredient of an otherwise full rate application is applied to the field in question. Reduction of pesticide application can be achieved through many possible ways including but not limited to: • Partial or spot treatment, banding, electrostatic spraying, directed spraying, or using precision sprayer technology (i.e., green sensors, sonar-based sensors, GPS-based variable rate application, computer-controlled spray nozzles, etc.). Implementation of other techniques not listed here but demonstrating a reduction of pesticide application of at least 50%.
Pesticide Application Reduction—**Moderate Reduction**	10	10	10		Assumes **at least a 25% reduction** in the amount of active ingredient of an otherwise full rate application is applied to the field in question. Reduction of pesticide application can be achieved through many possible ways including but not limited to: • Application timing (rain): Reduces exposure—delaying application when significant rainfall events are forecast that could produce substantial leaching or

IPM techniques [1]	Leaching	Solution runoff	Adsorbed runoff	Wind Born Loss-Drift	Function and performance criteria
					runoff can reduce pesticide transport to ground and surface water. • Partial or spot treatment, banding, electrostatic spraying, directed spraying, or using precision sprayer technology (i.e., green sensors, sonar-based sensors, GPS-based variable rate application, computer-controlled spray nozzles, etc.). Implementation of other techniques not listed here but demonstrating a reduction of pesticide application of at least 25%.
Pesticide Application Reduction—**Slight Reduction**	5	5	5		Assumes **at least a 10% reduction** in the amount of active ingredient of an otherwise full rate application is applied to the field in question. Reduction of pesticide application can be achieved through many possible ways including but not limited to: • Electrostatic spraying, directed spraying, or using precision sprayer technology (i.e., green sensors, sonar-based sensors, GPS-based variable rate application, computer-controlled spray nozzles, etc.). Implementation of other techniques not listed here but demonstrating a reduction of pesticide application of at least 10%.
Pesticide Drift Reduction—**Significant Reduction**				15	Assumes a **50% reduction or more** in the amount of expected drift losses at the edge of the field from the adoption of technologies listed below. Reduction of drift can be achieved through many possible ways including but not limited to: • Application parameter (wind direction): Spray when wind is blowing away from a sensitive area. • Setbacks – Drift – 100 feet (ground rig or manual application): Assumes that the setbacks with no application are at least one hundred feet wide or label specified width, whichever is greater. • Implementation of other techniques not listed here but demonstrating a reduction in drift of at least 50%. Some of those techniques could be shielded booms, canopy-targeted nozzles, electrostatic sprayers, alternative nozzles and pressures, using precision sprayer technology (i.e., green sensors, GPS-based variable rate application, computer-controlled spray nozzles, etc.), etc.
Pesticide Drift Reduction—**Moderate Reduction**				10	Assumes **at least a 25% reduction** in the amount of expected drift losses at the edge of the field from the adoption of technologies listed below. Reduction of drift can be achieved through many possible ways including but not limited to: • Application parameter (lower nozzle height): Reducing nozzle height can reduce pesticide drift. Nozzle height must be reduced by at least 20cm and be no higher than 50 cm. This may be most important to implement around the edges of the field that are most prone to drift losses impacting offsite resources. • Application timing (wind speed): Delaying application when wind speed is not optimal can reduce pesticide drift. Optimal spray conditions for reducing drift occur when the air is slightly unstable with a very mild, steady wind between 2 and 9 miles per hour or label specific range. The lower the speed in this range, the lesser the drift losses. • Setbacks – Drift – 30 feet (ground rig or manual application): Assumes that the setbacks with no application are at least thirty feet wide or label specified width, whichever is greater.

IPM techniques [1]	Leaching	Solution runoff	Adsorbed runoff	Wind Born Loss-Drift	Function and performance criteria
					• Setbacks – Drift – 100 feet (aerial application): Assumes that the setbacks with no application are at least one hundred feet wide or label specified width, whichever is greater. • Sprayer nozzle selection, maintenance and operation including calibration for herbicides: Selecting appropriate nozzle and pressure for herbicide application, with an emphasis on higher volume spray nozzles run at lower pressures, will produce larger droplets and a narrower droplet size distribution, which reduces spray drift. • Implementation of other techniques not listed here but demonstrating a reduction in drift of at least 25%. Some of those techniques could be shielded booms, canopy-targeted nozzles, electrostatic sprayers, alternative nozzles and pressures, using precision sprayer technology (i.e., green sensors, sonar-based sensors, GPS-based variable rate application, computer-controlled spray nozzles, etc.), etc.
Pesticide Drift Reduction—**Slight Reduction**				5	Assumes **at least a 10% reduction** in the amount of expected drift losses at the edge of the field from the adoption of technologies listed below. Reduction of drift can be achieved through many possible ways including but not limited to: • Application parameter (sprayer speed): Reducing traveling speed by half can significantly reduce pesticide drift. This may be most important to implement around the edges of the field that are most prone to drift losses impacting offsite resources. • Application timing (ambient temperature): spraying during cooler temperatures (e.g., early morning, late evening or at night) can help reduce drift losses. Avoid spraying in temperatures above 90 °F or label-specific temperatures. • Application timing (relative humidity): spraying when there is higher relative humidity reduces evaporation of water from spray droplets thus reducing drift losses. • Drift retardant adjuvants can reduce pesticide spray drift.[2,3] • Setbacks – Drift – 30 feet (aerial application): Assumes that the setbacks with no application are at least thirty feet wide or label specified width, whichever is greater. • Implementation of other techniques not listed here but demonstrating a reduction in drift of at least 10%. Some of those techniques could be canopy-targeted nozzles, electrostatic sprayers, alternative nozzles and pressures, using precision sprayer technology (i.e., green sensors, sonar-based sensors, GPS-based variable rate application, computer-controlled spray nozzles, etc.), etc.
Setbacks – Water Quality		5	5		Reduces exposure—reduces overall amount of pesticide applied; reduces pesticide lost from edge of field. Assumes that the setbacks with no application are at least thirty feet wide or label specified width, whichever is greater.

IPM techniques [1]	Leaching	Solution runoff	Adsorbed runoff	Wind Born Loss-Drift	Function and performance criteria
Soil incorporation [2, 3]		15	15		Reduces exposure—reduces solution and adsorbed runoff losses, but potentially increases leaching losses, especially for low K_{OC} pesticides. Only applicable to pesticides (typically, but not exclusively herbicides) that are labeled for this type of shallow mechanical incorporation or incorporation with water. This technique should not be used if pesticide leaching to groundwater is an identified natural resource concern and the pesticide and soil conditions are conducive to leaching or if soil erosion is not adequately managed.

1 Additional information on pest management mitigation techniques can be obtained from Extension pest management publications including IPM Guidelines and Crop Profiles, pest management consultants, and pesticide labels.

2 The pesticide label is the law—all pesticide label specifications must be carefully followed, including required mitigation. Additional mitigation may be needed to meet NRCS pest management requirements for identified resource concerns.

3 NRCS does not make pesticide recommendations. All pesticide application techniques selected by the producer must be recommended by Extension or an appropriately certified professional.

Table 2 Conservation Practices for Reducing Pesticide Environmental Risk by Mitigation Index Value (by pesticide loss pathway).

Pesticide mitigation conservation practices [1, 2]	**Leaching**	**Solution runoff**	**Adsorbed runoff**	**Wind-borne loss[3] -Drift and/or adsorbed**	**Function and performance criteria**
Alley Cropping (Code 311)	10	5	10	15	• Mature tree/vine root system reduces leachable pesticide losses under a significant portion of the cropped alley, depending on tree/vine row spacing and maturity. • Mature tree/vine rows can significantly reduce wind speed in the cropped alleys receiving pesticide applications thus reducing pesticide drift losses. • Must meet the "Additional Criteria to Improve Air Quality".
Anionic Polyacrylamide (PAM) Application (Code 450)		5	15		• Maintains infiltration rates; reduces surface runoff and soil erosion and flocculates clay particles allowing sedimentation within the field.
Conservation Cover (Code 327)[4]	10	10	10		• Increases infiltration; reduces soil erosion; and builds soil organic matter in the alleys of perennial cropping systems such as orchards, vineyards, berries, and nursery stock.
Constructed Wetland (Code 656)		5	10		• Captures pesticide residues and facilitates their degradation. • This practice should not be installed if organisms sensitive to the pesticides trapped will be present in the constructed wetland. • Must meet the "Additional Criteria for Constructed Wetlands for Water Quality Improvement".
Contour Buffer Strips (Code 332)[4]	5	5	10		• Increases infiltration; reduces soil erosion; intercepts pesticides mid-slope in the vegetated strips. • Because the location of a mid-slope buffer strip alone leaves the bottom portion of the field unmitigated, this CPS must be installed to meet the "Additional Criteria to Reduce Water Quality Degradation from the Transport of Nutrients Downslope" which requires a buffer strip at the bottom of the field that's at least two times the width of the narrowest buffer strip in the system.
Contour Farming (Code 330)		5	5		• Increases infiltration and deep percolation; reduces soil erosion.
Contour Orchard and Other Perennial Crops (Code 331)		5	5		• Increases infiltration and deep percolation; reduces soil erosion.
Cover Crop (Code 340) terminated with biomass that is incorporated into the soil	5	5	5		• Increases infiltration; reduces soil erosion; builds soil organic matter. • Assumes at least 3,000 pounds per acre (dry-weight basis) of live biomass at the time of termination and incorporation. • Effect is from the implementation of this practice prior to the crop receiving

Pesticide mitigation conservation practices [1, 2]	Leaching	Solution runoff	Adsorbed runoff	Wind-borne loss[3] -Drift and/or adsorbed	Function and performance criteria
					pesticide applications.
Cover Crop (Code 340) terminated with all above-ground biomass left on the surface for the subsequent crop	5	10	10		• Increases infiltration; reduces soil erosion; builds soil organic matter. • Requires at least 3,000 pounds per acre (dry-weight basis) of live biomass at the time of termination and at least 30 percent ground cover at the time of the pesticide application(s). • Effect is from the implementation of this practice prior to the crop receiving pesticide applications.
Cross Wind Ridges (Code 588)				5[5]	• Reduces wind erosion and adsorbed pesticide deposition in surface water. • Assumes the pesticide is applied while the field is in the ridged state.
Cross Wind Trap Strips (Code 589C)				10[5]	• Reduces wind erosion and adsorbed pesticide deposition in surface water; traps adsorbed pesticides. • Assumes the pesticide is applied when the practice is established in the field. • Must meet the “Additional Criteria to Reduce Wind Erosion and Particulate Matter Emissions”.
Deep Tillage (Code 324)		5	5		• Increases infiltration and deep percolation in soils with restrictive horizons thus, reducing runoff volumes. • Not appropriate if pesticide leaching to groundwater is an identified natural resource concern. • Must meet the “Additional Criteria to Reduce Soil Compaction by Fracturing Restrictive Soil Layers”.
Dike and Levee (Code 356)	5	10	10		• Reduces exposure potential by excluding outside water. • Only applicable to excluding water from entering the field.
Diversion (Code 362)	5	10	10		• Reduces exposure potential by excluding outside water. • Only applicable to excluding water from entering the field.
Drainage Water Management (Code 554)	5	5	5		• Drainage during the growing season increases infiltration and aerobic pesticide degradation in the root zone and reduces storm water runoff. • Manage drainage when the field is not being cropped to reduce discharge of pesticide residues from the previous growing season. • Must meet the “Additional Criteria to Reduce Nutrient, Pathogen, and Pesticide Loading”.
Field Border (Code 386) drift protection[4]				10	• Reduces pesticide wind-borne losses. • Must meet the “Additional Criteria to Reduce Erosion from Wind and Water and Reduce Excessive Sediment to Surface Waters” and the “Additional Criteria to Reduce Emissions of Particulate Matter”. • Must be installed to protect all identified sensitive areas adjacent to the field.

Pesticide mitigation conservation practices [1, 2]	**Leaching**	**Solution runoff**	**Adsorbed runoff**	**Wind-borne loss**[3] **-Drift and/or adsorbed**	**Function and performance criteria**
Field Border (Code 386) downslope edge[4]		5	10	5	• Increases infiltration and traps adsorbed pesticides; can reduce pesticide drift to surface water. • Must meet the “Additional Criteria to Reduce Sedimentation Offsite and Protect Water Quality and Excess Nutrients in Surface and Ground Waters” which requires a 30-foot minimum width. • Must be installed in the lower portion(s) of the field where water exits the field.
Filter Strip (Code 393)[4]		10	15	5	• Increases infiltration and traps adsorbed pesticides; often reduces application area resulting in less pesticide applied; also, can reduce pesticide drift to surface water. • Must meet the “Additional Criteria to Reduce Dissolved Contaminants, Suspended Solids and Associated Contaminants in Runoff and Excessive Sediment in Surface Waters” which requires a minimum flow length of 20 feet for suspended solids and associated contaminants and 30 feet for dissolved contaminants. • Requires the maintenance of uniform flow into the filter strip (i.e. no concentrated flows). • Pastures with cover meeting the vegetative criteria of CPS 393, not sprayed to the edge (30 ft) of the fields with uniform flow.
Grassed Waterway (Code 412)		5	5		• Can trap some pesticide movement either through infiltration (soluble pesticides in a waterway) or by trapping adsorbed pesticides in the sediment (higher K_{OC} pesticides deposited in the waterway) of smaller storm events. • Note that pesticides with long half-lives may still end up in the surface water if larger events flush out the waterway.
Hedgerow Planting (Code 442)				10[6]	• Reduces adsorbed pesticide deposition in surface water; also, can reduce pesticide drift to surface water. • Must meet the “Additional Criteria for Reducing Particulate Matter Movement” and the “Additional Criteria to Reduce Odor Movement and/or Chemical Drift”.
Herbaceous Wind Barriers (Code 603)[4]				10[6]	• Reduces wind erosion; traps adsorbed pesticides and can reduce pesticide drift to surface water.
Irrigation and Drainage Tailwater Recovery (Code 447)		15	15		• Captures pesticide residues and facilitates their degradation. • Must meet the “Additional Criteria Applicable to Improving Offsite Water Quality”.
Irrigation Water Management – Primary crop water source (Code 449)	15	15	15		• Applicable to field that receive ≥50% of crop water requirement from the irrigation system. • Reduces exposure potential—water is applied at rates that minimize pesticide transport to ground and surface water. • Must meet the “Additional Criteria for the Protection of Surface and Ground

Pesticide mitigation conservation practices [1, 2]	Leaching	Solution runoff	Adsorbed runoff	Wind-borne loss[3] -Drift and/or adsorbed	Function and performance criteria
					Water Quality”.
Irrigation Water Management – Supplemental crop water source (Code 449)	5	5	5		• Applicable to field that receive <50% of crop water requirement from the irrigation system. • Reduces exposure potential—water is applied at rates that minimize pesticide transport to ground and surface water. • Must meet “Additional Criteria for the Protection of Surface and Ground Water Quality”.
Mulching (Code 484) with natural materials		10	10		• Replacing plastic mulch with natural material mulches such as straw, wood products, erosion blankets made from coir or coconut material, etc. • Increases infiltration, reduces soil erosion and associated pesticide losses, promotes microbial degradation of pesticide residues and metabolites.
Residue and Tillage Management, No-Till (Code 329)	5	10	15		• Increases infiltration, reduces soil erosion, builds soil organic matter. • Assumes at least 60 percent ground cover at the time of application. • Must meet the “Additional Criteria to Reduce Sheet, Rill and Wind Erosion and Reduce Excessive Sediment in Surface Waters”.
Residue and Tillage Management, Reduced Till (Code 345)	10	5	10		• Increases infiltration, reduces soil erosion, builds soil organic matter. • Assumes at least 30 percent ground cover at the time of application. • Must meet the “Additional Criteria to Reduce Sheet, Rill and Wind Erosion and Reduce Excessive Sediment in Surface Waters”.
Riparian Forest Buffer (Code 391)		5	10	10	• Increases infiltration and uptake of subsurface water, traps sediment, builds soil organic matter, and reduces pesticide drift. • Must meet the “Additional Criteria to Reduce Transport of Sediment to Surface Water, and Reduce Transport of Pathogens, Chemicals, Pesticides, and Nutrients to Surface and Ground Water”. • This assumes a 50-foot minimum width or 35-foot width with a companion Filter Strip (CPS 393) or Field Border (CPS 386).
Sediment Basin (Code 350)			5		• Captures pesticide residues and facilitates their degradation. • Not applicable if less than 50 percent of the treatment area drains into the sediment basin. The sediment removed from these basins should be returned to the field(s) of origin and should not be dumped in or adjacent to sensitive areas.
Stripcropping (Code 585)	5	5	5		• Increases infiltration; reduces soil erosion and will only be treating half the area of concern. • Must meet the “Additional Criteria to Reduce Pesticide Transport to Surface Waters”.

Pesticide mitigation conservation practices [1, 2]	Leaching	Solution runoff	Adsorbed runoff	Wind-borne loss[3] -Drift and/or adsorbed	Function and performance criteria
Subsurface Drainage (Code 606)	5	5	5		• Increases infiltration and aerobic pesticide degradation in the root zone. • Consider potential impacts of pesticide residues in the drainage outflow on the receiving water body. • Not applicable if less than 50 percent of the field is drained.
Terrace (Code 600)		5	10		• Increases infiltration and deep percolation; reduces soil erosion. Drop inlets may require additional setbacks or mitigation.
Vegetative Barriers (Code 601)[4]		5	10	5	• Reduces soil erosion; traps sediment; increases infiltration. • This practice is most effective in smaller fields with closely spaced barriers as found in Pacific Basin and Caribbean Basin areas. When this practice is installed on larger fields with greater spacing, it can be overwhelmed by higher flows and lose their effectiveness. • Values are not applicable to Vegetative Barriers placed in concentrated flow areas. In those cases, this CPS may have little to minimal effect.
Water and Sediment Control Basin (Code 638)			10		• Captures pesticide-laden sediment; may increase infiltration in the basin. • Not applicable if less than 50 percent of the treatment area drains into the basin. • The sediment removed from these basins should be returned to the field(s) of origin and should not be dumped in or adjacent to sensitive areas.
Windbreak/Shelterbelt Establishment and Renovation (Code 380)				15[6]	• Reduces wind erosion; reduces wind-borne adsorbed pesticide deposition in surface water; reduces pesticide drift. • Must meet the "Additional Criteria to Improve Air Quality by Reducing and Intercepting Airborne Particulate Matter, Chemicals, and Odors".

1 Additional information on pest management mitigation techniques can be obtained from Extension pest management publications including IPM Guidelines and Crop Profiles, pest management consultants, and pesticide labels.

2 The pesticide label is the law. All pesticide label specifications must be carefully followed, including required mitigation. Additional mitigation may be needed to meet NRCS pest management requirements for identified resource concerns.

3 The wind-borne loss column primarily addresses drift losses. Entries in this column may also address adsorbed pesticide losses carried by wind to surface water, indicated by a superscript five (5) following the index value. In situations where both drift and adsorbed pesticides losses by wind can be mitigated, the index value will be followed by superscript six (6).

4 All conservation practices with vegetation components will be installed using certified seed mixes to prevent introduction of weeds and invasive species.

5 Mitigation applies to adsorbed pesticide losses being carried to surface water by wind.

6 Mitigation applies to drift and to adsorbed pesticide losses being carried to surface water by wind.