

National Park Service
U.S. Department of the Interior



Integrated Pest Management Program

Parameters for Pesticide Review

A Guidance Manual for IPM Coordinators

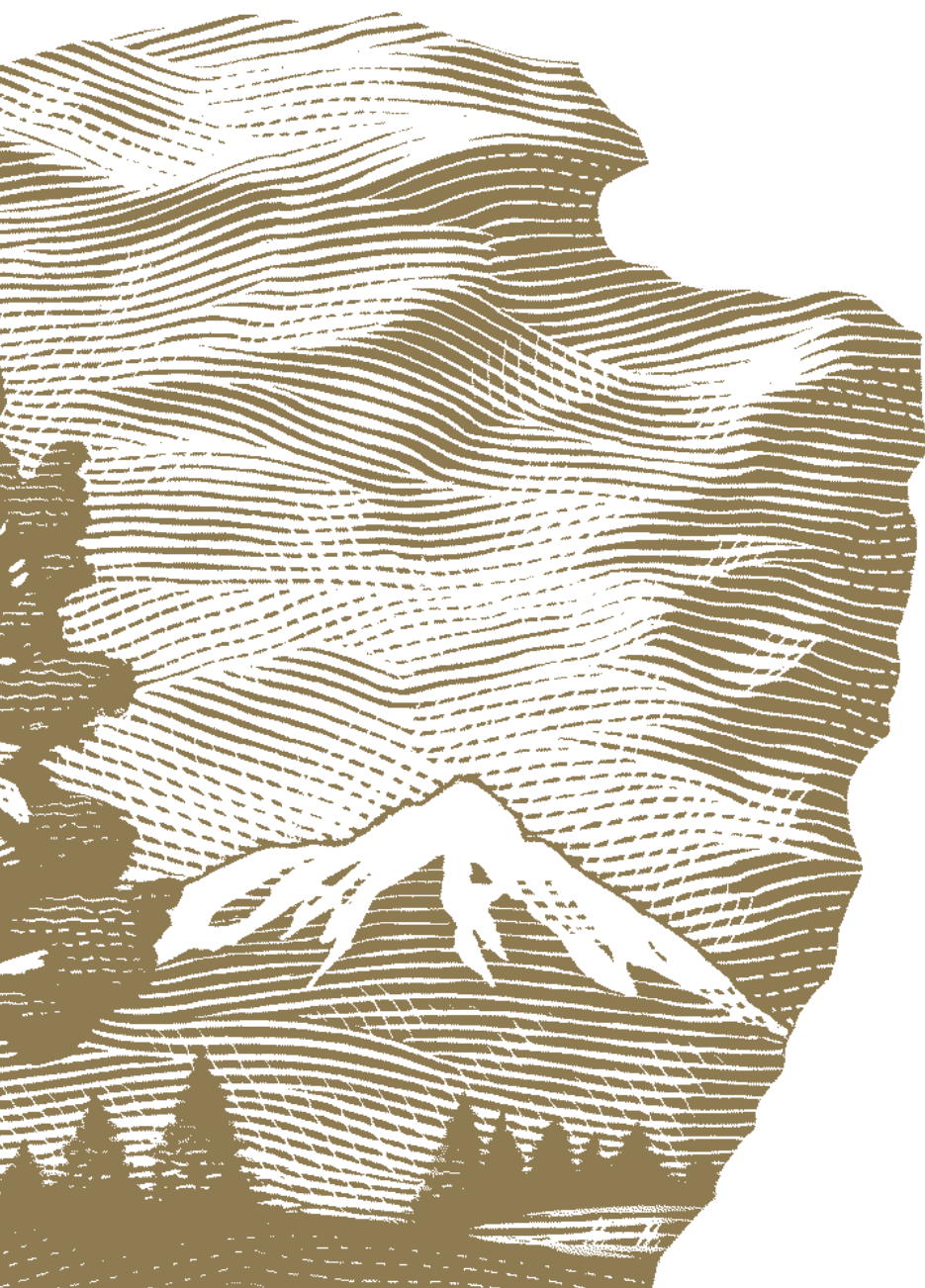


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Key Terms

The following definitions are provided in the context of these guidelines.

Absorption – Process whereby atoms, molecules, or ions are taken up by a gas, liquid, or solid material. This is a different process from adsorption, since molecules undergoing adsorption adhere to the surface and are not taken up by volume of the material.

Acute toxicity – A toxic effect(s) on an organism through a single or short-term exposure (i.e., acute exposure) to a chemical substance.

Adsorption – Process whereby a substance adheres to the surface of another substance.

Adsorption coefficient (Koc) – A measure of a material's tendency to adsorb to soil particles. Materials with high Koc values indicate a tendency for the material to be adsorbed by soil particles rather than remain dissolved in the soil solution. Strongly adsorbed molecules will not leach or move unless the soil particle to which they are adsorbed moves (as in erosion). Koc values of less than 500 indicate little or no adsorption and a potential for leaching.

Biobased (product) – A product determined by the U.S. Department of Agriculture (USDA) to be a commercial or industrial product (other than food or feed) that is composed, in whole or in significant part, of biological products, renewable domestic agricultural materials (including plant, animal, and marine materials), forestry materials or an intermediate feedstock.

Carcinogen – A substance that causes or aggravates tumors or other types of cancer.

Chronic toxicity – Toxicity caused by prolonged exposure to a chemical substance due to common/regular use, or by a substance that persists in the body.

Corrosive substance – A chemical that causes visible destruction of, or irreversible alterations to, living tissue by chemical action at the site of contact.

Decomposition products – Products formed from the physical or chemical breakdown of a substance.

Developed zone – An area where the natural landscape has been manipulated, modified, landscaped, or redesigned into a desired pattern (i.e., monuments, urban parks, visitor centers, concessions operations).

Flammability – The measure of how easily something will burn or ignite, causing fire or combustion.

Flash Point – The lowest temperature at which a volatile chemical can vaporize to form an ignitable mixture in air.

Groundwater – Water located in saturated zones below the soil surface. Many wells and springs are fed by groundwater.

Half-life – A way of measuring the persistence of a pesticide in the environment. The longer the half-life, the longer the pesticide will persist in the environment. The half-life of a chemical is highly dependent on the pH in the environment. The same pesticide may have varying half-lives in environments with different pH levels.

Incompatibility – An undesired chemical reaction when chemicals are mixed.

Integrated Pest Management (IPM) – A decision-making process that coordinates knowledge of pest biology, the environment, and available technology to prevent unacceptable levels of pest damage by cost-effective means while posing the least possible risk to people, resources, and the environment.

Irritant – A chemical that is not corrosive, but causes a reversible inflammatory effect on living tissue by chemical action at the site of contact.

Instar – A developmental stage of arthropods, such as insects, between each molt, until sexual maturity is reached.

Karst topography – A geological formation shaped by the dissolution of a layer or several layers of soluble bedrock; this usually includes carbonate rock such as limestone or dolomite, but it has also been documented for weathering resistant rocks, such as quartzite, given the right conditions.

Multiple chemical sensitivity – The Environmental Protection Agency (EPA) defines multiple chemical sensitivity as a condition in which a person reports sensitivity or intolerance (as distinct from “allergic”) to a number of chemicals and other irritants at very low concentrations. There are different views among medical professionals about the existence, causes, diagnosis, and treatment of this condition. NOTE: Multiple chemical sensitivity is controversial. The American Medical Association Council on Scientific Affairs believes that multiple chemical sensitivity should not be considered a recognized clinical syndrome, yet some doctors and many people suffering with unexplained symptoms believe that it is a real condition.

Mutagen – An agent that changes DNA, thereby increasing the frequency of genetic mutations.

Natural zone – An area where the land surface, soil horizon, and /or natural hydrology has not been disturbed and where naturally occurring ecosystems are functional.

Pesticide – The term “pesticide” means:

(1) any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest;

(2) any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant; and

(3) any nitrogen stabilizer, except that the term “pesticide” shall not include any article that is a “new animal drug” within the meaning of section 321 (w) of title 21, that has been determined by the Secretary of Health and Human Services not to be a new animal drug by a regulation establishing conditions of use for the article, or that is an animal feed within the meaning of section 321 (x) of title 21 bearing or containing a new animal drug. The term “pesticide” does not include liquid chemical sterilant products (including any sterilant or subordinate disinfectant claims on such products) for use on a critical or semi-critical device, as defined in section 321 of title 21. For purposes of the preceding sentence, the term “critical device” includes any device that is introduced directly into the human body, either into or in contact with the bloodstream or normally sterile areas of the body, and the term “semi-critical device” includes any device that contacts intact mucous membranes, but that does not ordinarily penetrate the blood barrier or otherwise enter normally sterile areas of the body.

pH – The measure of how acidic or basic a chemical is, based on the measure of hydrogen in solution. A pH of 7 is considered neutral.

Physical state – The physical form (solid, liquid) of the pesticide when it is applied to the environment.

Recreational zone – An area where the natural ecosystem has been altered or manipulated to support officially designated recreational activity such as football, baseball, and soccer fields.

Sensitivity – A chemical property that causes a substantial proportion of exposed people or animals to develop an allergic reaction in normal tissue after repeated exposure to the chemical.

Soil mobility – Movement of a compound through soil from the treated area by leaching, volatilization, adsorption and desorption, or dispersal by water. Leaching is of particular concern because of the potential for contamination of groundwater.

Soil properties – The physical, chemical, and biological properties of the soil.

Soil type – Refers to the different sizes of mineral particles in a particular soil sample. Soil is made up in part of finely ground rock particles, grouped according to size as sand and silt in addition to clay and humus, organic material such as decomposed plant matter.

Special use zone – An area that has been delineated for a specific event or function, such as a parade ground, campground, or public events arena.

Stability – The tendency of a material to resist change or decomposition due to internal reaction, or due to the action of air, heat, light, or pressure.

Surface water – Water at the soil surface in open bodies such as streams, rivers, ponds, lakes, or oceans.

Teratogen – A substance that can interfere with the development of a fetus.

Toxin – A poisonous substance that is a product of metabolic activity of living organisms.

Vadose zone – The weathered portion of the earth that extends to about six feet below the surface of the ground.

Viscosity – The internal friction of a fluid that retards its flow. In general, viscosity decreases as a fluid's temperature increases.

Water solubility – The ability of a chemical to dissolve in water. The solubility of a chemical is dependent on the temperature in the environment.

NOTE: Additional pesticide-related terms can be found on EPA's Glossary of Terms website at: www.epa.gov/iaq/glossary.html

Chapter 1: Introduction

National Park Service Integrated Pest Management Program Overview

The National Park Service (NPS) Integrated Pest Management (IPM) Program was established to reduce risks to the public, park resources, and the environment from pests and pest-related management strategies. Since the program began in the 1980s, the NPS has developed specific policy and procedures on the review and tracking of pesticides proposed for use in the parks.

The Washington Area Support Office (WASO) IPM Program is responsible for developing and implementing IPM policy, providing IPM training and technical guidance on pest issues, and tracking pesticide proposal and use. The program provides technical assistance to park staff to help them determine best pest management strategies for pests impacting NPS lands, resources, and public health, in accordance with NPS policies. IPM Program staff review, select, and track the proposed and actual use of biological control agents, genetically modified organisms, and chemical pesticides on a case-by-case basis, using the Pesticide Use Proposal System (PUPS), an intranet web-based database that is used by park, regional, and Servicewide IPM Coordinators

In addition, the IPM Program reports NPS use of pesticides annually, in accordance with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA, Title 7 USC 136r-1), DOI-DM 517 IPM and other Department of the Interior policies, state IPM laws and regulations, and specific NPS policy.

Pesticide Use

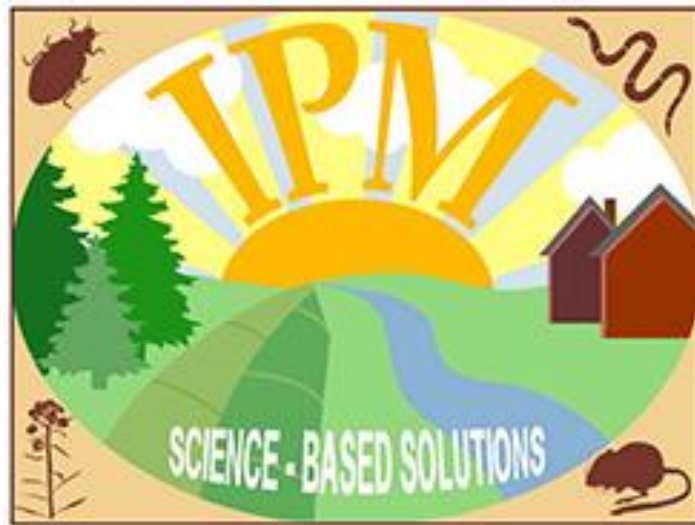
The prevention and management of pests on lands and properties follows NPS IPM policy, which includes use of the *11 Step Process for Developing and Implementing an IPM Strategy*¹ (Appendix A). The IPM approach involves the evaluation and use of different management tools, such as pesticides, biological control agents, genetically modified organisms, human behavior change, habitat modification, mechanical tools, physical tools, and other strategies. Each tool has specific risks associated with its use, which are dependent on the individual site's circumstances. Risk may be defined as the likelihood that an effect (injury, disease, death, or environmental damage) may result from a specific set of circumstances.

The IPM Program utilizes the PUPS, which is an intranet web-based database that is used by park, regional, and Servicewide IPM Coordinators to propose, review, and track pest management activities. Pesticide use proposals (proposals) are prepared annually on a case-by-case basis to determine if a pesticide, a biological control agent, or genetically modified organism is a necessary component of the overall pest management strategy for a specific issue. The proposal review process is required by NPS policy and incorporates 13 federal laws and regulations, including the National Environmental Protection Act, the Endangered Species Act, and the National Historic Preservation Act.

What is the purpose of this document?

Park, regional, and Servicewide IPM Coordinators must have an understanding of the risks associated with pesticides prior to submitting or making a decision to approve or deny a pesticide use proposal. The information in this document provides a process to help IPM Coordinators identify, understand, and define risk(s) associated with the use of proposed pesticides and ensures informed decision making regarding pesticide use.

¹ NPS 11 Step IPM Process for Developing and Implementing an IPM Strategy <http://www1.nrintra.nps.gov/BRMD/ipm>



About the IPM Program Logo

The NPS IPM logo is designed with the following design elements:

- *Sunray letters to represent the enlightened approach IPM provides when addressing pest issues;*
- *Trees to represent natural areas;*
- *Buildings to symbolize developed areas;*
- *A river to represent aquatic sites;*
- *Agricultural fields to represent historic landscapes;*
- *Examples of key organisms the Program addresses in each corner: vegetation, rodents, arthropods, and perimeter invaders; and*
- *The words, "Science-Based Solutions," to indicate that the Program incorporates science-based solutions when making all pest management decisions.*

Chapter 2: Key Roles and Responsibilities

Roles and responsibilities of the parks, regions, and WASO in conducting proposal reviews are defined by NPS Management Policies 2006 and NPS 77-7 Natural Resource Guidelines (1991). When it is finalized, Director's Order 77-7, *Integrated Pest Management*, will supersede NPS 77-7 and will serve as the authority for the NPS IPM Program roles and responsibilities. Annual guidance on pesticide use and reporting is provided in a yearly call memo that is sent by the Associate Director of Natural Resource Stewardship and Science to all Regional Directors (see Appendix B).

The park superintendent, park IPM Coordinator, regional IPM Coordinator, and Servicewide IPM Coordinator all play roles in managing pesticide use in the NPS. The NPS IPM Program requires coordination across the park, region, and Servicewide levels, regarding the review of pesticide use proposals.

Superintendents

Superintendents are responsible for all pest management issues within a park. They determine, within the context of NPS Management Policies and other guidance, what constitutes a pest in relation to the park's resources. The park superintendent designates a park IPM Coordinator to coordinate and participate in all management decisions that may directly or indirectly influence pest management. The superintendent is responsible for ensuring that the park IPM Coordinator reviews the pest issue, completes the required information for each pesticide use proposal in the park, and ensures that pesticide applications are supervised by a certified pesticide applicator. It is also the superintendent's responsibility to ensure that certification requirements established by federal and state laws and regulations are met by park employees applying or supervising the application of pesticides in the park.

Park IPM Coordinators

The park IPM Coordinator is designated by the park superintendent and is responsible for conducting the first of three levels of review required for pesticide use proposals, biological control agents, and genetically modified organisms proposed for use on park property. Prior to submitting a proposal, the park IPM Coordinator should ensure that it meets requirements under all other applicable laws, regulations, and policies. The park IPM Coordinator is responsible for recording and reporting proposed pesticide use on a project-by-project basis, using PUPS and ensuring that current conditions and needs are up to date to allow for accurate and timely review and approval by the Regional IPM Coordinator.

Regional IPM Coordinators

Regional IPM Coordinators are appointed by the Regional Director to ensure that the region's IPM program meets NPS policy and regulatory requirements. The regional IPM Coordinator must stay up to date with Servicewide policy, keep track of state and federal regulatory updates, and maintain a valid state pesticide applicator certification. He or she serves as the liaison between park IPM Coordinators and the Servicewide IPM Coordinator, providing consultation to parks on IPM policy and technical methodologies to help meet site-specific pest management needs. The regional IPM Coordinator reviews all pesticides, biological control agents, and genetically modified organism proposals for park lands and properties on a case-by-case basis and makes a determination to concur, non-concur, approve the request on a conditional basis, or elevate to the Servicewide IPM Coordinator for review.

Servicewide IPM Coordinator

The Servicewide IPM Coordinator is the leader of the NPS IPM Program and is responsible for recommending policy, providing oversight and uniformity to the IPM Program and database, managing and implementing the NPS IPM Program, and developing and implementing IPM training. He or she serves as a liaison with other NPS programs and other federal, non-profit, and private organizations. The dynamic nature of IPM requires that the Servicewide IPM Coordinator address major pest management issues, particularly issues that are multi-regional in scope. The Servicewide IPM Coordinator provides second-level reviews of pesticide proposals involving restricted use, aquatic applications, pesticides that might affect threatened or endangered species or habitat, applications to more than 400 contiguous acres, aerial application, new PUPS products, and pest management issues that may be politically sensitive. The Servicewide IPM Coordinator is responsible for ensuring Annual Pesticide Use Logs submitted by regions are complete. He or she is also responsible for responding to inquiries regarding pesticide use, such as products, quantities applied, and areas and acreage treated are addressed.

Chapter 3: Parameters for Reviewing Pesticide Use Proposals

Before preparing a pesticide use proposal, the park IPM Coordinator and other park staff should develop or review the existing pest and IPM strategy. The strategy should follow the *11 Step Process for Developing and Implementing an IPM Strategy* and ensure that: 1) pesticide use is a necessary and justified component of the IPM strategy and 2) the lowest risk, most effective pesticide for the target pest and pest situation is proposed. Knowing which pest you are attempting to manage will determine which IPM tools (e.g., chemical pesticides, biological control agents, mechanical) are most appropriate and effective to meet your site management objective. Park IPM Coordinators must also understand the characteristics of specific pesticides and the environmental conditions where they are proposed for use in order to understand the potential effectiveness of the application. Once this is accomplished, a proposal can be prepared (see Appendix C for a sample proposal form). More detailed information on how to prepare and review a proposal can be found in the PUPS User Manual at: www1.nrintra.nps.gov/BRMD/ipm or by contacting your regional IPM Coordinator or the Servicewide IPM Coordinator (see Appendix D).

Pesticide use proposals submitted through the PUPS are used to evaluate risks to people, resources, and the environment. Pesticides contribute significantly to the protection of food, resources, and public health; however, if not used correctly, they can present long-term or an immediate danger, including death, to the user or the resource. The PUPS review helps to ensure the proposed pesticide is a necessary component of the IPM strategy, and is labeled for the specific site (per FIFRA requirements. See: www.epa.gov/oecaagct/lfra.html). Once risks have been evaluated, the proposal is either approved, approved with conditions, or denied. If approved, the pesticide label must be followed. Sources of pesticide labels can be found in Appendix E.

Pesticide reviews must consider the pest biology, site purpose, composition of site resources, use of the site, chemical characteristics (e.g., ingredients, toxicity, surfactants, inert ingredients, half-life) of the proposed pesticide, and the location-specific environmental conditions (e.g., climate, physical parameters such as soil type, material/composition of site to be treated) in the area where the pesticide will be applied.

Pesticide

There are two main types of pesticides: general use and restricted use. General use pesticides are primarily those that will not cause unreasonable adverse effects to the user or environment when used in accordance with label instructions. Restricted use pesticides are limited in their use by pesticide applicators who are certified, or to people under the direct supervision of a certified applicator².

All pesticides go through a rigorous review process by the U.S. Environmental Protection Agency (EPA), except those that have been determined to be minimum risk. Minimum risk pesticides are a special class of pesticides that are not subject to federal registration requirements because their ingredients, both active and inert, are *demonstrably* safe for the intended use. Minimum risk pesticides do not require an EPA registration number. Additional information is available at www.epa.gov/oppbppd1/biopesticides/regtools/25b_list.htm). NPS policy requires that all pesticides, including Minimum Risk pesticides, be entered into PUPS and reviewed. They must be approved prior to use, and Pesticide Use Logs completed, as is required for pesticides with EPA registration numbers.

² U.S. EPA, Regulating Pesticides, Office of Public Affairs (A-107)

Pesticide applications must be specifically labeled for the application site. It is a violation of the law to use a pesticide on a site that is not listed on the label. There are rare occasions when a pesticide is proposed for an unlabeled use. FIFRA provides two mechanisms to review these types of proposals through temporary exemption permits under Section 18, Emergency Exemption or Section 24c, Special Local Need. Park IPM Coordinators should involve regional IPM Coordinators and /or the Servicewide IPM Coordinator early in the review process for situations that may involve requests for these types of exemptions.

Pest Biology

Understanding the pest life cycle is key when selecting a pesticide, biological control, or genetically modified organism. The pest's biology will determine the most vulnerable stage in the pest's life cycle to ensure the pesticide is used in the most effective, target-specific manner that will have the least risk to non-target organisms and the environment. The pest life stage will also determine what formulation of pesticide is most suitable. For example, insecticide Gypchek, specific only to gypsy moth, is most effective on early instar larvae. It must be applied just after egg hatch to young larvae in order for it to be effective. Gypcheck is not effective on older larvae³. For more information on Gypchek, go to: www.fs.fed.us/foresthealth/pesticide/pdfs/Gypchek_Label.pdf

Multiple Chemical Sensitivity

Multiple chemical sensitivity, or pesticide sensitivity, is “a condition in which a person reports sensitivity or intolerance (as distinct from "allergic") to a number of chemicals and other irritants at very low concentrations.”⁴

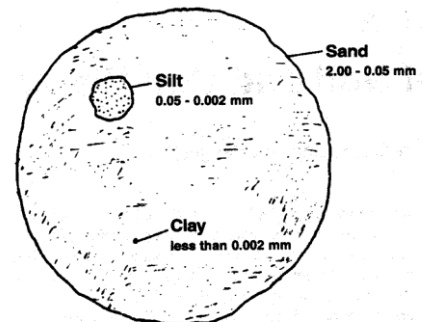
It is important to know your park users, employees, and neighbor's concerns, as well as your state Pesticide Board's regulations on this topic. Many states have established a Registry of Hypersensitive Individuals (e.g., Pennsylvania:

[www.agriculture.state.pa.us/portal/server.pt/gateway/PTARGS_6_2_75292_10297_0_43/AgWebsite/ProgramDetail.aspx?name=Pesticide-Hypersensitivity-Registry&navid=12&parentnavid=0&palid=112&"\),](http://www.agriculture.state.pa.us/portal/server.pt/gateway/PTARGS_6_2_75292_10297_0_43/AgWebsite/ProgramDetail.aspx?name=Pesticide-Hypersensitivity-Registry&navid=12&parentnavid=0&palid=112&) requiring citizens to be notified ahead of time if a pesticide application is going to be applied. Individuals may request to be notified or excluded from the application. Additional information on multiple chemical sensitivity is available at health.nih.gov/topic/MultipleChemicalSensitivity

Soil Type

Soil type will affect whether or not the pesticide application will adhere to soil particles or leach through soil and present a risk of contaminating groundwater.

Pesticides applied in clay type soils have a lower risk for reaching the groundwater than pesticides applied to sandy or gravel-type soils. This is because soils dominated by clay have binding sites for chemicals to attach, which deters the vertical movement of pesticides toward groundwater. For example, we may want to manage turf grubs (immature beetles) under the lawn surface and may select a



Source: CenUSA Bioenergy Online Peer Network, passel.unl.edu/communities/cenusabioenergy

³ http://www.fs.fed.us/foresthealth/pesticide/pdfs/Gypchek_Label.pdf

chemical insecticide that, once applied, will move laterally to spread just below the surface, providing good coverage to effectively kill the grubs. Read the product label and contact the technical representative to discuss your specific site situation.

Threatened and Endangered Species

Any pesticide applications that may affect, or have the potential to affect, threatened or endangered species require Section 7 Consultation under the Endangered Species Act (16 U.S.C. 1531 et seq.). Communicating with your park or regional Endangered Species Coordinator to discuss the proposal and initiate consultation with the Regional U.S. Fish and Wildlife Service (USFWS) Endangered Species office for consultation is essential prior to submitting a pesticide use proposal. For more information, please visit www.fws.gov/endangered

Historic Structures

Any proposed repairs, modifications, or pesticide applications that involve historic structures may require Section 106 compliance under the National Historic Preservation Act (16 U.S.C. 470 et seq.). IPM Coordinators should contact your park or regional Cultural Resource manager for consultation prior to submitting a pesticide use proposal.

Site Characteristics

Park IPM Coordinators, supported by the park superintendent, are responsible for understanding the characteristics of the site and pest before submitting a proposal to the regional IPM Coordinator for review. Site characteristics that influence the activity of pesticides include depth to groundwater, soil type and texture, amount of organic matter in soil, topographic position, distance to surface water, microbial ecology, and annual precipitation. Note that the pH of the water used to mix pesticides can also have an influence on its performance. Soil disturbances or amendments, whether man-induced or natural, will also affect how the soil and pesticide interact.

Chapter 4: Physical and Chemical Characteristics of Pesticides

Pesticides can be biobased or manufactured synthetic organic chemicals that are used to control a wide variety of pests⁵. Each pesticide has unique active ingredient that is designed specifically for the type of pest(s) being targeted. The chemical and physical properties of each pesticide, including the active ingredients, are important factors to weigh when considering how a pesticide is going to interact with the surrounding ecosystem and determining the direct effect it will have on human health and the environment.

Specific things to consider when selecting a pesticide include: the pesticide formulation; ability of the pesticide to migrate through soil, air, and water; potential for contact with surface water and groundwater; and potential for negative impacts to human health and the surrounding ecosystem. Pesticide reviewers should determine the physical and chemical characteristics of a pesticide in order to identify the risks involved with the preparation and application of the pesticide.

Environmental Pathways: Pesticide Movement and Risk

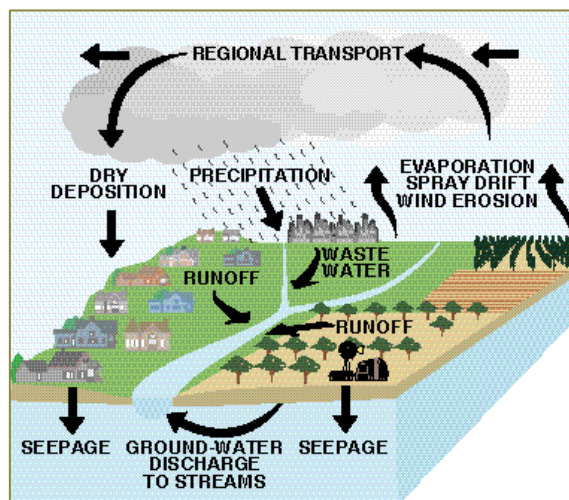
Pesticides enter the environment in different ways. One key path is the hydrologic cycle, which transports pesticides between ground, water, and atmosphere.

The Hydrologic Cycle

Water is one of the primary means by which pesticides are transported from their application areas to other parts of the environment. Thus, there is potential for movement of pesticides into and through all components of the hydrologic cycle⁶.

The USGS National Water Quality Assessment Program (NWQAP), which began in 1992, provides a national-scale assessment of the occurrence and behavior of pesticides in streams and groundwater of the United States and the potential for pesticides to adversely affect drinking water supplies or aquatic ecosystems. This information is available for reference when reviewing pesticide proposals (water.usgs.gov/nawqa/pnsp/).

In 2006, the NWQAP released a report titled, Pesticides in Streams and Ground Water (pubs.usgs.gov/fs/2006/3028/), which documents the occurrence of various pesticides in streams and groundwater across the U.S. from 1992 through 2001. The report concludes that pesticides are typically present throughout the year in most streams in urban and agricultural areas of the nation, but are less common in groundwater. The report also concludes that pesticides are seldom at concentrations likely to affect humans. However in many streams,



Source: water.usgs.gov/nawqa/pnsp/pubs/fs152-95/atmos_1.html

⁵ Biobased Pesticides, as defined by the 2002 Farm Bill, are commercial or industrial products, other than food or feed, that are composed in whole, or in significant part, of biological products, renewable agricultural materials (including plant, animal, and marine materials), or forestry materials.

⁶ water.usgs.gov/nawqa/pnsp/pubs/fs152-95/atmos_1.html

particularly those draining urban and agricultural areas, pesticides were found at concentrations that may affect aquatic life or fish-eating wildlife⁷.

Any pesticide proposed for application in, or with the potential to affect, aquatic systems may require a National Pollutant Discharge Elimination System (NPDES) permit. As authorized by the Clean Water Act, the NPDES permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Point sources are discrete conveyances such as pipes or manmade ditches. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters⁸. NPDES Individual State Information can be found at:

cfpub.epa.gov/npdes/stateinfo.cfm.

Physical Characteristics

There are two prominent physical characteristics to consider when evaluating a pesticide: 1) the formulation or *physical state* in which the pesticide is applied (e.g., liquid, granules) and 2) its *physical properties* in that physical state (e.g., flash point, viscosity, pH). The pesticide formulation can increase or decrease the risks associated with pesticide.

Pesticide formulations consist of the following components: the active ingredient that controls the target pest, the carrier (may be an organic solvent or a mineral clay), a sticker or spreader, inert ingredients, and/or other ingredients such as dyes or stabilizers to enhance or improve the activity of the pesticide⁹.

Inert ingredients are defined by EPA as any intentionally added ingredient in a pesticide product that does not exhibit a pesticide activity. This definition does not include impurities¹⁰. Additional information on inert ingredients and their toxicology can be found at: www.epa.gov/opprd001/inerts/fr52.htm.

The pesticide formulation is stated on the pesticide label and/or material safety data sheet (MSDS). Examples of pesticide formulations include:

- Aerosol - A
- Aqueous flowable - AF
- Bait - B
- Concentrate - C
- Dry flowable - DR
- Dust - D
- Emulsifiable concentrate - EC
- Flowable - F
- Granules - G
- Gel - GL
- Microencapsulated - M
- Pellets - P
- Soluble powder - SP
- Ultralow volume - ULV

⁷ www.usgs.gov/newsroom/article.asp?ID=1450

⁸ <http://www.epa.gov/compliance/monitoring/programs/cwa/npdes.html>

⁹ www.extension.umn.edu/pesticides/ppat_manual/Chapter_4.pdf

¹⁰ EPA May 2012. **Inert Ingredients in Pesticide Products; Policy Statement**, OPP-36140; FRL-3190-1
<http://www.epa.gov/opprd001/inerts/fr52.htm>

A more inclusive list and additional information on formulations can be found at:
[www.extension.umn.edu/pesticides/ppat_manual/Chapter 4.pdf](http://www.extension.umn.edu/pesticides/ppat_manual/Chapter_4.pdf).

The following table outlines the physical characteristics commonly found on pesticide MSDSs, along with typical ranges of acceptable values, common warnings, and useful information.

Table 4.1 – Physical States and Properties of Pesticides

	<i>Formulation or Physical State</i>	Low Risk	Moderate Risk	High Risk - Avoid
		Dry, Pellets, Granules	Liquid	Gaseous
Physical Property	Odor	Strong, Sulfur-like	Slight, Mild	Weak, None
	Decomposition Products	None	Non-Harmful	Carbon Monoxide, Nitrogen Oxides, Oxidizing Agents, HCL
	Incompatibility	None	Certain Metals	Strong Acids/Bases, Oxidizing Agents
	Flammability	Not Applicable	Ignitable	Combustible, Explosive
	Flash Point	Above 140 Degrees F	140 Degrees F	Below 140 Degrees F
	Stability	Stable under normal conditions	NA	Not stable under normal conditions
	Viscosity	<50	0-50	>0

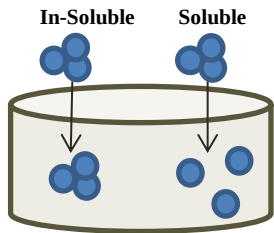
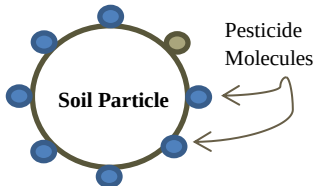
Source: Minnesota Department of Agriculture, "Minnesota Pesticide Management Plan," November 2007.

Chemical Characteristics

Each pesticide has specific chemical properties that indicate how it will impact and how long it will persist in the environment. When a pesticide is introduced into the environment, it reacts and decomposes or breaks down into other chemical products. The persistence of the reactions and the decomposition products that are formed are key to a pesticide evaluation, as each of these has its own characteristics and associated risk often very different from the original material. Some pesticide decomposition products are particularly harmful (see Table 4.1).

The initial chemicals and their subsequent products have unique reactions with the environment and will persist for varied amounts of time, depending upon the type of pesticide being used. Chemical characteristics such as adsorption, persistence, water solubility, and half-life are good indicators of how a pesticide will react in the environment. The important chemical characteristics of pesticides are listed below in Table 4.2. Information on a pesticide's specific chemical characteristics can be found on the pesticide's MSDS.

Table 4.2 – Chemical Properties of Pesticides*

Chemical Property	Low Risk	Moderate Risk	High Risk - Avoid
Water Solubility	<0.1 ppm (1 drop in 500 liters)	100 to 1,000 ppm (1 drop in 50 spoonfuls to half a gallon)	>10,000 ppm (1 drop into one-spoonful)
<div style="display: flex; align-items: center;"> <div style="flex: 1;">  </div> <div style="flex: 2;"> <p>Solubility is the ability of a pesticide to dissolve and break apart in water. The greater the solubility, the greater the chance for transport by either surface water (runoff) or groundwater (leaching). The solubility of a chemical is dependent on the temperature in the environment.</p> </div> </div>			
Adsorption ¹¹	300-500 L/kg	100-300 L/kg	0-100 L/kg
<div style="display: flex; align-items: center;"> <div style="flex: 1;">  </div> <div style="flex: 2;"> <p>Adsorption is the ability of a pesticide molecule to “stick” to a soil particle. Pesticides that have higher adsorption are less likely to remain in solution and decrease the amount transported through runoff and leaching. Pesticide molecules are generally too large to absorb to soil particles.</p> </div> </div>			
Half-Life (Persistence)	<30 days	30-100 days	>100 days
<div style="display: flex; align-items: center;"> <div style="flex: 1;"> <p>Day 0 (100mg) </p> <p>1 Day (50 mg) </p> <p>2 Days (25 mg) </p> <p>3 Days (12.5 mg) </p> </div> <div style="flex: 2;"> <p>Half-life is the time required for half of a pesticide solution to degrade or decompose. The longer the half-life of a pesticide, the longer it will persist in the environment. Half-life is highly dependent on the pH in the environment. Therefore, the same pesticide may have varying half-lives at different pH levels. The example chemical has a half-life of one day.</p> </div> </div>			
pH	~7.0	<7.0 Acidic	>7.0 Basic
<p>pH is the measure of how acidic or basic a chemical is, based on the measure of hydrogen in solution. A pH of 7 is considered neutral. The higher or lower the pH, the more potential for a hazardous interaction with other substances.</p>			

*Values and definitions derived from EPA and Occupational Safety and Health Administration (OSHA) standards.

¹¹ Absorption is not considered an important chemical characteristic because pesticide molecules are generally too large to absorb into soil particles.

Environmental and Human Health Hazards

The Federal Government, in cooperation with the states, regulates pesticides to ensure that they do not pose unreasonable risks to human health or the environment. EPA requires extensive test data from pesticide producers that demonstrate pesticide products can be used without posing harm to human health and the environment. EPA scientists and analysts carefully review these data to determine whether to register (license) a pesticide product or a use and whether specific restrictions are necessary. EPA performs human health risk assessments on pesticides using the National Research Council's four-step process for human health risk assessment, which includes:

(Note: click on the hyperlink for details.)

- [Step One](#): Hazard Identification
- [Step Two](#): Dose-Response Assessment
- [Step Three](#): Exposure Assessment
- [Step Four](#): Risk Characterization

Pesticides must always be applied in accordance with the label, as the label is the law and following it will minimize risk to humans, animals, park resources, and the environment. The IPM approach helps determine the lowest risk strategy. Risk can be mitigated by using the lowest risk alternatives or pesticides that will effectively manage the pest. Pesticide labels and MSDSs provide information on warnings and hazards, exposure response actions, personal protective equipment, and safety requirements.

EPA requires a signal word on most pesticide product labels. They also require it to be printed on the front panel, in all capital letters, to make it easy for users to find. The only pesticide products that are not required to display a signal word are those that fall into the lowest toxicity category by all routes of exposure (oral, dermal, inhalation, and other effects like eye and skin irritation). The three most common signal words are “caution,” “warning,” and “danger.”

“CAUTION” means the pesticide product is slightly toxic if eaten, absorbed through the skin, or inhaled, or causes slight eye or skin irritation.

“WARNING” indicates the pesticide product is moderately toxic if eaten, absorbed through the skin, or inhaled, or causes moderate eye or skin irritation.

“DANGER” means that the pesticide product is highly toxic by at least one route of exposure. It may be corrosive, causing irreversible damage to the skin or eyes. Alternatively, it may be highly toxic if eaten, absorbed through the skin, or inhaled. If this is the case, then the word “POISON” must also be included in red letters on the front panel of the product label.

The signal word will be printed on the front panel, in all capital letters, to make it easy for the users to find. The only pesticide products that are not required to display a signal word are those that fall into the lowest toxicity category by all routes of exposure (oral, dermal, inhalation, and other effects like eye and skin irritation). Detailed information on how to read a pesticide label can be found at EPA's interactive label site:

www.epa.gov/pesticides/label.

Table 4.3 outlines the major health considerations for pesticide exposure.

Table 4.3 – Health Concerns Related to Pesticide Use

Exposure	Description	Impact
Carcinogen	Any substance that is directly involved in causing cancer. A chemical is considered to be a carcinogen if it has been recognized by the IRAC, OSHA or NTP as such.	Chronic exposure, usually through inhalation, dermal contact, and oral consumption, heighten the risk of certain types of cancers
Corrosive	A chemical property that causes visible destruction of, or irreversible alterations to, living tissue by chemical action at the site of contact.	Acute exposure or accidental contact with skin or eyes will result in severe damage.
Toxin	A poisonous substance that is a product of metabolic activity of living organisms.	Poisoning can result from direct exposure or indirect exposure through the diet.
Irritant	A chemical, which is not corrosive, but which causes a reversible inflammatory effect on living tissue by chemical action at the site of contact.	The damage from exposure can range from minor to severe skin or eye irritation depending on the exposure time and the pesticide.
Sensitivity	A chemical property that causes a substantial proportion of exposed people or animals to develop an allergic reaction in normal tissue after repeated exposure to the chemical.	Exposure leads to an allergic response from contact of pesticide chemicals with the skin.
Mutagen	An agent that changes DNA, thus increasing the frequency of genetic mutations.	Pesticides containing mutagens can alter DNA through chronic exposure.
Teratogen	A substance that can interfere with the development of a fetus.	Exposure to certain pesticides may interfere with normal fertility and reproduction. This can result in birth defects and other reproductive issues.

Source: Nesheim, Fishel and Mossler, "Toxicity of Pesticides," University of Florida, 2009.

Toxicity

Toxicity is defined as the degree to which a chemical substance can damage living or non-living organisms. Toxicity can refer to the effect on a whole organism, such as an animal, bacterium, or plant, as well as the effect on a part of an organism, such as a cell (cytotoxicity) or an organ (organotoxicity). Exposure to toxic chemicals in animals occurs through oral intake, dermal (skin) exposure, or inhalation. The most important factors that determine toxicity are dose and exposure time; anything can be toxic if the dose is large enough and the exposure time long enough.

There are two types of toxicity in animals and humans: acute and chronic. Acute exposures are more dependent on dose, while chronic exposures are dependent on the how long the exposure occurs. The following sections go into more detail about factors pertaining to both acute and chronic toxicity.

Acute toxicity means that a chemical has a harmful effect(s) on an organism through a single or short-term exposure (i.e., acute exposure) to a chemical substance. Acute toxicity can result in oral, skin, or inhalation exposure to toxic substances, eye irritation, skin irritation, skin sensitivity, and nerve system damage.

Table 4.4 – Levels of Acute Exposure

Criteria	Relatively Non-Toxic	Slightly Toxic	Moderately Toxic	Highly Toxic
Signal Word*	None Required	Caution	Warning	Danger
Oral (mg/kg)- LD₅₀**	5,000+	500 to 5,000+	50 to 500	0 to 50
Dermal (mg/kg)- LD₅₀**	20,000+	2,000+20,000	200-2,000	0 to 200
Inhalation (mg/l) - LC₅₀***	20+	2.0-20	0.2-2.0	0-0.2

* Labeling that gives a general description of chemical toxicity.

** The dose that was lethal to 50% of the animals to whom the chemical was administered.

*** The concentration that was lethal to 50% of the animals to whom the chemical was administered.

Source: Dawson and Eddleston et. al., "Acute Lethal Toxicity of Agricultural Pesticides: a Prospect Cohort Study," PLoS Medicine, 2007.

Chronic toxicity is caused by prolonged exposure to a substance due to common/regular use, or by a substance that persists in the body. Exposure to toxic chemicals can also lead to chronic oral, dermal, and inhalation of toxic substances, non-cancer chronic effects, and cancer. In addition, EPA tests for birth defects to the child of an exposed pregnant female, how pesticide exposure affects the ability of a test animal to reproduce, a pesticide's potential to affect the cell's genetic components (resulting in mutation), and the potential to disrupt the endocrine system and disturb hormone production. There are no reliable methods to determine exact chronic toxicities besides knowledge that chronic exposure to certain chemicals has been linked to these various symptoms.

Whether the exposure to a pesticide is acute or chronic, it is important to have an understanding of the pesticides that have been linked to human illness and mortality. In 2009 alone, there were 92,000 cases of human exposure to pesticides, ranging from minor to fatal.

The following table lists the top ten pesticides that have been linked to major poisonings, injuries, and illnesses, according to 2004 data from the American Association of Poison Control Centers Toxic Exposure Surveillance System. Although these are not the only pesticides that should be avoided due to health effects, it is important to be aware of highly toxic pesticide products when determining what pesticide(s) to use for a particular application.

Table 4.5 – Top 10 Pesticides Linked to Major Poisonings, Injuries, and Illnesses

Rank	Pesticide or Pesticide Class	Major Exposures	Total Exposures
1	Organophosphates (Orthene, Diazinon, Monitor)	56	5,874
2	Pyrethrins and pyrethroids (Capture, Ammo, Tame)	36	23,726
3	Anticoagulant Rodenticides (Quintox, Rampage, ZP)	23	16,354
4	Carbamate Insecticides (Tamik, Award, Larvin)	13	3,632
5	Chlorinated Hydrocarbons (Kelthane, Phaser, Thiodan)	9	1,228
6	Glyphosate (Helosate, Monterey, Eraser 41)	6	4,425
7	Strychnine (Certox, Ro-Dex, Sanaseed)	6	121
8	Chlorophenoxy (Weedar, Butoxone, Butyrac)	3	2,339
9	Bromethalin (Talprid, Fastrac, Motomco)	3	643
10	Paraquat (AGreen, Solera, Silicone)	2	57
11	All other pesticides and pesticide related products	219	102,754

Source: Watson et. al., American Association of Poison Control Center's Toxic Exposure Surveillance System, 2004.

Chapter 5: Evaluating Pesticide Risks in the Environment

As previously discussed, chemical and physical properties are an important part of understanding how a given pesticide will react when applied to the environment. This chapter is intended to help IPM Coordinators evaluate the vulnerability of a geologic area in a park to groundwater contamination from the surface application of a pesticide. Note: it is important to obtain and read the full pesticide label for complete information. Labels may be downloaded from the websites listed in Appendix E.

Current environmental models have been developed to assess the potential environmental impacts and risks of a proposed pesticide in relation to the park's unique environmental conditions. EPA provides several models that are appropriate for aquatic, terrestrial, atmospheric, and health evaluations (www.epa.gov/pesticides/science/models_pg.htm). Each model has advantages and limitations. It is important to determine which is most appropriate for your site and conditions.

Below are two examples for evaluating relative environmental impacts of various pesticides:

- **DRASTIC Model** – This model is designed to be used in any of the 15 eco-regions of the U.S. It incorporates several parameters to characterize the hydrogeological setting and evaluate groundwater pollution risk. Each of these parameters is part of a weighted model, resulting in a map of relative sensitivity within the region with a rated scale of 1 to 10. Areas with a rating of 8, 9, or 10 are highly sensitive to contamination. The DRASTIC¹² Model determines a qualitative risk of low, medium, or high rating;
- **Relative Aquifer Vulnerability Evaluation (RAVE) Model** – This model provides a scaled numeric scoring system for evaluating potential on-site groundwater contamination by pesticides, *mainly in arid regions such as the Southwest*. It includes nine factors, and scores can be assigned by completing a simple site inspection.

Data Sources

Parks can contact the following sources for information on the hydrology and soils in their area:

- **The US Geologic Survey (USGS)** provides technical information on hydrology, geology, and geography. For information on aquifers, visit: <http://water.usgs.gov/ogw/basics.html>.
- **Water Information For the Nation** provides information on surface water and groundwater and the effects of pesticides. For more information, visit: <http://waterdata.usgs.gov/nwis>.
- **The National Conservation Resource Service (NRCS)** works with landowners through conservation planning and assistance designed to benefit the soil, water, air, plants, and animals and result in productive lands and healthy ecosystems. NRCS provides soil maps and data online for more than 95 percent of the nation's counties, and the organization anticipates having 100 percent in the near future. www.nrcs.usda.gov/wps/portal/nrcs/site/national/home/
- **WSS-Web Soil Survey (WSS)** provides soil data and information produced by the National Cooperative Soil Survey and provides access to the largest natural resource information system in the world. The site is updated and maintained online as the single authoritative source of soil survey information. websoilsurvey.nrcs.usda.gov/app/HomePage.htm

¹² **D**epth to water, **N**et recharge, **A**quifer media, **S**oil media, **T**opography, **I**mpact of the vadose zone, and hydraulic **C**onductivity

- **National Soil Survey Center** provides assistance on policy, technical guidance, procedures, and standards; soil investigations; soil survey laboratory functions; developing handbooks and manuals to guide soil survey operations; training on a group and individual basis; developing and maintaining soil survey data and information systems; planning regional work planning conferences; liaison support to National Soil Survey Center Regional Agriculture Experiment Station Soil Survey Committees; and technical coordination at the national level (soils.usda.gov/about/nssc)
- **Soil Web App** is an interactive map that allows you to explore USDA-NCSS soil survey data for locations throughout most of the U.S. It is compatible with smartphones, tablets, and desktop computers (casoilresource.lawr.ucdavis.edu/gmap).

The DRASTIC Model

The DRASTIC model is a qualitative method that can be used to understand which large geologic areas (or regions) are more or less likely to be impacted by pollutant-contaminated surface waters migrating into groundwater aquifers. [EPA DRASTIC guidance document (EPA, 1987)]

The DRASTIC model is a useful tool to evaluate relative groundwater vulnerability to pesticide contamination. It should be noted that, although the DRASTIC model will help guide you on the impact of a pesticide application, it is not the only factor to consider. This model should be used along with quantitative human and environmental exposure risk data to make a final determination on pesticide use.

The DRASTIC model contains two main parts: 1) the designation of geologic/hydrogeological units (e.g., depth to water, net recharge) and 2) the application of DRASTIC ratings for each unit. This combination of data provides users with information to identify regions where groundwater is more or less susceptible to impacts from pollution.

To simplify the characterization of each application area, the DRASTIC model standardizes 15 regions within the United States. Each region is defined by typical geologic and hydrogeology features and characteristics in that region. The list of regions is as follows:

1. Western Mountain Ranges
2. Alluvial Basins
3. Columbia Lava Plateau
4. Colorado Plateau and Wyoming Basin
5. High Plains
6. Non-glaciated Central Region
7. Glaciated Central Region
8. Piedmont and Blue Ridge
9. Northeast and Superior Uplands
10. Atlantic and Gulf Coastal Plain
11. Southeast Coastal Plain
12. Alluvial Valleys
13. Hawaiian Islands
14. Alaska
15. Puerto Rico and Virgin Islands

Region descriptions should be used in site-specific evaluations of where pesticides will be applied and should be used to complement all factors described in this model.

The DRASTIC ratings, from which the model gets its name, consist of the most significant, mappable geologic and hydrogeologic factors, correlated with a weighted score for each. These factors include:

- D = Depth to groundwater
- R = (Net) Recharge of groundwater
- A = Aquifer type
- S = Soil media
- T= Topography (Slope)
- I = Impact of vadose zone media
- C = (Hydraulic) Conductivity of the aquifer

The score that is computed by this model identifies areas that are more likely to be susceptible to groundwater contaminations, relative to one another. The higher the score, the more likely the chances are for contamination. Table 5.1 provides general information on DRASTIC score meanings. NOTE: These are not absolute answers, but are intended as guidance for the user's discretion.

Table 5.1 – Total DRASTIC Score

Low Risk	Moderate Risk	High Risk
>100	100-200	<200

Source: "U.S. Environmental Protection Agency, "EPA DRASTIC Guidance Document," 1987

Each of these factors is explained in the sections below.

Depth to Groundwater

The distance between the application of a pesticide and groundwater is important because the longer the pesticide has to travel, the greater the opportunity for oxidation from atmospheric oxygen and biological process from soil and rock contact. These processes reduce the chance for pesticides to reach groundwater systems in a form that is harmful to humans and the environment. Groundwater depths, their DRASTIC ratings, and weighted scores are shown below in Table 5.2.

Table 5.2 – Depth to Groundwater Scores

Depth to Groundwater (Feet)	Rating	Weighted Score (rating x 5)
100	4	20
75-10	5	25
50-75	6	30
30-50	7	35
15-30	8	40
5-15	9	45
0-5	10	50

Source: "U.S. Environmental Protection Agency, "EPA DRASTIC Guidance Document," 1987

Net Recharge

Groundwater recharge is a hydrologic process in which water moves downward from the surface to groundwater. Groundwater recharge can move pesticides off site from the surface area and to the water table. The less water introduced to the environment after a pesticide has been applied, the less chance for the chemical to migrate from the application site to groundwater. The DRASTIC rating for net recharge describes the effect of the precipitation that reaches groundwater has on an application area. Groundwater recharge amounts with their DRASTIC ratings and weighted scores are shown in Table 5.3.

Table 5.3 – Net Groundwater Recharge Scores

Net Recharge (Inches per year)	Rating	Weighted Score (rating x 4)
0-2	1	4
2-4	3	12
4-7	6	24
7-10	8	32
10+	9	36

Source: "U.S. Environmental Protection Agency, "EPA DRASTIC Guidance Document," 1987

Aquifer Media

An aquifer is a wet underground layer of water-bearing permeable rock or unconsolidated materials (e.g., gravel, sand, or silt) containing groundwater. The type of aquifer material can dictate if and how contaminated surface waters come in contact with the groundwater. The smaller the fractures and grain size, the less permeable an aquifer material is to water. An aquifer that is less permeable, in general, has a higher attenuation capacity and decreased chance for pesticide-contaminated water to further affect the groundwater source. Table 5.4 lists the various aquifer materials with their DRASTIC ratings and weighted scores.

Table 5.4 – Net Recharge Scores

Aquifer Material	Rating	Weighted Score (rating x 3)
Massive Shale	2	6
Metamorphic/Igneous	3	9
Weather Metamorphic/Igneous	4	12
Bedded Sedimentary	5	15
Massive Sandstone	6	18
Massive Limestone	7	21
Sand and Gravel	8	24
Basalt	9	27
Karst Limestone	10	30

Source: "U.S. Environmental Protection Agency, "EPA DRASTIC Guidance Document," 1987

Soil Type

The DRASTIC Model refers to soil as the uppermost portion of the vadose zone, usually the weathered portion of the earth, about six feet in depth. The type of soil in an application area will affect how the pesticide moves along the surface and through the soil to groundwater and can also influence biological activity such as adsorption and oxidation. The porosity of soil determines the amount of surface water runoff versus the amount of water moving down through the soil toward the groundwater. There are a range of soil types, with clays being least porous and gravel being the most porous. A listing of soil types and their DRASTIC ratings and weighted scores is shown in Table 5.5.

Table 5.5 – Soil Type Scores

Soil Type	Rating	Weighted Score (rating x 5)
Non Shrinking and Non Aggregated Clay	1	5
Muck	2	10
Clay Loam	3	15
Silty Loam	4	20
Loam	5	25
Sandy Loam	6	30
Shrinking and/or Aggregated Clay	7	35
Peat	8	40
Sand	9	45
Gravel	10	50
Thin or Absent	10	50

Source: "U.S. Environmental Protection Agency, "EPA DRASTIC Guidance Document," 1987

Topography

The slope or downgrade of the pesticide application area influences the amount of runoff that is possible. A flatter surface allows for contaminated water to seep into the soil and potentially reach the groundwater. Therefore, a higher slope is considered to present less of a risk to groundwater. However, when applying pesticides to a slope, ensure that there is no runoff into any surface water sources. Table 5.6 presents slope ranges with their DRASTIC ratings and weighted scores.

Table 5.6 – Soil Type Scores

Slope (%)	Rating	Weighted Score (rating x 3)
18+	1	3
12-18	3	9
6-12	3	9
2-6	9	27
0-2	10	30

Source: "U.S. Environmental Protection Agency, "EPA DRASTIC Guidance Document," 1987

Impact of the Vadose Zone Media

The vadose zone is the layer of material above the water table that extends up to the surface. This zone is classified by unsaturated or intermittently saturated media. A less permeable vadose layer reduces the chance for interaction with a groundwater aquifer. The type of material (media) in the vadose zone also determines biological processes that can reduce the impact of pesticides on groundwater. Processes such as biodegradation, neutralization, and dispersion are all examples of process that can reduce significant pollutant impacts to groundwater. Table 5.7 lists vadose zone media with their DRASTIC ratings and weighted scores.

Table 5.7 – Vadose Zone Media Scores

Vadose Zone Media	Rating	Weighted Score (rating x 4)
Containing Layer	1	4
Silt/Clay	3	12
Shale	3	12
Metamorphic/ Igneous	4	16
Limestone	6	24
Sandstone	6	24
Bedded Sedimentary	6	24
Sand and Gravel with Silt and Clay	6	24
Sand and Gravel	8	32
Basalt	9	36
Karst Limestone	10	40

Source: "U.S. Environmental Protection Agency, "EPA DRASTIC Guidance Document," 1987

Hydraulic Conductivity

Hydraulic conductivity is a property of soil or rock that describes the ease with which water can move through pore spaces or fractures. Hydraulic conductivity depends on the permeability of the material and on the degree of saturation. A material with high hydraulic conductivity allows more water to flow through it; the higher the hydraulic conductivity of a material, the greater the potential for groundwater pollution. Hydraulic conductivity ranges with corresponding DRASTIC ratings and weighted scores are presented in Table 5. 8.

Table 5.8 – Hydraulic Conductivity Scores

Hydraulic Conductivity (GPD/FT)	Rating	Weight (Multiply by 2)
1-100	1	2
100-300	2	4
300-700	4	8
700-1000	6	12
1000-2000	8	16
2000+	10	20

Source: "U.S. Environmental Protection Agency, "EPA DRASTIC Guidance Document," 1987

Using the DRASTIC Model

Using the DRASTIC Model is relatively straightforward. This model is useful for areas of 100 acres or more. The general steps to use the model are as follows:

1. Identify the region in which the area is located.
2. Identify which hydrogeologic setting most closely approximates the conditions of the area of proposed pesticide application.
3. Obtain information for each DRASTIC parameter. It is acceptable to average or estimate appropriate values to complete each parameter (see "Data Sources" below).
4. Determine the range of values for each parameter.
5. Each range of values equates to a rating. Determine the rating for each parameter (see Tables 5.2-5.8 above).
6. Multiply each rating by the weight (see Tables 5.2-5.8 above).
7. Add all parameters and evaluate that number to determine relative risk.

Assumptions

The DRASTIC Model only works under the following assumptions:

- The contaminant (pesticide) is introduced at the ground surface;
- The contaminant is flushed into the groundwater by precipitation;
- The contaminant has the mobility of water; and
- The parameters for the model apply to an area of at least 100 acres.

Data Sources

In order to apply the DRASTIC Model, you must first obtain reliable and accurate data for all seven parameters described above. The less data you have, the less accurate the model becomes. The most common sources of information for each parameter are listed in Table 5.9.

Table 5.9 – Sources for DRASTIC Parameters

Source of Information	Depth to Water	Net Recharge	Aquifer Media	Soil Media	Topography	Vadose Media	Hydraulic Conductivity of the Aquifer
USGS	✓	✓	✓		✓	✓	✓
State GS	✓	✓	✓			✓	✓
State Department of Natural Resources	✓	✓	✓			✓	✓
State Department of Environmental Protection	✓	✓	✓			✓	✓
U.S. Department of Ag-Soil Conservation Service	✓	✓		✓	✓		
Clean Water Act “208” and Regional Planning Authorities	✓	✓	✓			✓	✓
County and Regional Water Supply Agencies and Companies	✓		✓			✓	✓
Private Consulting Firms	✓		✓			✓	
Related Studies	✓		✓			✓	
Professional Societies (ex. GSA)	✓	✓	✓			✓	✓
Colleges and Universities	✓	✓	✓			✓	✓
Other Federal/ State Agencies (ex NOAA)	✓	✓	✓			✓	

Source: “U.S. Environmental Protection Agency, “EPA DRASTIC Guidance Document,” 1987

Evaluating Each Parameter

When evaluating an area for vulnerabilities, each parameter needs to be evaluated individually and then collectively to obtain the relative DRASTIC vulnerability score. There should be a general understanding of each parameters relative risk.

In Example A, most parameters are in the moderate range, and the total score is also in the moderate range (see Table 5.1). In Example B, there are three high risk parameters and four low risk parameters, with the total score indicating a moderate risk. Although both examples have an overall moderate risk, Example B has three parameters (depth to water, net recharge, and topography) that indicate a high risk. Therefore, when evaluating a pesticide, it is important to compare each parameter individually and then evaluate the total score as a relative risk indicator.

Example A

Parameter	Site-Specific Info	Rating	Pesticide Weighted Risk
Depth to Water	25 ft.	8	40
Net Recharge	3 in	3	12
Aquifer Media	Massive Sandstone	6	18
Soil Media	Muck	2	10
Topography	13%	3	9
Valdose Zone	Sandstone	6	24
Hydraulic conductivity	600 GPD/FT	4	8
DRASTIC VULNERABILITY SCORE			121

Example B

Parameter	Site-Specific Info	Rating	Pesticide Weighted Risk
Depth to Water	5 ft.	10	50
Net Recharge	20 in	9	32
Aquifer Media	Massive Shale	1	3
Soil Media	Muck	2	10
Topography	1%	10	30
Valdose Zone	Shale	3	12
Hydraulic conductivity	250 GPD/FT	4	8
DRASTIC VULNERABILITY SCORE			145

The RAVE Model

The RAVE model considers the following parameters to characterize the hydrogeological setting and evaluate groundwater pollution risk assessment:

- Depth to groundwater – The distance in vertical feet below the soil surface to the water table;
- Soil texture – Gravel, sand, loam, or clay;
- Percent soil organic matter – The relative amount of decayed plant residue in the soil may be estimated by soil color. Darker color generally indicates higher organic matter;
- Topographic position – The physical surroundings of the area where the pesticide application is to be made:
 - Flood Plain – within a river or lake valley
 - Alluvial Bench – lands immediately above a river or lake valley
 - Foot Hills – rolling uplands near mountains
 - Upland Plains – high plains not immediately affected by open water or mountains
- Annual precipitation – Inches of precipitation per year;
- Distance to surface water – The distance in feet from treatment boundary to the nearest flowing or stationary surface water;
- Application frequency – The number of times in a year that the pesticide is applied;
- Application method – How the pesticide is applied, either directly to soil or onto plants (foliar); and
- Leaching potential – The potential for the pesticide to move downward in soil and ultimately contaminate groundwater. This ranking is based on the persistence and mobility of the pesticide used.

The table below can be used to determine the value for each of the nine RAVE factors.

Table 5.10 – RAVE Factor Scores

<u>Depth to Groundwater</u> <ul style="list-style-type: none"> ○ 2 to 10 feet: 20 ○ 10 to 25 feet: 12 ○ 25 to 50 feet: 5 ○ > 50 feet: 0 	<u>Topographic Position</u> <ul style="list-style-type: none"> ○ Flood Plain: 15 ○ Alluvial Bench: 10 ○ Rolling Foothill: 5 ○ Upland Plain: 2 	<u>Pesticide Application Frequency</u> <ul style="list-style-type: none"> ○ Once/year: 5 ○ Once/year: 2 ○ < Once/year: 1
<u>Soil Texture</u> <ul style="list-style-type: none"> ○ Gravelly: 15 ○ Sandy: 15 ○ Loamy: 10 ○ Clayey: 5 	<u>Distance to Surface Water</u> <ul style="list-style-type: none"> ○ 0 to 100 feet: 5 ○ 100 to 500 feet: 3 ○ > 500 feet: 2 	<u>Pesticide Application Method</u> <ul style="list-style-type: none"> ○ Soil Applied: 5 ○ Foliar Applied: 2
<u>Percent Soil Organic Matter</u> <ul style="list-style-type: none"> ○ 0% to 1%: 5 ○ 1% to 3%: 3 ○ > 3%: 2 	<u>Annual Precipitation</u> <ul style="list-style-type: none"> ○ 60 inches: 5 ○ 30 to 60 inches: 2 ○ < 30 inches: 0 	<u>Pesticide Leaching Potential</u> <ul style="list-style-type: none"> ○ High: 20 ○ Moderate: 10 ○ L: 5

Source: National Park Service, Southern Utah Group, "Appendix G: RAVE Model (Relative Aquifer Vulnerability Evaluation Model)," Exotic Plant Management Plan, Environmental Assessment.

The values for each factor are then added together to get a final score for the application. The final score indicates the relative threat to groundwater, as follows:

- 65 -100 – High potential for groundwater contamination.
- 45 to 65 – Moderate to low potential for groundwater contamination.
- 45 or less – Low potential for groundwater contamination.

Example

A pesticide application has the following characteristics and RAVE factor scores:

- There is a 10-25 foot distance to groundwater; factor score = 12
- There is a 100-500 foot distance to surface water; factor score = 3
- The application is on rolling foothills (topographic position); factor score = 5
- The soil texture is sandy; factor score = 15
- Annual precipitation is 60 to 60 inches; factor score = 2
- The soil contains greater than 3% organic matter; factor score = 2
- Application occurs more than one time per year ranks; factor score = 5
- Foliar application; factor score = 2
- Pesticide leaching potential is high; factor score = 20 points.

The example above has a total RAVE score of 66, which ranks just above moderate concern.

Chapter 6: Risk Assessments

The USFS and the Bureau of Land Management (BLM) have developed human health and ecological risk assessments and guidance documents on several active ingredients and pesticides. The NPS IPM Coordinators are encouraged to use these assessments as references when evaluating NPS pesticide use proposals. In Table 6.1 below, click on the active ingredient name to see the USFS and or BLM Risk Assessment.

Table 6.1 – USFS Risk Assessments

Herbicides	Insecticides
<u>Aminocyclopyrachlor</u> (1.8 MB PDF) <u>Aminocyclopyrachlor EPA Bibliography</u> (320 KB PDF)	<u>Btk</u> (850 KB PDF)
<u>Aminopyralid</u> (1.38 MB PDF)	<u>Carbaryl</u> (1.72 MB PDF)
<u>2,4-D</u> (1.4 MB PDF)	<u>Diflubenzuron</u> (Dimilin) (1.15 MB PDF)
<u>Chorsulfuron</u> (941 KB PDF)	<u>Dinotefuran</u> (1.63 MB PDF)
<u>Clopyralid</u> (940 KB PDF)	<u>DDVP</u> (551 KB PDF)
<u>Dicamba</u> (Vanquish) (1 MB PDF)	<u>Emamectin Benzoate</u> (1.4 MB PDF)
<u>Endothall</u> (1.28 MB PDF)	<u>Gypchek</u> (414 KB PDF)
<u>Fluridone</u> (1.1 MB PDF)	<u>Imidacloprid</u> (1.25 MB PDF)
<u>Fluroxypyr</u> (1.4 MB PDF)	<u>Lambda-Cyhalothrin</u> (1.54 MB PDF)
<u>Glyphosate</u> (Accord, Rodeo, Roundup, Roundup Pro) (1.84 MB PDF)	<u>Malathion</u> (1.93 MB PDF)
<u>Glyphosate Appendices</u> (1.3 MB PDF)	<u>Tebufoenozide</u> (Mimic) (884 KB PDF)
<u>Hexazinone</u> (1.3 MB PDF)	
<u>Imazamox</u> (1.3 MB PDF)	
<u>Imazapic</u> (602 KB PDF)	
<u>Imazapyr</u> (Arsenal, Chopper, Stalker)(1.8 MB PDF)	
<u>Metsulfuron Methyl</u> (Escort) (928 KB PDF)	
<u>Oxyfluorfen</u> (1.16 MB PDF)	

<u>Picloram</u> (2.37 MB PDF)	
<u>Sethoxydim</u> (Poast) (603 KB PDF)	
<u>Sulfometuron Methyl</u> (876 KB PDF)	
<u>Triclopyr</u> (2.37 MB PDF) <u>Triclopyr APPENDICES</u> (946 KB PDF)	
<u>Trifluralin</u> (2.16 MB PDF)	
Pheromones	Fungicides
<u>Disparlure</u> (413 KB PDF)	<u>Borax</u> (621 KB PDF)
<u>Methylcyclohexene-1-one</u> (MCH) (267 KB PDF)	
<u>Verbenone</u> (240 KB PDF)	
Other Risk Assessments	
<u>Aqueous Chlorine-Based Antimicrobial/Disinfectant</u> (999 KB PDF)	
<u>Gypsy Moth Risk Comparison</u> (570 KB PDF)	
<u>Marker Dyes</u> (204 KB PDF)	
<u>Neurotoxicity, Immunotoxicity, and Endocrine Disruption with Specific Commentary on Glyphosate, Triclopyr, and Hexazinone: Final Report</u> (251 KB PDF)	
<u>Preparation of Environmental documentation and Risk Assessments</u> (992 KB PDF)	
<u>Rotenone</u> (1.64 MB PDF)	
<u>Strychnine</u> (2.46 MB PDF)	
<u>Surfactants Effects on Glyphosate Toxicity</u> (149 KB PDF)	
<u>Tussock Moth Biocontrol Toxicity</u> (198 KB PDF)	
<u>An Evaluation of Gleams-Driver for Estimating Concentrations of Pesticides in Surface Water</u> (851 KB PDF)	
<u>Technical Comparison of EPA, BLM and Forest Service Pesticide Risk Assessments</u> (198 KB PDF)	
<u>Worker Exposure 2012</u> (1.8 MB PDF) <u>Worker Exposure 2012 Appendices</u> (236 KB DOCX)	

Source: www.fs.fed.us/foresthealth/pesticide/risk.shtml

The BLM has prepared risk assessments on 18 active ingredients for which an analysis of risks to humans and non-target plants and animals was conducted for the U.S. Department of Agriculture. The following active ingredients are in herbicides approved for use on BLM lands in 17 western states:

- 2,4-D
- Bromocil
- Chlorsulfuron
- Clopyrralid,
- Dicamba
- Diflufenzopyr (in formulation with dicamba, known as the product Overdrive)
- Diquat
- Diuron
- Fluidone
- Glyphosate
- Hexazinone
- Imazapic
- Imazypyr
- Metulfuron methyl
- Picloram
- Sulfometuron methyl
- Tebuthiuron
- Triclopyr

The risk assessments for each of the above chemicals are available in the BLM 2007 Record of Decision on herbicide active ingredients at:

www.blm.gov/pgdata/etc/medialib/blm/wo/Planning_and_Renewable_Resources/veis/dear_reader_letter.Par.95872.File.dat/RecordofDecision.pdf.

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Appendix A - An 11 Step Process for Developing and Implementing an IPM Strategy

National Park Service
U.S. Department of the Interior

Integrated Pest Management Program
Biological Resource Management Division



11 Step Process to Developing and Implementing an Integrated Pest Management Strategy August 7, 2006

1. Describe your site management objectives and establish short and long term priorities.
2. Build consensus with stakeholders-occupants, decision makers and technical experts (ongoing).
3. Document decisions and maintain records.
4. Know your resource (site description and ecology).
5. Know your pest. Identify potential pest species, understand their biology, and conditions conducive to support the pest(s) (air, water, food, shelter, temperature, and light).
6. Monitor pests, pathways, and human and environmental factors, including population levels and phenological data.
7. Establish "action thresholds," the point at which no additional damage or pest presence can be tolerated.
8. Review available tools and best management practices. Develop a management strategy specific to your site and the identified pest(s). Tools can include: 1) no action, 2) physical, 3) mechanical, 4) cultural, 5) biological, and 6) chemical management strategies.
9. Define responsibilities and implement the lowest risk, most effective pest management strategy, in accordance with applicable laws, regulations, and policies.
10. Evaluate results; determine if objectives have been achieved; modify strategy if necessary (adaptive management).
11. Education and outreach. Continue the learning cycle, return to Step 1.

US Fish and Wildlife Service
National Conservation Training Center



National Park Service
U.S. Department of the Interior

Integrated Pest Management Program
Biological Resource Management Division



- Is it a pest? (Is it interfering with your management objectives?)
- Is it a native or nonnative organism?
- What conditions foster the pest?
- What management zone is it in?
- What are the chances of successful management?



Appendix B - Example Annual Pesticide Use Reporting Call Memo



United States Department of the Interior

NATIONAL PARK SERVICE

1849 C Street, N.W.
Washington, D.C. 20240

IN REPLY REFER TO:

N50 (2301)

MAY 07 2012

Memorandum

To: Regional Directors

From: Associate Director, Natural Resource Stewardship and Science

Subject: Reporting 2011 Use of Pesticides, Biological Control Agents and Genetically Modified Organisms

Reply Due: June 8, 2012

The National Park Service (NPS) is required to record and annually report its use of the pesticides in accordance with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA, U.S. 16, Sec. 136r-7), Department of the Interior - Departmental Manual 517 Integrated Pest Management (IPM), and NPS Policy, and to meet its administrative record keeping responsibilities to the National Archives and Records Administration, pursuant to Title 44 USC and Title 36 CFR Chapter 7 concerning the use pesticides, biological control agents, and genetically modified organisms (GMOs) for pest management purposes within the units of the National Park System.

To meet these reporting requirements, please ensure that all 2011 data on park pesticide use is entered into the Pesticide Use Proposal System database and use of biocontrol agents and GMOs reported to your Regional IPM Coordinator no later than **June 8, 2012**. Future pesticide proposals cannot be reviewed or approved until the previous year's use logs are completed. Specific guidance on past and proposed use of biological control agents, GMOs, and pesticides, is available under Resources and Links at <http://www1.nrintra.nps.gov/BRMD/ipm/>.

For additional information, please contact Carol DiSalvo, Servicewide IPM Coordinator, at 202-513-7183, or carol_disalvo@nps.gov.

Cc:

WASO-PFM-T. Harvey;
WASO-PH-C.Higgins;
WASO-PPSS-P.Gregorson;
WASO-RM-R.Powell;
WASO-CS-J. Pendry

Appendix C - Servicewide and Regional IPM Coordinators

CAROL DISALVO

Servicewide IPM Coordinator
National Park Service
Biological Resources Mgmt. Div. MS 2430

1201 I (Eye) Street
11th Fl., Cube #48,
Washington, DC 20005

202-513-7183 office
703-638-0461 blackberry
202-371-2131 fax
Carol_DiSalvo@nps.gov

JAMES C. HOWARD IV

IPM Program Biotech
National Park Service
Biological Resources Mgmt. Div.
Natural Resource Stewardship and Science

1201 Oakridge Drive, Suite 200
Fort Collins, CO 80525

970-267-2130 office

James_C_Howard@nps.gov

BRUCE BADZIK

IPM Coordinator
Golden Gate NRA
National Park Service

Bldg.201 Ft. Mason
San Francisco, CA 94123

415-561-2893
415-441-6538 fax
Bruce_Badzik@nps.gov

MYRON CHASE

IPM Coordinator
Intermountain Region
National Park Service

IMDE-DNR
12795 W. Alameda Parkway
Lakewood, CO 80228-2838

303-969-2863
303-969-2717 fax
Myron_Chase@nps.gov

CHRIS FURUERON

Program Coordinator for
IPM and Exotic Plant Management Teams
Southeast Region
National Park Service

1924 Building
100 Alabama Street, SW
Atlanta, GA 30303

404-507-5812
404-562-3201 fax
404-569-6687 cell
Chris_furqueron@nps.gov

ERV GASSER

IPM Coordinator
Pacific West Region
National Park Service

Pacific West Region
909 First Avenue
Seattle, WA 98104

206-220-4263
206-220-4160 fax
Erv_gasser@nps.gov

WAYNE MILLINGTON

IPM Coordinator
Northeast Region
National Park Service

424 Forest Resources Bldg
University Park, PA 16802

814-863-8352

814-863- 2621 fax

<http://www.nps.com/nero/ipm>

PAT OWEN

IPM Coordinator
Alaska Region
National Park Service

Denali National Park and Preserve
Mile 237 Parks Highway
Denali Park, AK 99755

MAILING ADDRESS:

Denali National Park and Preserve
P.O. Box 9
Denali Park, AK 99755

907-683-9547

907-683-9639 fax

Pat_Owen@nps.gov

JOHN SOWL

IPM Coordinator
Midwest Region
National Park Service

601 Riverfront Drive
Omaha, NE 68102-4226

(402) 661-1872

(402) 661-1983 fax

John_Sowl@nps.gov

JIL SWEARINGEN

IPM and Invasive Species Coordinator
National Capital Region
National Park Service

Center for Urban Ecology
4598 MacArthur Blvd., NW
Washington, DC 20007

202-342-1443 X 218

202-282-1031 fax

jil_swearingen@nps.gov

Appendix D - Sources for Pesticide Labels and Chemical Information

The best place to start when reviewing a pesticide is to obtain and review the pesticide label. Labels can be obtained by contacting the manufacturer and by using one of the databases listed below.

Active Ingredients and Pesticide Labels

1. [NPIRS Pesticide Products Information System \(PPIS\)](#) - Purdue University The National Pesticide Information Retrieval System (NPIRS) uses data from [U.S. EPA's Pesticide Product Information System \(PPIS\)](#) to retrieve information on EPA-registered and cancelled pesticide products, chemical ingredients, and firms/registrants.
2. (IRMA USING THIS ONE NOW) [Pesticide Product Label System \(PPLS\)](#) - Environmental Protection Agency (EPA) Search for pesticide product labels by EPA Registration number.
3. [CDPR Databases](#) - California Department of Pesticide Regulation (CDPR) Search for chemical ingredients, products, labels and registrant information for pesticide products registered in California.
4. [CDMS Label and MSDS Database](#) - Crop Data Management System, Inc. This collection includes product labels and MSDS for agricultural pesticide products.
5. [Pesticide Manufacturers](#) - NPIC Find their websites, contact information, and direct links to their product search interfaces.
6. EPA Chemical Pesticide Search *Conventional, Antimicrobial, and Biopesticide Active Ingredients* <http://iaspub.epa.gov/apex/pesticides/f?p=CHEMICALSEARCH:1:0::NO:1::>

Analyzing Pesticide Risks

1. [Household Products Database](#) - National Library of Medicine This database includes health and safety information on household products.
2. [DOD Standard Pesticides and Pest Control Equipment Lists](#) - Armed Forces Pest Management Board These lists include product labels and MSDS for each product.
3. [National Pesticide Information Retrieval System \(NPIRS\) Searchable Databases](#) - Purdue University This collection of pesticide-related databases is available through subscription.
4. ~~[2014 Georgia Pest Management Handbook](#) - The University of Georgia's College of Agriculture and Environmental Sciences handbook. Online version is available for free.~~

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS, Integrated Pest Management Program, January, 2013

National Park Service
U.S. Department of the Interior



Natural Resource Stewardship and Science

1201 Oakridge Drive, Suite 150

Fort Collins, CO 80525

www.nature.nps.gov

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