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Pest Management in the Conservation Planning Process

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Pest Management in the Conservation Planning Process

Introduction

This technical note is designed to help conservation planners apply the Natural Resources Conservation Service (NRCS) Integrated Pest Management (IPM) Conservation Practice Standard (CPS) Code 595 and other NRCS conservation practices in the conservation planning process to prevent and/or mitigate pest management risks to natural resources.

The term "integrated pest management" and its acronym "IPM" are widely used and can refer to anything from an individual pest management technique to a complex year-round pest management system. This document references IPM techniques, elements, strategies, guidelines, systems, and programs, but the NRCS IPM conservation practice is very specifically defined by CPS Code 595 available at: ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/595.docx.

NRCS pest management policy

The NRCS pest management policy is contained in GM_190_404_A–D, Amendment 12, dated March 2009, available at: http://directives.sc.egov.usda.gov/RollupViewer.aspx?hid=17015.

The NRCS pest management policy states that conservation planners have four roles in pest management:

1. Evaluate environmental risks associated with a client's probable pest suppression strategies
2. Provide technical assistance to clients to mitigate identified environmental risks
3. Assist clients to adopt IPM techniques that protect natural resources
4. Assist clients to—
   - inventory, assess, and suppress noxious and invasive weeds on noncropland
   - suppress weeds to ensure successful implementation and/or maintenance of permanent vegetative conservation practices (e.g., buffer-type conservation practices)

Pest management in conservation planning

Conservation planners start by identifying site-specific natural resource concerns in the conservation planning process. For pest management related concerns, this can include the potential for pest management activities to impact soil, water, air, plants, animals, and humans. Once site-specific natural resource concerns are identified, conservation planners perform NRCS pest management policy roles 1, 2, and 3 in the conservation planning process by evaluating the potential for site-specific pest management risks to identified natural resources and applying appropriate NRCS conservation practices (including the NRCS IPM conservation practice) to prevent and/or mitigate identified risks.

For example, if a conservation planner identified a concern about potential pesticide impacts on a nearby drinking water reservoir, he or she would use the NRCS Windows Pesticide Screening Tool (WIN–PST) to evaluate potential pesticide risks to drinking water from pesticide losses in surface runoff. Based on site-specific WIN–PST results, the NRCS IPM conservation practice and other conservation practices could then be applied as appropriate to prevent/mitigate hazardous pesticide losses to the reservoir.

Pest management risks can 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 also perform role 4 in the NRCS pest management policy in the conservation planning process, but with the application of the NRCS Brush Management, CPS Code 314 and NRCS Herbaceous Weed Control, CPS Code 315. Both of these conservation practices are used on noncropland to address natural resource concerns related to plant pests, including invasive, noxious, and prohibited plants. The NRCS IPM conservation practice can also be used to prevent and/or mitigate pest management environmen-

tal risks associated with the application of the NRCS Brush Management and Herbaceous Weed Control conservation practices.

Applying the NRCS IPM conservation practice

The NRCS IPM conservation practice is specifically designed to document the application of IPM techniques that address site-specific natural resource concerns. The NRCS IPM conservation practice is not designed to manage pests. Technical assistance for managing pests on cropland is **not** an identified role for conservation planners, but they must still work closely with the Cooperative Extension Service, producers, and their crop consultants to appropriately integrate all planned pest management activities into the conservation planning process. The adoption of a comprehensive IPM system is always preferred, but the NRCS IPM conservation practice 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 identify what constitutes a comprehensive IPM system. These guidelines should be used to help document the application of the NRCS IPM conservation practice. Comprehensive IPM systems use a site-specific combination of pest prevention, avoidance, monitoring, and suppression (PAMS) strategies. For more information, see:

- http://www.ipmcenters.org/ipmelements/index.cfm
- http://www.ipm.ucdavis.edu/PMG/crops-agriculture.html
- http://www.ipmcenters.org/ipmsymposiumv/posters/142.pdf

While efficacy will always play an important role in what IPM techniques are appropriate for each site, the NRCS IPM conservation practice is only used to document specific environmental risk prevention and/or mitigation benefits, not efficacy. The goal of the NRCS IPM conservation practice is to prevent environmental risks with an efficient IPM system, if possible, and mitigate any environmental risks that cannot be prevented.

A comprehensive IPM system will prevent and avoid pests as much as possible to reduce the need for pest suppression, including the use of hazardous pesticides.

A comprehensive IPM system also includes carefully monitoring pest populations and only using suppression techniques when the economic benefit is greater than the cost. These economic pest thresholds must be developed by the Cooperative Extension Service and other IPM experts for each pest in each cropping system 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.

A comprehensive IPM system also includes carefully managing the use of different pest suppression 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 and delaying the onset of pest resistance.

Finally, a comprehensive IPM system must also mitigate environmental risks that cannot be prevented by using appropriate IPM techniques that help minimize risks to nontarget species in the field and reduce offsite movement of hazardous pesticides.

In some cropping systems, a comprehensive IPM system will not be feasible because appropriate IPM technology has yet to be developed. In these cases, the NRCS IPM conservation practice can be used to support the application of individual IPM techniques if they appropriately mitigate site-specific pest suppression risks to natural resources and/or humans.

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

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 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 (licensed) by the EPA before they may be sold or distributed in commerce. The EPA will 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 "unreason-

able adverse effects on the environment" as: "…any unreasonable risk to man or the environment, taking into account the economic, social and environmental costs and benefits of the use of any pesticide…"

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

With the passage of FQPA, both major pesticide statutes were amended. 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, including any pesticide label use restrictions, is based on a comprehensive pesticide risk assessment for typical conditions under which the pesticide will be used. This risk assessment is designed to address many different risks to many different species that might be impacted by a particular pesticide use, but it does not address how these risks can vary substantially across the landscape. Even when a pesticide is applied according to pesticide label instructions, site-specific conditions may cause that pesticide to pose significant risks to nearby water resources.

The EPA generally only registers pesticides that will have substantially more benefits than risks, and they include appropriate risk mitigation in pesticide label guidance. However, there are obvious limitations on how well a pesticide label can address site-specific concerns that often vary widely across the landscape.

One of the most carefully regulated pesticide concerns is preventing drinking water contamination; yet, many public drinking water suppliers must still filter pesticide residues out of our drinking water to meet EPA guidelines. Pesticide impacts on aquatic life are much more widespread than drinking water concerns. The U.S. Geological Survey (USGS) National Water Quality Assessment Program (http://water.usgs.gov/nawqa/) found at least one pesticide in almost every water and fish sample collected from streams and in more than 50 percent of shallow wells. Most importantly, more than 50 percent of the streams in the United States had a least one detection of a pesticide that exceeded a guideline for the protection of aquatic life. Also, toxicity tests have not been conducted on the "pesticide soup" found in most samples: a mixture of many pesticides at low concentrations throughout the year supplemented with higher pesticide concentration pulses soon after pesticide application.

Mitigating pesticide risks to natural resources is part of the NRCS's mission, so conservation planners need to coordinate their work with the way risks are mitigated with pesticide registration label requirements. NRCS technical assistance and financial assistance programs must comply with FIFRA and all pesticide label requirements including mitigation, but conservation planners can still help producers properly interpret the mitigation requirements on pesticide labels for a particular site and also recommend supplemental mitigation to protect sensitive natural resources.

Conservation planners can use the WIN–PST for water quality pesticide risk analysis. The risk analysis done with WIN–PST for drinking water and aquatic habitat is not as comprehensive as the risk assessment that supports the EPA's pesticide registration process, but WIN–PST is sufficient to guide site-specific application of mitigation techniques to address natural resource concerns identified in the conservation planning process. Conservation planners use WIN–PST to identify soil/pesticide combinations that need mitigation to help protect site-specific natural resources.

Using WIN–PST

WIN–PST is the NRCS-supported technical tool that is used to assess 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
- broadcast/banded/spot treatment
- surface-applied/incorporated/foliar
- standard/low rate/ultra low rate
- humid/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
- chronic (long-term) pesticide toxicity to humans in drinking water and fish in aquatic habitat

- the combination of pesticide loss potential with pesticide toxicity to humans and fish to provide 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. It is the responsibility of the conservation planner to put these hazard ratings into proper context by using their professional judgment to assess the potential for pesticide movement below the bottom of the root zone and beyond the edge of the field to identified ground or surface water resources, as well as the potential for that pesticide contamination to impact identified water resources based on watershed and water body characteristics. This entire process is considered a risk analysis, so the term "hazard" is used in the final WIN–PST ratings to remind users that they must put these partial ratings into the proper context to fully analyze risk to human drinking water and aquatic habitat.

WIN–PST provides ratings for five different 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 adsorbed runoff risk to aquatic habitat including benthic organisms

  Note: there is no WIN–PST rating for Human Hazard Adsorbed since human exposure to sediment is minimal.

The final WIN–PST Soil/Pesticide Interaction Hazard ratings are very low, low, intermediate, high, or extra high.

To fully evaluate the risk of a pesticide to a human drinking water supply or aquatic habitat, the conservation planner must consider the impact of flow path characteristics between the field and the water body of concern (through the vadose zone to groundwater or overland flow to surface water), watershed characteristics, and water body characteristics.

For example, on the high end of the overall risk spectrum, the flow path from the field to the water body will be shorter and more direct with little opportunity for pesticide degradation or assimilation, the watershed will have significant pesticide loading potential from numerous fields that are managed in a similar fashion as the field being analyzed, and the water body will be sensitive to pesticide contamination due to limited flushing and dilution. At the other extreme on the low end of the overall risk spectrum, the flow path to the water body will be longer and more arduous with lots of opportunity for pesticide degradation and assimilation, the watershed will have only a few fields that are managed in a similar fashion so there will be limited loading potential for the pesticide in question, and the water body will not be very sensitive to pesticide contamination due to lots of flushing and dilution.

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

Appropriate mitigation for water quality should be chosen based on final WIN–PST hazard ratings for all applicable pesticide loss pathways to all identified water resource concerns. This will require sufficient mitigation to be applied for the highest risk(s) 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 (generally those that cover 10 percent or more of the area).

Step 2 Choose all the pesticides that the client is planning to use.

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 concern(s) 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.

In this example, the high rating for the combination of soil C with pesticide Y would be selected to plan an appropriate level of mitigation to protect the aquatic habitat.

Soil/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 in the NRCS IPM conservation practice

If a conservation planner identifies natural resource concerns related to pest management activities, NRCS conservation practices can be applied to address those concerns. The NRCS IPM CPS Code 595 has specific mitigation requirements for identified natural resource concerns.

For water quality concerns related to pesticide leaching, solution runoff, and adsorbed runoff, WIN–PST must be used to evaluate potential hazards to humans and/or 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. The minimum level of mitigation required 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

Mitigation requirements can be met with other conservation practices as well as IPM techniques applied with the NRCS IPM conservation practice. 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 or conservation practices from table 2 that address solution runoff must be applied so that the sum of the index values from either table in the solution runoff column for the selected IPM mitigation techniques and conservation practices will be 20 or more. Similarly, a high rating would require a sum of 40 or more, and an extra high rating would require a sum of 60 or more. This will be the case for all natural resource concerns and all applicable pesticide loss pathways identified by the conservation planner with the aid of WIN–PST. In some cases, mitigation requirements may be met without applying any IPM techniques, so the NRCS IPM conservation practice is technically not required, but it can still be used to document that all identified natural resource concerns are adequately addressed.

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

Pesticide drift has also been identified as a major pesticide loss pathway. Predicting spray drift is difficult because it is influenced by many rapidly changing site-specific factors including wind speed, relative humidity, temperature, and the presence of temperature inversions. Spray droplet size as determined by nozzle configuration and pressure also plays an important role in spray drift.

Pesticide drift that leaves the application area may impact nearby crops that are sensitive, 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 minimum level of mitigation required 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, one or more of the following VOC mitigation techniques must be applied:

- Use lower VOC-emitting pesticide formulations—specifically eliminating the use of emulsifiable concentrates when other formulations are available.
- Use precision pesticide application or smart sprayer technology including:
  - near-infrared-based weed sensing systems
  - 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 to October time frame 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 for several years before replanting an orchard crop or inoculate young trees (e.g., with yeast) to reduce fumigant use.

Pesticide direct contact can affect pollinators and other beneficial species in the application area while pesticides are being applied and later when pollinators and other beneficial species reenter the treated area. Pollinators that have been exposed in the application area at sublethal concentrations can return to the hive and affect others. Direct exposure to pesticides in the application area can occur even when spray drift is minimized.

For more information, see How to Reduce Bee Poisoning from Pesticides available at: http://extension.oregonstate.edu/catalog/pdf/pnw/pnw591.pdf.

If the conservation planner identifies a pesticide direct contact concern to pollinators and other beneficial species, two or more of the following mitigation techniques must be applied:

- Time pesticide applications when pollinators are least active (e.g., at night or when temperatures are low). Note that dewy nights may cause an insecticide to remain wet on the foliage and still be active the following morning, so exercise caution.
- Time pesticide applications when crops are not in bloom and keep fields weed free to discourage pollinators from venturing into the crop.
- Use pesticides that are less toxic to pollinators and beneficial species. **Note:** all pesticide recommendations must come from the Cooperative Extension Service or an appropriately certified crop consultant.
- Use selective insecticides that target a narrow range of insects (e.g., *Bacillus thuringiensis* (Bt) for moth caterpillars) to reduce harm to beneficial insects like bees.
- Use liquid or granular formulations instead of dusts and fine powders that may become trapped

in the pollen, collecting hairs of bees and consequently fed to developing larvae.

- Use alternatives to insecticides such as pheromones for mating disruption and kaolin clay barriers for fruit crops.

Cultural and mechanical pest management techniques can cause natural resource degradation. For example, burning for weed control can cause air pollution and tillage for weed control can cause soil erosion. All natural resource concerns from all forms of pest management should be evaluated, and significant natural resource concerns should be addressed to FOTG quality criteria levels.

IPM plans

What constitutes an IPM plan can range from an efficient pesticide recommendation based on monitoring results all the way to a detailed year-round plan that address 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 they must carefully coordinate the conservation plan with the IPM plan. As long as the IPM plan or the application of individual IPM techniques appropriately mitigates site-specific pest suppression risks to natural resources and/or humans, the requirements of the NRCS IPM conservation practice are met.

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 land-grant university should be used where available. A national listing is available at: http://www.ipmcenters.org/ipmelements/index.cfm. 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. IPM helps assure that unnecessary environmental risks are avoided. The best way to develop a good IPM system is to consider economics, efficacy, and environmental risk all at the same time.

IPM plans have traditionally been developed for efficient pest control including economics, efficacy, and resistance management. Environmental risk reduction is 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 National Road Map for Integrated Pest Management can be viewed at: http://www.ipmcenters.org/Docs/IPMRoadMap.pdf.

Developing an IPM plan as part of the overall conservation planning process will allow the IPM plan to directly address identified natural resource concerns as well as provide a broader context to areawide pest management considerations and habitat management for beneficial species.

It may take several passes through the IPM planning process to achieve all of the producer's goals. The first pass through 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 like Conservation Crop Rotation, Cover Crop, and Field Border 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 the IPM planner 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 land-grant university IPM programs, but NRCS conservation planners have to be certain that the Cooperative Extension Service or an appropriately certified farm advisor supports and recommends the site-specific use of these techniques. The NRCS pest management policy does not support NRCS conservation planners changing the way a pesticide is applied or substituting a different pesticide on their own. The NRCS fully supports the conservation benefits of each of these IPM risk prevention/mitigation techniques as long as they are recommended by the Cooperative Extension Service or an appropriately certified farm advisor.

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 drift. The pesticide drift pathway also applies to pesticide impacts on air quality.

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 practices function and the performance criteria that the index values are based on. 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 will ultimately determine 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. 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 generally provide more or less 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 generally have the potential to reduce losses by 10 to 5 percent. IPM techniques or NRCS conservation practices having an index value of 10 generally have the potential to reduce losses by about 25 percent, and IPM techniques or NRCS conservation practices having an index value 15 generally have the potential to reduce losses by 50 percent or more.

States can make adjustments to tables 1 and 2, but any adjustments should be coordinated across State lines through NRCS regional agronomists.

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 IPM techniques for reducing pesticide environmental risk

IPM techniques [1]	Mitigation index value [4] (by pesticide loss pathway)				Function and performance criteria
	Leaching	Solution runoff	Adsorbed runoff	Drift	
Application timing—ambient temperature				5	• Reduces exposure—spraying during cooler temperatures (e.g., early morning, evening or at night) can help reduce drift losses • Avoid spraying in temperatures above 90 °F
Application timing—rain	15	15	15		• 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
Application timing—relative humidity				5	• Reduces exposure—spraying when there is higher relative humidity reduces evaporation of water from spray droplets thus reducing drift losses
Application timing—wind				10	• Reduces exposure—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
Formulations and adjuvants [2, 3]	5	5	5	5	• Reduces exposure—specific pesticide formulations and/or adjuvants can increase efficacy and allow lower application rates; drift retardant adjuvants can reduce pesticide spray drift
Monitoring + economic pest thresholds	15	15	15	15	• Reduces exposure—reduces the amount of pesticide applied with preventative treatments because applications are based on monitoring that determines when a pest population exceeds a previously determined economic threshold
Partial treatment	15	15	15	10	• Reduces exposure—spot treatment, banding and directed spraying reduces amount of pesticide applied • Assumes less than 50 percent of the area is treated
Precision application using smart sprayers	10	10	10	10	• Reduces exposure—using smart sprayer technology (i.e., green sensors, sonar-based sensors, GPS-based variable rate application, computer controlled spray nozzles, etc.) can substantially reduce the amount of pesticide applied
Setbacks	5	5	5	10	• Reduces exposure—reduces overall amount of pesticide applied; reduces offsite pesticide drift • Assumes that the setbacks with no application are at least 30 feet wide
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 • Applicable to shallow mechanical or irrigation incorporation • Not applicable if pesticide leaching to groundwater is an identified natural resource concern • Not applicable if soil erosion is not adequately managed

Table 1 IPM techniques for reducing pesticide environmental risk—Continued

IPM techniques [1]	Mitigation index value [4] (by pesticide loss pathway)				Function and performance criteria
	Leaching	Solution runoff	Adsorbed runoff	Drift	
Spray nozzle selection, maintenance, and operation				10	• Reduces exposure—selecting appropriate nozzle and pressure for the 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 • Proper nozzle spacing, boom height, and boom suspension, along with frequent calibration and replacement of worn nozzles and leaking tubing, can increase efficacy and reduce drift potential
Substitution—cultural, mechanical, or biological controls	15	15	15	15	• Reduces risk—partial substitution of alternative cultural, mechanical, or biological pest suppression techniques reduces the application of a pesticide that poses a hazard to an identified natural resource concern • Not applicable if hazards from alternative suppression techniques are not adequately managed
Substitution—lower risk pesticides [2, 3]	15	15	15	15	• Reduces risk—partial substitution of an alternative lower risk pesticide reduces the application of a pesticide that poses a hazard to an identified natural resource concern • Not applicable if the alternative pesticide is not explicitly recommended by Extension or an appropriately certified crop consultant because the NRCS cannot make pesticide recommendations
Substitution—semiochemicals	15	15	15	15	• Reduces risk—using semiochemicals (e.g., mating disruption pheromones) to decrease reproductive success or control population density/location reduces the application of a pesticide that poses a hazard to an identified natural resource concern

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/ Teh NRCS does not make pesticide recommendations. All pesticide application techniques must be recommended by Extension or an appropriately certified crop consultant and selected by the producer.

4/ Numbers in these columns represent index values that indicate relative effectiveness of IPM mitigation techniques to reduce hazardous pesticide losses through the identified pathways.

Table 2 Conservation practices for reducing pesticide environmental risk

Pesticide mitigation conservation practices [1, 2]	Mitigation index value [4] (by pesticide loss pathway)				Function and performance criteria
	Leaching	Solution runoff	Adsorbed runoff	Drift	
Alley Cropping (Code 311)	5	5	10	10	• Increases infiltration and uptake of subsurface water; reduces soil erosion; can provide habitat for beneficial insects, which can reduce the need for pesticides; also can reduce pesticide drift to surface water
Anionic Polyacrylamide (PAM) Erosion Control (Code 450)		5	15		• Increases infiltration and deep percolation; reduces soil erosion
Bedding (Code 310)	5	5	5		• Increases surface infiltration and aerobic pesticide degradation in the root zone
Conservation Cover (Code 327)	10	10	10		• Increases infiltration; reduces soil erosion; and builds soil organic matter in perennial cropping systems such as orchards, vineyards, berries, and nursery stock
Conservation Crop Rotation (Code 328)	10	10	10		• Reduces the need for pesticides by breaking pest life cycles • Rotation shall consist of at least two crops in the rotation and no crop grown more than once before growing a different crop
Constructed Wetland (Code 656)	5	5	10		• Captures pesticide residues and facilitates their degradation
Contour Buffer Strips (Code 332)		10	10		• Increases infiltration; reduces soil erosion
Contour Farming (Code 330)		5	5		• Increases infiltration and deep percolation; reduces soil erosion
Contour Orchard and Other Fruit Area (Code 331)		5	5		• Increases infiltration and deep percolation; reduces soil erosion
Cover Crop (Code 340) that is incorporated into the soil	5	5	5		• Increases infiltration; reduces soil erosion; builds soil organic matter • Assumes at least 4,000 pounds per acre of live biomass at the time of tillage
Cover Crop (Code 340) for weed suppression that is mulch tilled or no-tilled into for the next crop	10	10	10	10	• Increases infiltration; reduces soil erosion; builds soil organic matter • Requires at least 4,000 pounds per acre of live biomass at the time of tillage and at least 30 percent ground cover at the time of the pesticide application
Cross Wind Ridges (Code 588)			5 [3/]		• 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 [3/]		• Reduces wind erosion and adsorbed pesticide deposition in surface water; traps adsorbed pesticides
Deep Tillage (Code 324)		5	5		• Increases infiltration and deep percolation • Not applicable if pesticide leaching to groundwater is an identified natural resource concern

Table 2 Conservation practices for reducing pesticide environmental risk—Continued

Pesticide mitigation conservation practices [1, 2]	Mitigation index value [4] (by pesticide loss pathway)				Function and performance criteria
	Leaching	Solution runoff	Adsorbed runoff	Drift	
Dike (Code 356)		10	10		• Reduces exposure potential—excludes outside water or captures pesticide residues and facilitates their degradation • Not applicable if pesticide leaching to groundwater is an identified natural resource concern
Drainage Water Management (Code 554)		10	10		• Drainage during the growing season increases infiltration and aerobic pesticide degradation in the root zone and reduces storm water runoff • Managed drainage mode when the field is not being cropped reduces discharge of pesticide residues from the previous growing season • Seasonal saturation may reduce the need for pesticides • Not applicable if pesticide leaching to groundwater is an identified natural resource concern
Field Border (Code 386)		5	10	5	• Increases infiltration and traps adsorbed pesticides; often reduces application area resulting in less pesticide applied; can provide habitat for beneficial insects, which reduces the need for pesticides; can provide habitat to congregate pests, which can result in reduced pesticide application; also can reduce inadvertent pesticide application and drift to surface water • Assumes 20-foot minimum width
Filter Strip (Code 393)		10	15	10	• Increases infiltration and traps adsorbed pesticides; often reduces application area resulting in less pesticide applied; can provide habitat for beneficial insects,,which reduces the need for pesticides; can provide habitat to congregate pests, which can result in reduced pesticide application; also can reduce inadvertent pesticide application and drift to surface water • Assumes 30-foot minimum width
Forage Harvest Management (Code 511)	10	10	10	10	• Reduces exposure potential—timely harvesting reduces the need for pesticides
Hedgerow Planting (Code 442)			10 [3/]	10	• Reduces adsorbed pesticide deposition in surface water; also can reduce inadvertent pesticide application and drift to surface water
Herbaceous Wind Barriers (Code 603)			5 [3/]	5	• Reduces wind erosion; traps adsorbed pesticides; can provide habitat for beneficial insects, which reduces the need for pesticides; can provide habitat to congregate pests, which can result in reduced pesticide application; and can reduce pesticide drift to surface water
Irrigation System, Microirrigation (Code 441)	10	15	15		• Reduces exposure potential—efficient and uniform irrigation reduces pesticide transport to ground and surface water

Table 2 Conservation practices for reducing pesticide environmental risk—Continued

Pesticide mitigation conservation practices [1, 2]	Mitigation index value [4] (by pesticide loss pathway)				Function and performance criteria
	Leaching	Solution runoff	Adsorbed runoff	Drift	
Irrigation System, Sprinkler (Code 442)	10	10	10		• Reduces exposure potential—efficient and uniform irrigation reduces pesticide transport to ground and surface water
Irrigation System, Surface and Subsurface (Code 443)	5	5	5		• Reduces exposure potential—efficient and uniform irrigation reduces pesticide transport to ground and surface water
Irrigation System, Tail Water Recovery (Code 447)		15	15		• Captures pesticide residues and facilitates their degradation
Irrigation Water Management (Code 449)	15	15	15		• Reduces exposure potential—water is applied at rates that minimize pesticide transport to ground and surface water, promotes healthy plants which can better tolerate pests
Mulching (Code 484) with natural materials	10	10	10		• Increases infiltration, reduces soil erosion, reduces the need for pesticides
Mulching (Code 484) with plastic	10	5	5		• Reduces the need for pesticides. Not applicable if erosion and pesticide runoff from nonmulched areas is not adequately managed
Residue and Tillage Management, No-till/Strip-Till/Direct Seed (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
Residue and Tillage Management, Mulch-Till (Code 345)	5	5	10		• Increases infiltration, reduces soil erosion, builds soil organic matter • Assumes at least 30 percent ground cover at the time of application
Residue and Tillage Management, Ridge Till (Code 346)	5	5	10		• Increases infiltration, reduces soil erosion, builds soil organic matter
Riparian Forest Buffer (Code 391)	5	15	15	10	• Increases infiltration and uptake of subsurface water, traps sediment, builds soil organic matter, and reduces pesticide drift • This assumes 30-foot minimum width
Riparian Herbaceous Cover (Code 390)	5	10	10	5	• Increases infiltration, traps sediment, builds soil organic matter, and reduces pesticide drift. Assumes 30-foot minimum width
Sediment Basin (Code 350)			10		• Captures pesticide residues and facilitates their degradation • Not applicable if less than 50 percent of the treatment area drains into the sediment basin
Stripcropping (Code 585)		15	15	5	• Increases infiltration; reduces soil erosion and generally will only be treating half the area of concern
Subsurface Drainage (Code 606)	5	10	10		• Increases infiltration and aerobic pesticide degradation in the root zone • *Note: avoid direct outlets to surface water
Surface Roughening (Code 609)			5 [3/]		• Reduces wind erosion and adsorbed pesticide deposition in surface water

Table 2 Conservation practices for reducing pesticide environmental risk—Continued

Pesticide mitigation conservation practices [1, 2]	Mitigation index value [4] (by pesticide loss pathway)				Function and performance criteria
	Leaching	Solution runoff	Adsorbed runoff	Drift	
Terrace (Code 600)		10	15		• Increases infiltration and deep percolation; reduces soil erosion • Not applicable if pesticide leaching to groundwater is an identified natural resource concern
Vegetative Barriers (Code 601)			10		• Reduces soil erosion; traps sediment; increases infiltration
Water and Sediment Control Basin (Code 638)		10	15		• Captures pesticide residues and facilitates their degradation; increases infiltration and deep percolation • Not applicable if pesticide leaching to groundwater is an identified natural resource concern
Windbreak/Shelterbelt Establishment (Code 380)			10 [3/]	10	• Reduces wind erosion; reduces adsorbed pesticide deposition in surface water; traps adsorbed pesticides; reduces pesticide drift

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

4/ Numbers in these columns represent index values that indicate relative effectiveness of pesticide mitigation techniques to reduce hazardous pesticide losses through the identified pathways.