

South East IPMT Herbicide Training

What Is an Herbicide?

Herbicides are substances, often chemical, which are toxic to plants and are used to destroy or manage unwanted vegetation. We use herbicides as one weed management tool in our toolbelt for removing invasive plants from our National Parks. There are a variety of different kinds of herbicides, but two major groups we typically use are Selective and Non-Selective herbicides. Selective herbicides are designed to affect specific groups of plants, while non-selective herbicides are designed to affect all plants.

Why Do We Use Herbicides?

1. Herbicides allow us to control invasive vegetation safely and effectively
2. When used correctly, herbicides greatly reduce the need for retreatment
3. Environmentally “safe,” when applied appropriately

NPS Herbicide Use Policy

The Regional IPM Coordinator, prior to use in National Parks, must approve all herbicides. Herbicides labeled as restricted use by the U.S. Environmental Protection Agency require permission from the Washington Office through the regional IPM coordinator for use. Restricted use herbicides contain chemicals that may bio-accumulate, remain persistent in soil or groundwater, have an increased ability to cause off target damage or be hazardous to the applicator or resource. Annual herbicide usage must be reported by park staff.

Labels and the Law

Prior to mixing, handling, or applying any herbicide, individuals **must** read and understand the label. It is a violation of Federal law to use an herbicide in a manner inconsistent with its label. In short, **the label is the law!**

The label provides the following information:

- Product trade name
- Manufacturer
- Signal word *
- EPA Registration Number
- Hazards to applicator
- Environmental hazards
- First aid recommendations
- Site specific information
- Emergency spill procedures and contacts

You MUST Read and Understand the Label, Prior to Use!

Signal Words

Nearly all chemicals, household cleaners, or fuels have a label with a signal word. These words describe the acute (short term) toxicity of the chemical based on all routes of exposure; oral, dermal, inhalation, and other effects like eye and skin irritation. Herbicide labels always have one of three signal

words printed in bold letters to indicate their level of toxicity to people. These indicators can assist applicators in selecting the least toxic herbicides and heighten awareness when handling more toxic formulations. Applicators should recognize that the chemical continues to have the potential to be harmful despite the signal word. Signal words are ranked as follows:

1. **Caution** indicates the pesticide product is slightly toxic if eaten, absorbed through the skin, inhaled, or it causes slight eye or skin irritation
2. **Warning** indicates the pesticide product is moderately toxic if eaten, absorbed through the skin, inhaled, or it causes moderate eye or skin irritation to an applicator if used or handled incorrectly
3. **Danger** indicates the pesticide product is highly toxic by at least one route of exposure. It may be corrosive, causing irreversible damage to the eyes or skin. 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.

When mixing an herbicide that has the signal word **caution** with a surfactant that has a signal word of **warning**, follow the safety precautions that fit the **warning** label. Essentially, always follow the precautions for the more damaging chemical while mixing.

$$\text{Risk} = \text{Toxicity} \times \text{Exposure}$$

Herbicide Modes of Action

Mode of Action: Describes a functional or anatomical change, resulting from a living organism to a substance. Within the context of herbicide treatments, mode of action describes the way in which a plant is affected by the herbicide.

Half-Life: Describes the time required for an herbicide to reduce its presence in a given system to half its initial value.

1. **Aminopyralids:** Milestone, Capstone and Opensight
 - a. Mode of Action: Aminopyralids attack plants by confusing their metabolic pathways into thinking the herbicide is a growth hormone, which the plant then consumes until it dies. Aminopyralids are selective herbicides that focus on annual, biennial and perennial broadleaf weeds, as well as some woody plants.
 - b. Half-Life: Aminopyralids have shown to have an average half-life of 34.5 days in North American sites. They are also mobile within soils.
2. **Glyphosate:** Roundup, Accord, and Rodeo
 - a. Mode of Action: Glyphosate products attack plants by inhibiting the creation of amino acids and other vital processes within the plant. After being absorbed by the plant, Glyphosate is moved throughout the plant to all meristematic (actively growing) areas. This prevents the plant from growing, but also causes a build-up of resources within the plant, diverting these resources and energy away from other necessary processes, killing the plant. Glyphosate is non-selective used to control most annual and perennial plants.
 - b. Half-Life: Glyphosate has shown a half-life of between 2 to 197 days, with an average of 47 days in North American test sites.
3. **Triclopyr:** Garlon3A, Garlon4 Ultra, Element 4, and Remedy
 - a. Mode of Action: Much like Aminopyralids, Triclopyr attacks woody and herbaceous broadleaf plants by confusing the herbicide as a growth hormone, causing the plant to consume it and grow itself to death. Triclopyr is a selective herbicide used for woody and herbaceous plants.

- b. Half-Life: Triclopyr has shown a half-life between 3.7 to 314 days, but with an average half-life of 30 days within soils.
- 4. **Imazapyr:** Arsenal, Chopper, and Stalker
 - a. Mode of Action: Imazapyr is a slow-killing herbicide, which focuses on reducing the production of enzymes within a plant that are required for protein synthesis and cell growth, functionally disabling the plant's ability to grow. Imazapyr is a non-selective herbicide used to control a variety of weeds, including some grasses, broadleaf plants, woody species, and some riparian and emergent aquatic plants.
 - b. Half-Life: Imazapyr has a long half-life, showing between 69-155 days depending on a variety of factors.
- 5. **Imazapic:** Plateau, Plateau Eco-Pak, and Cadre
 - a. Mode of Action: Imazapic, similarly to Imazapyr, kills plants slowly by reducing a plant's ability to create enzymes responsible for amino acid and protein productions. Imazapic is a selective herbicide, covering some perennial grasses and broadleaf weeds.
 - b. Half-Life: Imazapic has shown a half-life between 7 and 150 days, due to a variety of factors.
- 6. **2,4-D:** Navigate, Class, Weed-Pro, and Justice
 - a. Mode of Action: 2,4-D, much like Triclopyr and Aminopyralids, mimic a plant's natural growth hormone, leading to uncontrolled growth which kills the plant. 2,4-D is a selective herbicide that kills dicots.
 - b. Half-Life: 2,4-D has a relatively short half-life in soils, averaging 10 days, though it has been shown between several hours to several months depending on a variety of factors.
 - c. Important Note: "2,4-D is one of the oldest herbicides used in the United States. It was first developed during World War II and became famous as a component of the controversial Agent Orange used during the Vietnam War. Today, 2,4-D continues to be one of the most commonly used herbicides on the market." Weed Control Methods Handbook, The Nature Conservancy, Tu et al.
- 7. **Clopyralid:** Transline, Reclaim, and Curtail
 - a. Mode of Action: Much like 2,4-D, Triclopyr and Aminopyralids, Clopyralids mimic plant growth hormones, causing uncontrolled growth which kills the plant. Clopyralids focus on annual and perennial broadleaf weeds, particularly the sunflower, legume, nightshade, knotweed, and violet families.
 - b. Half-Life: Clopyralid has an average half-life of 40 days but has shown up to one year.
- 8. **Picloram:** Tordon-K, Access, Pathway, and Grazon
 - a. Mode of Action: Picloram operates much like other herbicides by mimicking plant growth hormones, causing unregulated growth which kills the plant. Picloram is a selective herbicide used for the control of annual and perennial broadleaf herbs and woody plants.
 - b. Half-Life: Picloram is not easily degraded in soils and can thus remain in soils for long periods of time, maintaining its plant-killing ability. The average half-life is approximately 90 days, though it has been shown to be between one month to three years.
- 9. **Sethoxydym:** Poast, Torpedo, Ultima, Vantage, Conclude, and Rezult
 - a. Mode of Action: Sethoxydym causes plant death in grasses by shutting down the lipid system, preventing them from building functional cell walls. It is transported throughout the plant rapidly, moving through meristematic tissues, typically absorbed through leaf structures. Sethoxydym is a selective herbicide used to control grasses and some other monocot species.
 - b. Half-Life: Sethoxydym has an average half-life of approximately 5 days, but has shown between a few hours and 25 days, dependent on a variety of soil factors.

Commonly Used Herbicides

Most commonly used herbicides are systemic. This means that they enter the plant through the cambium or through the foliage. They are also categorized as -amine or -ester. Amine herbicides are water based and use salts to stabilize them (i.e. Isopropylamine salt of Glyphosate). Herbicides categorized as -Ester are oil based. These could be mineral oil or petroleum based.

1. **Garlon3A:** Triclopyr-amine 44.4%
 - a. Controls woody stemmed and broad leaf plants
 - b. Becomes adsorbed with soil contact, binding with clay particles – Can have some activity in sandy soils
 - c. Can be applied in cut stump treatments at higher rates (50%) and in foliar applications at reduced rates (.5 – 5%)
 - d. Approved for near and in-water use
 - e. PPE when mixing and applying is eye protection, chemically resistant gloves, long sleeves, boots, and socks
 - f. Garlon3A has a signal word of ***danger*** and has the ability to become a corrosive eye agent, causing irreparable eye damage with prolonged contact – This is caused by the chemical being an alkaline formula much like a strong detergent
2. **Garlon4:** Triclopyr-ester 61.6%
 - a. Controls broad leaf and woody stemmed plants
 - b. Can be applied as a basal treatment when mixed with agricultural oil at moderate rates (10-20%) or in foliar applications (.5- 5%)
 - c. Has the potential to vaporize and be absorbed by overhead foliage in hot and humid conditions
 - d. Not approved for near water use because it has an oil base (ester)
 - e. PPE for mixing is eye protection, chemically resistant gloves, long sleeves, boots, and socks.
 - f. Garlon4 has a signal word of ***caution***
3. **Roundup Pro:** Glyphosate 41% - 17.4% Surfactants
 - a. Can be used to control woody stemmed vegetation in the late summer and fall but is most effective on grasses and perennial weeds – This is a nonselective herbicide
 - b. Chemical is adsorbed upon contact with organic soils – Can remain active in sandy soils
 - c. Can be used in stump cut applications (15-50%) or as a foliar spray (.5- 5%)
 - d. Not approved for near water use because it includes surfactants
 - e. PPE for mixing, handling, and applying is long sleeves, eye protection, socks, and boots
 - f. Signal word is ***caution***
4. **Accord Concentrate:** Glyphosate 41.5% - No additional surfactants
 - a. Can be used to control grasses, perennial weeds, and broad leaf woody plants
 - b. This is a nonselective herbicide
 - c. Can be applied as a foliar spray (.5- 5%) with additional surfactants or as a cut stem treatment (15- 100%)
 - d. Has been approved for near and in water use because of the absence of surfactants
 - e. Surfactants should be added to foliar mixes when possible
 - f. PPE for mixing, handling, and applying is eye protection, long sleeves, socks, and boots
 - g. Signal word is ***caution***
5. **Milestone:** Aminopyralid 40.6%
 - a. Targets legumes, Ailanthus, and thistles
 - b. Not approved for near water use and can be soil active

- c. PPE for mixing, handling and application is chemical resistant
- d. Signal word is **Caution**
- e. Follow manufacturer's guidelines for application rates: One tablespoon per three-gallon backpack typically satisfies the acceptable label rate for spot treatment – Maximum amount for application is 7 ounces per acre per year

Herbicide Fun Fact: The average herbicide costs approximately \$250 Million to produce, and requires 10 years of research and permitting for a new herbicide to be market ready. The patent is in effect for 17 years.

Mixing Herbicides

All herbicides should be mixed according to predetermined specifications using calibrated measuring equipment. All herbicides should be mixed over some form of watertight, chemically resistant container for the safe collection of accidental spills. Proper PPE must always be worn. Exteriors of containers and sprayers should be thoroughly rinsed if herbicide, surfactants and/or dyes are present. All empty herbicide and surfactant containers are required to be triple rinsed when emptied punctured and recycled or disposed of. Dye containers can be disposed of in the same manner.

Care should be taken not to mix Triclopyr and Glyphosate. This creates a substance similar to the consistency of a dissolved paper towel, which clogs and damages sprayers.

Additional dyes tend to be extremely messy and a small amount goes a long way. Use chemically resistant gloves and caution while handling.

Emergency spill kits should always be kept nearby and should be readily available in any mixing or handling situation. All persons must wash hands after mixing, applying, or handling herbicides and prior to eating, drinking, chewing gum, using the toilet, or using tobacco products, even if no herbicide has come in contact with skin. If contact with skin occurs, quickly wash the contaminated areas with soap and water. If irritation occurs, continuously flush with water and seek medical attention.

The smallest amount of concentrated herbicide is recommended when creating herbicide formulations. *However*, this sometimes causes ineffective control and a need for retreatment. Use an appropriate concentration of herbicide to control your target species.

Mixing Agents

Herbicides should be mixed and diluted with several different agents to allow the target species to properly absorb the plant killing agent. Herbicides can only be absorbed when they are wet. Some invasive exotic vegetation requires several chemicals mixed into one formulation to make them most effective.

- **Surfactants and Adjuvants:** Often added to foliar formulations, these are additional chemicals that assist herbicide absorption. They are emulsifying, dispersal, anti-foaming, drift control, wetting or surface modifying agents. When selecting a surfactant, check to make sure it is intended for agricultural use and compatible with the herbicide you intend to use. These chemicals sometimes contain detergents that may be corrosive and cause skin and eye irritation or damage. Check labels for warning or danger signal words. Proper PPE should be worn when handling concentrates to prevent contact. Do not use household soaps as a substitute for agricultural surfactants.
- **Agricultural Oils:** Used when girdling or during basal applications. These oils are often non-food grade vegetable oils or mineral oils that are mixed with concentrated herbicides. The oil keeps the

herbicide wet, stuck to the plant and assists with penetration into the cambium layer for maximum absorption of the killing agent. Some trade names of common agricultural oils are JLB Oil and Impel Red.

- **Water:** Used to dilute herbicide in foliar, girdle and cut stump formulations. Simply reduces the amount of concentrated herbicide. Surfactants, adjuvants, and dyes can later be added as required. Water must be free of sediment and algae.
- **Dyes:** Added to assist the applicator in seeing where herbicides have been applied. This prevents excessive amounts of chemicals from being introduced to the environment. Add the smallest amount of dye possible.

Storing Herbicides

All herbicide containers, sprayers, rinse water jugs and spray bottles **must** be labeled with the formulation. Anything that contains an herbicide should be stored in an herbicide locker, over a containment sump or in some form of secondary containment. All herbicides should be kept under lock and key to ensure that only authorized personnel have access to them. Areas where herbicides are kept should be well ventilated.

Transporting Herbicides

When transporting herbicides, all containers with mixed or concentrated herbicides, mixing agents, surfactants or adjuvants, dyes, or mixing water must be in some form of watertight, chemically resistant, secondary containment. Action Packers and five-gallon buckets satisfy this requirement. Wooden boxes do not meet the standards. Wands from sprayers should be placed in a downward position inside secondary containment. All sprayers should also be depressurized when transported or not in use. All herbicide containers and secondary containers should be properly secured to prevent shifting or moving during transportation. This can be done with rope, tie down straps or bungee cords. Herbicides must be labeled and a copy of a Material Safety Data Sheet (MSDS) or a complete legible label from original herbicide container must be present during all operations. Herbicides and fuel may never be transported in the same compartment as passengers or operators of a vehicle.

Applications – How to Kill a Plant

Several methods are available when attempting to eradicate invasive exotic vegetation. Some methods work better than others depending on the type of plant, its size, and its location. Care should always be taken to prevent accidental off-target damage, including plant identification, control of over-spray, selecting the best technique according to weather and applying the appropriate amount of chemical.

- **Foliar:** Applying a low concentration (.5-5% concentrated herbicide) to the leaves or foliage of the target species. Foliar sprays often contain water, adjuvants/surfactants, and dyes. For effective control, all foliage should be sprayed-to-wet from the top of the plant, continuing downward until the plant is covered. “Spray-to-Wet” means applying the formula to the point before it starts to run off the foliage. Care should be taken to ensure the growing tip or tallest lead is adequately covered in herbicide. Usually done on smaller trees, ground covering vines, shrubs, bushes, and grasses as well as in large-scale operations to control unwanted vegetation in field management. Foliar applications have the greatest chance of non-target damage due to over spray, especially in windy conditions.
- **Girdle or Frill:** Using a machete, knife, handsaw, or chainsaw to remove the layers of the plant between the bark and sapwood of trees, vines, shrubs, and bushes. This must be done completely around the entire circumference of the plant to be effective. This eliminates the flow of

nutrients up and down the plant. An herbicide must be used with this method, as girdling is not enough to kill the plant. Failure to apply a cut stump or basal formula will result in re-sprouting.

- **Cut Stump:** Using any type of cutting tool to cut the tree, vine, bush, or shrub at its lowest point to the ground then immediately following through with an herbicide application. Cut stump formulations usually run a little higher with the amount of concentrated herbicide (25-50%). Use of chainsaws or handsaws are recommended for this type of treatment as it offers a clean flat surface with limited exposure of the cambium layer where the herbicide is to be applied and absorbed. A machete or knife effectively does the same thing but offers more exposure of the cambium layer through jagged edges and offers a greater chance of missing a spot with the herbicide. The entire exposed cambium layer must be covered with the herbicide to reduce the chance for re-sprouting. Herbicide should be applied as soon as safely possible after cutting. Water based herbicides tend to mix better with the hydrolipid system, resulting in better kill than with oil-based herbicides.
- **Basal or Basal Bark:** Applying an oil-based herbicide that has been diluted with agricultural oil to the entire circumference of the trunk or stem at the base of the target species. Desired heights to apply the herbicide will vary depending on the size of the tree, vine, bush, or shrub. The larger the plant, the higher up the herbicide will be applied. This should also be applied as spray to wet; spray the stem or trunk until the point just before runoff. Care should be taken to spray all exposed roots and/ or multiple stems. Failure to spray completely around the stem or trunk may result in re-sprouting. High pressure in the sprayer will also result in splattering the chemical resulting in off target damage. Avoid treating any trees with thick bark as the formula will not penetrate. Basal formulas usually contain 8- 25% concentrated herbicide.

Spray Pattern Adjustment

Adjusting the sprayer tip to get the correct spray pattern is important. A direct stream, in most instances, will result in applying an excessive amount of herbicide and off target damage. Adjust the spray pattern to give the most amount of coverage and least amount of off target damage and drift. The spray pattern will be different for cut stump as opposed to foliar. Avoid applying a mist as wind currents can carry the herbicide solution a great distance and cause damage to surrounding vegetation.

Spills

The first step in dealing with any chemical spill is to have on all necessary PPE and ensure that those around you or those who may help in the clean up or containment also have on proper PPE. Keep others who do not have appropriate PPE away from the contaminated area. Do not approach or handle any spilled chemicals without PPE. Do not approach or attempt to contain any chemical spill if you do not know what chemical is present. Do not leave the spill unattended. The overall size of an herbicide or chemical spill will determine what course of action is required. Simple spills of a few ounces over soil can be cleaned up by digging up the contaminated soil and placing the soil in a double plastic bag. Smaller spills over black top, concrete or other hard surfaces can be controlled by using oil absorbing rags or cloth, or sweeping cat litter or other similar oil absorbing compounds over the spill, collecting the contaminated materials and placing them in a double plastic bag. For larger spills containment is the priority before cleanup can begin. Areas on a slope, with a hard surface or a wet surface will make the spill spread faster. Protect nearby drains, water sources, stream etc. from runoff. The use of oil absorbing booms or large amounts of cat litter can slow and reduce the rate of spread. Try and head off the spill if possible. Make sure all contaminated materials are placed in double plastic bags or a single plastic bag and into a chemically resistant container.

Personal Protective Equipment – PPE

Personal Protective Equipment is important to reduce the risk of on the job injury. Exotic plant management has an inherent risk through the common use of tools like machetes, chainsaws, hand saws, brush cutters, all-terrain vehicles, and chemicals. Work performed outdoors can be in remote areas, on steep terrain, during periods of uncomfortable cold and heat and in areas inhabited by poisonous snakes, fire ants and black bears. Protective gear will be readily available and, in most cases, must be worn as part of OSHA and NPS standards.

Field Work and Herbicide

The label on the concentrated herbicide jug will describe, in detail, the exact PPE required for each application. As a rule of thumb, when applying a mixed herbicide, the minimum PPE to be worn is eye protection, boots and socks, long pants, long sleeve shirt and gloves. When mixing, handling, or pouring any concentrated or mixed herbicides the minimum PPE is the same as that in application but requires the use of chemically resistant gloves. Additional PPE may include face shields, respirators, Tyvek suit and a hard hat.

Further Reading

Here are a few additional sources that are worth reading to inform yourself on Herbicides and their effects

Penn State's Intro to Weeds and Herbicides

<https://extension.psu.edu/introduction-to-weeds-and-herbicides#section-31>

The Nature Conservancy's Weed Control Handbook

<https://www.invasive.org/gist/products/handbook/methods-handbook.pdf>

EPA's Regulatory Information by Topic: Pesticides

<https://www.epa.gov/regulatory-information-topic/regulatory-information-topic-pesticides>