safe herbicide handling in natural areas

a guide for land stewards and volunteer stewards

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SAVING THE LAST GREAT PLACES ON EARTH

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The mention of trade names in this document is for descriptive purposes only and does not constitute an endorsement by The Nature Conservancy of any particular product or manufacturer

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Introduction

The protection and perpetuation of biological diversity is a complex undertaking that requires active management (stewardship). Stewardship is a critical part of preserving the ecological integrity of ecosystems, but this work is often resource intensive and is usually expensive. In lean economic times, intensive land management is viewed as too expensive to fully fund. Even in good times, ecological management and research is underfunded relative to the task at hand. Nature will ultimately take care of herself; however, human stresses to our ecosystems have produced unintended consequences — the degradation and loss of native plant and animal communities foremost among them.

Invasive species are a huge threat to native biodiversity around the world. Indeed, non-native species continue to be introduced intentionally for agricultural, horticultural, commercial or recreational purposes, whereas others enter our borders unintentionally as hitchhikers on produce and nursery stock or as stowaways in packing materials, shipping containers, and ballast waters (Environmental Law Institute 2002). Fragmented landscapes such as eastern North America are particularly vulnerable to this degradation. We know which species are already troublesome, and we know about others that are likely to become widespread and disruptive, but there are not enough conservation professionals alone to combat the existing problems or head off new invasions. Hope for our biodiversity lies in a new stewardship ethic among the public, volunteers, and all people interested in the outdoors.

When they dominate natural areas, invasive species can interfere with what we are trying to protect (biodiversity). They can be costly to remove or control and can impede restoration efforts. Invasive species can actively compete and displace native plant species. For example, garlic mustard may keep out native wildflowers, or in eastern forests, bush honeysuckle can replace wildflowers, sedges, and ferns with a dense shrub thicket. The worst invaders modify

ecosystem processes. Furthermore, invasive species typically displace native plant and animal species by several methods, often by modifying the availability of food, cover, and nesting sites (Hillmer et al. 1999).

Stewardship action is needed when the invasive species' threat to a preserve would create more disruption to the site than the efforts to control it would. If removal of the invader is more disruptive to the ecosystem than the invader itself, then acceptance of the infestation may be inevitable. This is often the case with invasive insects and pathogens. The difficult question to answer is whether doing nothing about the threat will cause the eventual loss of the "native character" of an area (Hillmer et al. 1999).

Each state has specific legal requirements for persons applying pesticides commercially or on property owned by another person or entity. This guide is no substitute for knowing and meeting those requirements; however, pesticide certification literature rarely includes detailed information about highly selective application and precautions for sensitive natural areas, where one species must be removed without damage to surrounding species. This guide is for land stewards, volunteer stewards, and for seasonal employees who will assist with selective herbicide applications in natural areas. It assumes that the employees and volunteers will be working under the supervision of persons with additional technical training, but it does not cover the technical details of herbicide mixing, loading, or transport. A companion guide, "Upkeep and Maintenance of Herbicide Equipment" (Hillmer and Liedtke 2003) and technical publications (Ohio State University Extension 1992, Tu et al. 2001, Harrison and Camm 1996) address those issues.

Why Herbicides?

Determining the right course of action in weed management can be difficult, as there are many tools and techniques available, all with pros and cons. Deciding *whether* to use herbicides is often a calculated risk which is not to be taken lightly. Knowing when to begin management action is the key to catching an infestation before successful control becomes unfeasible. As with medicine, herbicides must be used judiciously to be safe and effective.

Herbicides belong to a group of chemicals known as pesticides, which prevent, destroy, repel, or mitigate a pest. Herbicides are any chemical substance that is used specifically to kill plants. Modern systemic herbicides are frequently used to control invasive plants. Many of the modern herbicides that are used in natural areas target specific plant processes or pathways and are relatively harmless to animals. They are applied to the aboveground part of the plant and are transported throughout the plant to the root system. Selective application methods include foliar spray or wicking, cut stump applications, and basal bark applications to standing shrubs and thin-barked trees. Each technique is designed to minimize the amount of herbicide used as well as the risk of damage to non-target plants (Windus and Kromer 2001, Tu et al. 2001).

Sizing Up the Invasion (Site Assessment)

Herbicide use is one of many components of land management. Stewards must define the goals and value of a site and why it is being protected. Clear, written goals for the preservation and ecological management of a site is the foundation for invasive plant removal. Management resources are always limited relative to the scope of invasive species threats.

Good goals include a description of the ecological community being managed, the desired site condition, timelines for management actions, and a method for monitoring results.

Sizing up the site includes measuring the size and scope of the infestation(s), assessing the quality of the habitat being invaded, knowing what species are likely to replace the invader, estimating the resources needed to meet the management goals, and knowing when not to undertake an invasive removal project. The most effective approach for successful invasive species management is prevention, followed by then the removal of new or scattered populations, and finally tackling the heavy infestations from the outside edges inward. Multiple techniques or approaches are used for the best control; sometimes a non-chemical approach will suffice, but sometimes chemicals are necessary or the best option for adequate control.

Successful weed eradication is a long-term endeavor requiring patience, perseverance, and persistence. Except in the earliest stages of invasion, complete eradication of the infestation is unlikely. Decide what level of infestation is acceptable for a *specific site*, then work to maintain that. For example, one approach to managing a widespread infestation in a natural area is to divide the site into management units requiring different management intensity such as:

1. Maintenance (the management unit is relatively weed-free, or the invader is present in low and manageable numbers);
2. Rescue (the unit has potential, but intensive management is required for a year or more before the native community recovers naturally); and
3. Restoration (the unit is heavily degraded and requires extensive weed control and replanting with natives, or other complex and expensive work).

Monitoring progress is as essential for the spirit of stewardship as it is for conservation science. Even simple permanent photo points showing the changes to the managed site over time are enough to sustain volunteer enthusiasm and demonstrate successful work. Monitoring is good for morale, good for recruiting more volunteers, and good for generating interest and funding for the project. Monitoring is a launching point for learning and teaching about the biological diversity of a site as well. Tracking the results of management over time is an ideal project for all students of natural history, and it builds community and appreciation for local landscapes.

Herbicides in the Environment (Site Conditions)

Site conditions to be considered before any herbicide application include assessing the species itself, seasonal timing of the application, the presence of desirable species and communities, accessibility for the applicator and equipment, soil types, weather conditions, location of surface water, depth to groundwater, and the site's sensitivity to trampling when the herbicide is being applied (Windus and Kromer 2001).

The behavior of an herbicide in water is dictated by its solubility in water. Water bodies can be contaminated when directly sprayed upon, or when herbicides drift, volatilize (vaporize), leach into to groundwater, or are carried in surface or subsurface runoff. Amounts of leaching and runoff largely depend on total rainfall the first few days after an application (Ohio State University Extension 1992). To prevent water contamination, carefully consider

the hydrology of the system that is being treated. Hypothesize potential runoff scenarios and take appropriate measures to prevent environmental damage. Some herbicides will volatilize in hot weather and drift even on windless days. Improper spray pressures or techniques can cause droplets or clouds of herbicide to drift and land on non-target vegetation. The herbicide label will usually provide information about potential off-target risks (Tu et al. 2001, Ohio State University Extension 1992).

Which Herbicides?

A discussion of the array of herbicide types and formulations on the market is beyond the scope of this guide. The herbicides that are discussed in this guide are "non-selective herbicides," meaning they are formulated to damage or kill all vegetation on contact. Different brands and formulations of herbicides act differently on different plants, so it is imperative to understand how a given product will behave in the plants, soil, and water. For sensitive sites, the best rule of thumb is usually "the safer*, the better."

In natural areas, TNC-Ohio selects herbicides that are effective against the target weed, unlikely to move offsite through the air or water, nontoxic to people and other organisms, not persistent in the environment and relatively easy to apply. In some circumstances, however, a single application of a more toxic or persistent chemical that eradicates the weed may be preferable to repeated applications of a safer product which removes a smaller percentage of the total number of invasive plants. Preserve stewards must strike a balance between the strength or effectiveness of the product and the total negative impact to the environment (Tu et al. 2001). The information used to make these decisions comes from the pesticide labeling, experienced land managers, pesticide dealers, and other experts.

* as measured by half-life mobility in soil and water, levels of toxicity, conditions or substances that degrade the herbicide, etc.

Table 1. Types of herbicide formulations and active ingredients used in Ohio TNC preserves.

Trade Name (active ingredient)	Formulation	Mixes with	Cut stump	Basal bark	Foliar spray	Hand wicking	Restrictions (do not use under these conditions)	Use in wetlands?
Glypro (glyphosate)	amine (salts)	water	cambium only	no	in full leaf	in full leaf	precipitation expected within 4 hours	yes
Garlon 4 (triclopyr)	ester (fats)	oil	cambium plus stem	band around stem at base	not recommended	not recommended	wet bark; snow on ground; precip. within 4 hours; over 80 deg. F	no

Table 2. General use and concentration guidelines for selective herbicide application in nature preserves.

		Used on		Dilute with		Add dye?	Application technique and % herbicide by volume				
Trade Name	Active Ingredient	Woody plants	Herbaceous plants	water	oil		cut stump, woody plants	cut stem, herbs	basal bark	foliar spray	hand wicking
Glypro	glyphosate	X	X	X		X	25%	10%		2-5%*	25%
Garlon 4	triclopyr	X			X	X	25%		25%		

* Add a sticker-spreader and other required adjuvants for use on both woody plant and herbs

Application Methods

Herbicides can be applied in various ways, depending on the species to be treated, the herbicide being applied, the skills of the applicator, the application site, and current environmental conditions. Standard application techniques (which are often used in agricultural or forestry settings) can sometimes be modified to better suit the needs of natural area management. When selecting a technique, land managers should choose one that minimizes risks of exposure to the applicator and others who may be in the area during and after herbicide application AND minimizes release of herbicide in the environment, particularly if the herbicide comes in contact with non-target species.

Methods of application can be broadly classified as follows (Tu et al. 2001):

1. foliar (to intact, green leaves)
2. spot spray (backpack applicator, spray or squeeze bottle)
3. wick (wipe onto leaves)
4. boom spray (mechanized equipment, seldom used in natural areas)
5. basal bark (circling the base of the trunk on the intact bark)
6. frill, or hack and squirt (to cuts in the trunk)
7. inner-bark injection (requires special equipment and herbicide products)
8. cut stump (to freshly-cut stems or stumps)
9. pellet (at plant base; rarely used in natural areas)
10. pre-emergent soil treatment (before the target species emerge; rarely used in natural areas).

Selective Application Tip Sheet:
Basal Bark Treatment

Consult complete label information before using herbicides. Wear all required protective equipment when mixing and applying herbicide.

Used on: Standing woody plants (trees, shrubs, and vines)
Seasons: Any season, best from midsummer through late winter
Site Conditions: Bark and ground must be dry; should not be used when precipitation is forecast within a few hours; should not be used when temperatures are above about 80° Fahrenheit

Herbicides used: Garlon 4 (ester formulation)
Adjuvants: Mixes with a special basal oil, can have dye added or not
Herbicide mix concentrations: Usually about 25%; follow label

Advantages: Fast and effective; vegetation does not have to be mowed or cut before treatment
Disadvantages: Uses more herbicide than stump treatment; vegetation brown-out may be an aesthetic problem in public areas; oil-based herbicide can damage spray equipment over time; can volatilize in hot weather and drift to off-target plants; does not work well on thick-barked plants

Applied how: Applied to bark from root crown (base of stem) in a band encircling trunk; width of the band varies according to the diameter of the stem. See Photo A.

Photo A. Basal bark application. A band of oil-carried herbicide penetrates the bark from the root crown up the stem for several inches. Photo: J. Hillmer

Equipment used: Lab wash bottles, sprayers, or bristle paint brush

Precautions / restrictions: Cannot be used in wetlands or where surface water is present. Spray equipment must be kept clean because the petroleum products in the herbicide will eventually degrade and break down sprayer seals. Should not be used when temperatures are over 80° F because the product will volatilize and drift.

Selective Application Tip Sheet:
Cut Stump Treatment

Consult complete label information before using herbicides. Wear all required protective equipment when mixing and applying herbicide.

Used on: Woody plants (shrubs and trees); can be used at lower concentrations on fleshy, thick herbs like cattails; may or may not be effective on woody vines
Seasons: Mid growing season through early winter (less effective in late winter or early spring when sap is rising)
Site conditions: Used when target species need to be physically removed from site (compare to basal bark treatment); can be used in wetlands or sensitive areas

Herbicides used: Glypro or Garlon 4
(Note: opinions vary about whether glyphosate or triclopyr is more effective at woody plant control. Both are similarly effective relative to some stronger restricted-use herbicide active ingredients, such as picloram or imazapyr. See Tu at al. 2001).
Adjuvants: Usually dye; adjuvants are usually not necessary but may be added to oil formulations
Herbicide mix concentrations: usually 25%-50%

Advantages: Uses minimal amount of herbicide; shows immediate progress in removal of target population; takes a shorter amount of time for herbicide to be absorbed than basal bark due to lower surface area treated
Disadvantages: Very labor intensive; easy to miss untreated stumps

Applied how: Stem of plant is cut off within 6 inches of the ground, with the cut surface flat and parallel to the ground; herbicide is applied to the top of the stem around the edges of bark and wood (the cambium layer, which transports water and nutrients). Herbicide must be applied within 5 minutes after being cut, for good kill results. See Photo B (1&2).

Photo B(1). Cut stump treatment.
Before treatment: A glossy buckthorn stump has been cut close to the ground, with the cut surface parallel to the ground. Photo: J. Hillmer

Photo B(2) Cut stump treatment. After treatment. Garlon 4 has been applied to the top of the stump, as well as down the sides to the root crown. (If Glypro were used, only the top of the stump would be treated.) Photo: J. Hillmer

Equipment used: Hand saws, loppers, hand pruners; or chain saws and hand tools; herbicide applied with lab wash bottles, bristle paint brush

Precautions / restrictions: Cannot be used when precipitation is forecast within a few hours. Stumps must be treated immediately upon cutting (within about 5 minutes) for water-based herbicides (amine formulations) to be absorbed by the plants.

A Few Extra Notes Regarding Cut Stump Treatments:

During the work day: In areas containing many small stems, make small piles of brush as you work, but save the removal of brush for another day to avoid trampling on freshly treated stumps.

Remember the formulation difference between Garlon 4 and Glypro:

Garlon 4 is carried in an oil (an ester formulation), which is designed to penetrate the bark into the cambium layer. On a cut stump, Garlon 4 is applied to the top and down the sides of the bark to the root crown – but not onto the ground. This is why the bark must be dry – otherwise the oil will not make it past the water into the cambium.

Glypro is carried in water (an amine formulation), so it can only be absorbed by freshly exposed cambium tissue – the top of a freshly cut stump. It is applied to the outer edge of the top of the stump. It does not penetrate bark.

Selective Application Tip Sheet:
Foliar Spray

Consult complete label information before using herbicides. Wear all required protective equipment when mixing and applying herbicide.

Used on: Herbaceous or woody plants that are in full leaf and actively growing.
Seasons: During the growing season, generally recommended for mid season when the target plants have maximized their root reserves and resources. For annuals, treat at or before flowering to prevent seed set. For perennials, treat at or before flowering, or in the late fall during the time of carbohydrate sequestration (for winter-dormant plants)
Site conditions: Vegetation must be dry; easiest to use for vegetation that is less than 2 meters tall.

Herbicides used: Glypro or other glyphosate based herbicides in amine formulations
Adjuvants: Usually dye and sticking / wetting agents.
Herbicide mix concentrations: Usually 2% to 5%; some spot treatments can be as high as 10% in limited circumstances – follow label recommendations

Advantages: Faster than cut stump or basal bark, can get good coverage of smaller plants such as re-sprouted stumps, seedlings, or large patches of vegetation like Phragmites or Multiflora rose
Disadvantages: Can be difficult to achieve full coverage of taller shrubs or small trees; drift or over spray can cause off-target damage; can be cumbersome to mix and transport enough spray to remote sites

Applied how: Directed, low-pressure spray to leaves; wet leaves well, but not to the point of runoff or dripping. "Shielded spray" is done either with a special cone-shaped collar to direct spray, or by holding or placing a barrier to protect desirable plants. See Photo C.

Photo C. Foliar Spray.
The reed canarygrass in this meadow was sprayed with a backpack sprayer at low pressure, with the nozzle tip close to the leaves. Note that off-target effects are minimal. Photo: J. Hillmer

Equipment used: Backpack pressure sprayers, hand sprayers, occasionally mechanized equipment (such as a boom sprayer mounted on an all-terrain vehicle). Flat-fan nozzle tips (such as T-Jet®), pressure check valves, and other equipment can help minimize off-target spraying.

Precautions / restrictions: Spraying with high-pressure can cause drift, damaging valuable plants; should not be used in strong winds or when precipitation is forecast within several hours.
The higher the pressure, the smaller the droplet; the smaller the droplet the further it will be wind carried off target (drift) to desirable vegetation.

Selective Application Tip Sheet:
Hand Wicking

Consult complete label information before using herbicides. Wear all required protective equipment when mixing and applying herbicide.

Used on: Herbaceous, narrow leaved plants such as cattails that are in full leaf
Seasons: Growing season, particularly when plants are close to flowering
Site Conditions: Easiest to use on populations which are somewhat scattered; very dense populations may be better sprayed, depending on habitat quality and adjacent vegetation; often used in wetland habitats such as fens

Herbicides used: Glypro, with same adjuvants as for foliar spray
Herbicide mix concentrations: Follow label instructions, but it may be necessary to retreat at label recommendations

Advantages: Can treat individual plants with minimal off-target effects; faster than cut stem treatment; best used as a preventative or as follow-up treatment
Disadvantages: Very labor intensive; can be difficult in tall vegetation; can be difficult to get enough herbicide onto leaves for complete control (coverage should be similar to amount from low-volume selective spray)

Applied how: Wear long sleeves tucked into long (13+ inches) chemical-resistant gloves. Cuff the ends of the gloves to catch drips or runs. Wear a cotton wicking glove over a chemical resistant glove. Herbicide is applied to the thumb, fingers, and palm of the wicking glove and wiped onto the leaf surface. Special rope wicks are sometimes used for cattails – they require two people to use. See Photo D.

Photo D. Hand Wicking.
Herbicide is applied to an absorbent glove (1), then wiped onto individual cattail stems (2). Note the chemical-resistant glove under the wicking glove is cuffed to catch drips.
Photo: R. Beck

Equipment used: Lab wash bottles & wicking gloves (plus chemical resistant gloves which are required personal protective equipment)

Precautions / Restrictions: Small spray bottles also work for putting herbicide on the palm, but they can spatter more herbicide onto clothing. Wicking gloves will become saturated with herbicide; keep used wicking gloves separate from other protective equipment, and dispose of properly. (See Hillmer and Liedtke 2003 for additional information.)

Record Keeping

When using herbicides, it is critical (and often required by law) to keep records of all plants/areas treated, amounts and types of herbicide used, and dates of application (Ohio Department of Agriculture, Hillmer and Liedtke 2003). This information will be important in evaluating the project's success, improving methodology, and identifying mistakes. In addition, it documents the procedure for future site managers and biologists. Notes on the abundance and growth stage of the targeted weeds and type and condition of the surrounding plant community before and after treatment are invaluable for tracking treatment results. (See Figure 1.)

Figure 1. Sample Herbicide Application Record

Herbicide Application Record

Name and address of Certified Applicator: *J. Hillmer* * [Person with ODA Applicator License]
Name(s) of any other persons applying pesticides: *D. Liedtke*

Name and address of person contracting services: The Nature Conservancy, 6375 Riverside Dr, Dublin OH 43017 ** J. Hillmer*
Habitat description *open to shrubby cinquefoil-sedge fen, into shrub fens*

Preserve: *Beck Fen*
Was the application on TNC property? If not, list name and address of owner: *Yes*

Date of application: *Sept. 15, 2002* Date of previous treatment: *Oct. 4, 2001*
Starting and stopping times: *10:30a.m - 4:00p.m.* Restricted entry interval: *4 hours*
[see "Ag. Use Requirements on herbicide label]
Target species (type of plant, crop, or animals treated): *Rhamnus frangula*
Principal pests to be controlled: *N/A*
Acreage, or number of plants and animals treated: *about 3 A. scouted/treated*
Abundance and density of targets: *frequent in patches; scattered, infreq. elsewhere*
Growth stage of targets (flowering, fruiting, etc.): *some vegetative, some in fruit*

Location, or field identification, of treatment area (include map or detailed sketch on back) :
NE ¼, from resto. plot w. to main meadow & N Fen ext.; S. to Sedge Edge
GPS Coordinates of treatment site: *41.2447°N, 81.3808°W (WGS84/NAD83)*

Chemicals used

See map & notes on back

Brand (Trade) name: *Glypro* EPA Reg. No. : *62719-324*
Product concentration: *53.8% a.i.* Dilution of product: *50% by volume*
Carrier/adjuvants used: *H2O, Doublecheck Dye* Total amount of product used: *1750 ml*

Mode of application (foliar spray, cut stump, etc.) & equipment used:
Cut stump: hand pruners, pruning saws, lab wash bottles
Weather

During application
Temperature: *78 deg. (1:00 p.m.)*
Wind speed/direction: *WSW 5-10 mph*
Precipitation: *none*
Relative humidity: *65% (at 1:00 p.m.)*

24 hours before
Temperature: *mid 70's*
Wind speed/direction: *WSW, light*
Precipitation: *showers overnight (9/14)*
Relative humidity: *moderate*

24 hours after
Temperature: *mid 80's*
Wind speed/direction: *S 5-10*
Precipitation: *none*
Relative humidity: *muggy!*

Do Crop Rotations Exist? Yes No *N/A*
Site revisit/follow-up schedule *check in late spring 2003*
Remarks
** [This record is a hypothetical example for the guide "Upkeep & Maintenance of Herbicide Equipment, 2003"]*

Please return to:
The Nature Conservancy
6375 Riverside Dr. S. 50
Dublin, OH 43017
Attn: Vol. Coordinator

Figure 1, continued Sample Herbicide Record, back side

Beck Fen, 9/15/02 Herbicide Application Record, cont.

Mix notes:
Glypro 50% mixed 9/14/02
no adjuvant besides dye, as we were stump treating

Starting qty 2000 ml
Ending qty - 250 ml
Qty used = 1750 ml

Comments:
Many small Rhamnus (<1 m tall) persist in "the nest" area between main meadow and NE section restoration plot. Beyond that, Rhamnus are infrequent, and we have caught many of the larger plants in previous trips. Very few found within the restoration plot boundaries; herbaceous fen spp. have become dominant since we began removing Typha angustifolia and selected shrub spp. (esp. Cornus spp.).

Preserve base map showing treatment locations attached.

J.H. 9/16/2002

Personal Protection

Protective clothing, properly functioning equipment, and careful application methods all help minimize exposure to pesticides during all phases of handling, including storage, mixing, transportation, application, and cleanup. The following is modified from the "core manual" for pesticide applicators (Ohio State University Extension 1992).

- Any time you handle pesticides, wear at least a long-sleeved shirt and long-legged pants made of sturdy material. Fasten the shirt collar completely to protect the lower part of your neck. A hat is also recommended and coveralls may prove to be useful. Also, bring along an extra change of clothing to avoid contaminating car seats or chairs.
- Canvas, cloth, and leather shoes or boots are almost impossible to clean adequately. Therefore, chemical resistant footwear, such as rubber boots, should be worn. If lower legs and feet will be exposed to pesticides or residues, wear chemical resistant boots that come at least halfway to the knee.
- TNC recommends the wearing of goggles or safety glasses when spraying chemical solutions and when mixing or pouring herbicides. They should be rinsed after each use, dried, and stored in a clean place.
- Pesticide handlers receive the most exposure on their hands and forearms. As a result, wear chemical-resistant gloves at all times. (Nitrile gloves will be provided by TNC.) In colder weather, polypropylene thermal liners can be worn under the nitrile gloves. To reduce exposure further, sleeves should be tucked into gloves that should reach up the forearm, with cuffs to catch runs and drips.
- Make sure gloves are clean, in good condition, and worn properly; replace gloves often.
- Wash gloves thoroughly before taking them off, and wash your hands thoroughly and dry them before you put the gloves on again.
- Wash hands thoroughly before eating, drinking, using tobacco, or going to the bathroom.

Exposure

Pesticides contact your body in four main ways:

1. Oral exposure (when you swallow herbicide)
2. Inhalation exposure (when you breathe in herbicide)
3. Ocular exposure (when you get herbicide in your eyes)
4. Dermal exposure (when you get herbicide on you skin)

In most herbicide-handling situations, the skin is the part of the body that is most likely to receive exposure. However, the amount of pesticide that is absorbed through your skin and into your body depends on the pesticide itself, the area of the body exposed (the genital area tends to be the most absorptive while the scalp, ear canal, and forehead are also highly absorptive), and the condition of the skin exposed.

Label Requirements (Personal Protective Equipment)
The label is the law. You must wear the personal protective equipment required on the pesticide label. It is a good idea to go "beyond the label" for your own safety, for example, wearing safety glasses, and chemical resistant gloves and boots for any herbicide handling activity.

Laundry
Careful handling and application technique should minimize the amount of herbicides you get on your clothing. The best procedure for washing non-chemical-resistant items is to

- Rinse in a washing machine or by hand.
- Wash only a few items at a time so there will be plenty of agitation and water for dilution.
- Wash in a washing machine, using a heavy-duty liquid detergent and hot water for the wash cycle.
- Rinse twice using two complete rinse cycles and warm water.
- Use two entire machine cycles to wash items that are moderately to heavily contaminated.
- Run the washer through at least one additional complete cycle without clothing, using detergent and hot water, to clean the machine after each batch of pesticide contaminated items, and before any other laundry is washed.

The best procedure for drying non-chemical-resistant items is to
- Hang the items out to dry, if possible for at least 24 hours in an area with plenty of fresh air. Do not hang in living areas.
- Use a clothes dryer for fabric items, if it is not possible to hang them to dry. However, over a period of time, the dryer may become contaminated with pesticide residues.

Cleanup
- Wash the outside of your gloves and shoes with detergent and water before you remove them.
- Change clothing as soon as possible and place contaminated clothing in a plastic box or bag to avoid cross contamination. Do not allow children or pets near the contaminated clothing.
- Use a mild liquid detergent and warm water to wash hands, forearms, face and any other area that may have been exposed to herbicides. Take a warm shower to wash hair and body at the end of the workday.

First Aid
The general recommendations here are for acute exposure of restricted use pesticides, which often carry higher-level warning labels than the herbicides discussed in this guide. Nevertheless, quick care and caution are always warranted for accidental chemical exposure.

The best first aid in pesticide emergencies is to stop the source of pesticide exposure as quickly as possible. Have the pesticide label at hand if further medical treatment is sought.

Pesticide on skin:
- Drench skin and clothing with plenty of water
- Remove personal protective equipment
- Dry victim and wrap in blanket or any clean clothing on hand

Pesticide in eye:
- Wash eye quickly but gently for 15 minutes with saline solution or plain water.
- Seek prompt medical attention

Pesticide in mouth:
- Rinse mouth with plenty of water and give victim up to one quart of milk or water to drink
- Induce vomiting only if instructions to do so are on the pesticide label

Inhaled pesticide:
- Get victim to fresh air and loosen tight clothing that would constrict breathing.

General Precautions
- If other people are in or near the area, warn them of the danger
- Know where the nearest phone and hospital are located. Maps and phone numbers to the closest hospitals, and a first aid kit should always be kept with the pesticide labels on the work site.

Conclusions

Non-native species are entering the United States at an unprecedented rate. Those that prove to be invasive are causing serious damage to our nation's croplands, forests, wetlands, waterways, and parks by destroying native plant and animal communities, disrupting ecological processes, and threatening the stability of our ecosystems (Environmental Law Institute 2002). Educational tools such as this guide help to inform the public of the environmental dangers of invasive species. This guide creates awareness and enables individuals to participate in the prevention and eradication of invasive plants. Herbicides are a powerful tool to use within a regime of natural area stewardship. When used with care and respect for the environment, they can leverage the work of stewardship professionals and volunteers alike.

References and Recommended Reading

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