From: "Santner, Darian" <DARIANS@BES.CI.PORTLAND.OR.US>
To: "'Steve Mullinax'" <steve.mullinax@attbi.com>
Cc: "Reed, John" <PKJOHNR@ci.portland.or.us>; "Schiller, Jim" <JimSc@BES.CI.PORTLAND.OR.US>
Sent: Monday, April 28, 2003 5:34 PM
Subject: RE: Bridlemile - Albert Kelly Park CWSGrant Draft for Comment

Steve,

Attached is some information I had related to herbicide use. In reading through these, there are a couple of things to keep in mind:

-Control of invasive species is a secondary goal of this project- the first is establishing a healthy stand of native plants. To this end, and integrated approach will be used that may include brush cutting, mowing, pulling, mulching, shading, as well as spraying. Herbicide is only one possible tool that we may use, depending on the site conditions. A certain amount of weeds on the site will be tolerated so long as the native plants are not threatened. The scorched-earth approach is not the idea here.

-The likely progression of events will be to cut or mash the blackberries first, then to have a contractor spot-spray the resprouts with a broadleaf herbicide called triclopyr (sold as Garlon 3A), to be applied from backpack hand sprayers. I anticipate that this will be very effective, and that further herbicide applications will be necessary but infrequent. In order to minimize runoff and drift, spraying will only be done in dry weather, and with low pressure equipment (backpack). The fencing that Parks/BNCS will install will keep people and dogs off of the treatment area.

-Over the years, the BES has experimented with different methods and timings for controling weeds like blackberries on restoration projects sites. We have found that in order to successfully establish native trees and shrubs in areas that are full of blackberries, manual cutting or removal alone are not sufficient. In order to keep seedlings free to grow, blackberries must be cut back with mowers or chainsaws 4-5 times per growing season for at least the first 2-3 years, and 2-3 times per season in the 4-5 year. At almost $1300/acre for one cut, this adds up to a costly, very intrusive regimen of work. Herbicide application costs less than $500/acre and if done correctly in conjunction with some manual cutting, can be done much less frequently, resulting in less disturbance of the site. Our approach to this project will involve planning and timing those treatments which will achieve the project goals of establishing a healthy stand of native trees and shrubs while minimizing intrusion into the natural area and costs.

I have attached some information that I have abou natural areas management and herbicide use. The one called Riparian Program is a good overview of what will happen during the course of the project. The others are more specifically related to herbicides used in this context. Also below is an email I recieved from John Reed at Parks (who is their contact for pesticide issues) which has its own attachment (triclopyr info.doc).

Darian

P.S. I got a call from a neighbor near the park about a year ago who was concerned about spraying. Her name is Ann Holtznagel, 244-0202.

Below is John Reed's Message:

Darian,

While others can carry information about our pest management practices and materials to the public, I want to make sure that we remain the ultimate sources of information. I think the message we want them to make clearly is that if there are additional concerns, they are answered by us.

The TNC document is pretty good and is as good a backgrounder about reveg use of triclopyr as there is. We should be clear we are using the amine formulation. Some points we also want passed along might be that the usage will comply with the NOAA Fisheries approved ESA 4(d) PP&R Pest Management Program. And while it will not be used in an aquatic manner, Triclopyr has received its aquatic label recently which does speak to the sensibility of its use in riparian buffers. Also a good message to impart is that this sort of reveg work, and use of Garlon is similar to other organizations that have a great concern about the environment, such as TNC.

Last fall I developed a short fact sheet on some of the characteristics using three internet based databases on triclopyr. I'll attach it.

John Reed
Pest Management Program Coordinator
Horticultural Services
503-823-1636

City of Portland
Bureau of Environmental Services
Watershed Revegetation Program

Riparian Revegetation Program Description

Introduction

The Watershed Revegetation Program was developed to restore and maintain native vegetation in the upland, riparian, and wetland habitats of watersheds located in the City of Portland. It accomplishes this task by focusing on several issues: the removal of exotic, invasive plants that are out-competing native plant communities; reintroduction of native tree, shrub, and herbaceous plant communities, reduction of erosion into streams and sloughs by using bioengineering techniques; and enhancement, restoration and creation of wetland habitat to help replace wetland losses due to development and lack of vegetation management. Riparian and wetland restoration will provide an enhanced native plant landscape and improve water quality by increasing stream shading, groundwater recharge, flood storage capacity and biofiltration of sediments. In addition, native vegetation will provide habitat for wildlife and increase aesthetic values.

PROGRAM OUTLINE

The following process is used in this revegetation program:

Site Selection

BES selects potential planting sites that will most effectively improve water quality, wildlife habitat, existing plant communities and other resource values in a cost effective manner. Other criteria include proximity to other management areas and landowner agreement. During the site selection process, BES also identifies appropriate sites for wetland restoration, stream bank regrading, and other enhancement treatments.

Landowners are identified and approached for inclusion into this program.

Site Preparation

Site preparation allows access to planting sites and provides open initial growing conditions for planted seedlings. Workers remove exotic vegetation using chainsaws, weedeaters, industrial mowing equipment, and herbicides, depending on site conditions such as degree and species of invasive plant coverage, slope, and proximity to open water/wetland areas.

Plant Material

All plant material installed on restoration project sites is native to the Portland area. The plant inventory is stocked from several nurseries that grow local, native species and Portland Parks Mount Tabor Nursery, which works in conjunction with BES. Seed from native trees and shrubs are collected throughout the year from populations in the Portland metro area. Native seed is processed and propagated at nurseries. Collecting and propagating local, native seed preserves local plant genetics, increases survival and growth rates, helps restore native plant communities, and is cost effective.

Initial Planting
Plantings are designed to establish a cover of native trees, shrubs, and other plants as rapidly as possible, and to accentuate remnant native vegetation. Planters plant a variety of species at different spacings, in mixtures and as single-species groves.

Planting designs match species to compatible microsites. For example, willow, dogwood, and ash are planted on wet sites, alder and cottonwood on mesic (moist) sites; and conifers on mesic to dry sites. Native wetland emergent plants may be planted at the waterline or at wetland sites.

Actual species composition will vary depending on individual site characteristics to provide species and structural diversity, and to meet specific land management objectives of landowners.

Animal Damage Protection
Beaver, nutria, voles, and other rodents can rapidly eliminate tender young trees and shrubs over large areas. To reduce these losses, planters protect seedlings with vexar tubing (photo-degradable plastic mesh tubing installed on individual plants). In addition, planting mixtures will include species which appear to be less prone to damage by rodents; including conifers, red elderberry, and snowberry.

Mulch
The application of mulch is effective in maintaining soil moisture and suppressing the regrowth of competing non-native vegetation. In areas with poor soil moisture retention or heavy competition from invasive grasses, mulch enables seedlings to grow competitively longer into the summer.

Watering
The first two years are critical in the establishment of seedlings. If severe hot and/or dry weather is jeopardizing young plants, sites will be hand irrigated.

Monitoring
BES has prepared monitoring and documentation guidelines for riparian and wetland areas to assess conditions and identify trends to increase continued success of planting projects. Monitoring includes assessment of plant mortality and its causes. BES will interplant areas where stocking falls below a level that will assure occupancy of the site by native plants within 10 years, or as dictated by permit requirements. BES may prescribe other treatments to reduce further plant mortality or to further enhance project areas.

Other Treatments
Particularly steep and unstable banks may require excavation to a more stable angle prior to planting or stabilization using bioengineering techniques. Other treatments, such as removal of ivy or clematis vines from existing canopy, soil amendment, or removal of exotic trees species may be necessary or desirable on some sites to achieve particular management goals. BES prescribes these treatments on a site-by-site basis.

Five-Year Maintenance
Competition exerted on native seedlings from resprouting exotic vegetation is the single largest threat to project success. Throughout the project duration, BES applies maintenance treatments to reduce coverage of invasive plants. Workers selectively remove invasives from amongst planted native seedlings using chainsaws, hand tools, herbicide application tools, and where possible, mowing equipment. BES monitors planting survival and exotic vegetation re-growth, and prescribes additional treatments as needed.

Project Costs
The Watershed Revegetation Program has been able to minimize project cost, by implementing cost-effective measures. The program operates on a large, industrial scale resulting in wholesale purchasing power for labor, plants and materials. Program savings are passed on to landowners who choose to partner with the Watershed Revegetation Program.

Long-Term Maintenance and Enhancement
Most BES revegetation projects come to a close after five project years. By this time, native trees and shrubs should be established. Stands of young hardwoods and conifers will become very dense, shading out most exotics. Maintenance in these stands should be minimal after five years. Shade tolerant weeds such as nightshade, English ivy, and holly will require continued monitoring and treatment. Areas planted with native shrubs, forbs, and wetland emergent plants will require extended maintenance.

In situations where funding allows, BES may renegotiate with project property owners to allow access to the project site beyond the duration of the original project agreement, if further work is required to ensure that installed projects are stable and self-sustaining. Public, private or other funds may be used to finance this additional work.

Accomplishments
As of early 2003, the Watershed Revegetation Program is currently working on over nine hundred acres within the City of Portland, and has planted approximately 1.8 million trees and shrubs since 1995. Some 60 miles of streambank have been planted. Numerous wetland creation, bank stabilzation, water quality facility, and other habitat/vegetation related projects have been installed and are performing well. 150-200 acres of new project area are expected to be brought into program management in each of the next several years.

Vegetation Management Strategies

Our current strategy is based on the resources currently available to us, and the responses to treatments we have been able to observe to this point, it needs to be noted that assigning vegetative treatments is an evolving process. Management goals normally are weighted towards control of various noxious species that are ever present in western Oregon, the treatments will be listed in the context of the species we are trying to control. Emphasis is also given to the limited herbicide choices available to us under the NMFS listing that we operate under.

Himalayan Blackberry

Garlon 3-a, Garlon 4, and Round-Up are the herbicides available to control Himalayan blackberry (hbb). Garlon is our primary choice given that Round-Up is only effective in late fall and even then the effectiveness is inconsistent; Garlon, on the other hand, is effective any time of year.

In all cases we cut and spray black berries, we have the option of either cutting 1st then spraying the regrowth or mashing the canes down and then spraying, with a follow up cutting a couple of weeks latter. Both techniques have their advantages and disadvantages: mashing compresses the time needed for site preparation but requires a higher volume of spray mixture because the plants have more leaf surface, is logistically more difficult as two visits by the cutters are required and the effectiveness will vary depending on the amount of damage to the canes from mashing and if portions of the foliage are shielded by the upper layers of leaves. Cutting then spraying regrowth has the advantages of reduced spray volume, better release of desirable native plants, less damage to non-target vegetation and better access to the sprayer, however waiting to long to spray the regrowth can result in an additional cutting.

Timing of the spray is based on several factors: amount of time available before the site is to be planted, the number of naturals intermixed, height and density of the berries.

In either situation, herbicide will be applied by licensed contractors or licensed City of Portland Staff.

Watershed Revegetation Program
City of Portland, BES

1. **Herbicide Methods.**

Herbicide use is part of an overall strategy that is designed to decrease the total volume of herbicide use through the life of the project. There are three distinct phases of a typical project, initial site preparation, establishment and the maintenance phases.

- **Initial Site Preparation** (year one)

  -This includes the initial vegetative cutting of the existing noxious weed material typical of a new project site. This initial vegetative reduction reduces the amount of herbicide mixture needed to treat the project, this first treatment still represents the single highest volume of herbicide that will ever be applied to the site.

  -A second herbicide treatment will be prescribed, if needed, this second treatment is normally a much lower volume of herbicide than the initial site preparation treatment.

  -It is our intention to reduce the existing weed problems as completely as possible before installing any new plantings, it is much more feasible to treat a site before any native species are reintroduced.

  -Once the site is stabilized native grass and herbaceous species are then sown on the project to provide competition against re-establishment of aggressive non-native weed species.

- **Establishment Period** (years two and three)

  -After the initial noxious weed population has been mechanically reduced, it's re-growth treated with herbicides and the native groundcover established we then plant appropriate native tree and shrub species.

  -Significantly lower quantities of herbicide are now needed to maintain this more stable site condition.

  -Monitoring and proactive herbicide treatments designed to prevent new introductions or re-introductions of noxious weeds are the focus of this phase of the project life.

- **Maintenance Phase** (years four and five)

  -Once the native groundcover is well established and the installed native trees and shrubs are becoming established, even less herbicide will typically be needed to maintain the project. Again monitoring and prevention are the keys to continued success in managing the noxious weed populations

  -Some noxious weed species that particularly difficult to control, such as Reed Canary Grass, require a slightly different approach; again cutting and herbicides are used to reduce the initial weed problem, native groundcovers are then seeded over the project.

  -During the second establishment and all of the maintenance years, vegetative treatments will be favored over herbicide use. In this way we are acknowledging the overwhelming challenge of complete control of specific noxious weed species such as Reed Canary Grass, and utilizing an alternative approach to weed control.

Triclopyr Information

http://infoventures.com/e-hlth/pestcide/triclopy.html

Triclopyr
Pesticide Fact Sheet

Prepared for the U.S. Department of Agriculture, Forest Service by Information Ventures, Inc

Aquatic Animals: Triclopyr is low in toxicity to fish. The ester form of triclopyr, found in Garlon 4, is more toxic, but under normal conditions, it rapidly breaks down in water to a less toxic form. Triclopyr does not accumulate in fish. Triclopyr is slightly toxic to practically non-toxic to invertebrates.

III. Environmental Effects/Fate

Soil:

Residual Soil Activity: Triclopyr is active in the soil, and is absorbed by plant roots.
Adsorption: Triclopyr is adsorbed by clay particles and organic matter particles in soil.
Persistence and Agents of Degradation: Microorganisms degrade triclopyr rapidly; the average half-life in soil is 46 days. Triclopyr degrades more rapidly under warm, moist conditions.
Metabolites/Degradation Products and Potential Environmental Effects: 3,5,6-Trichloro-2-pyridinol is the major initial product of degradation. It has a half-life of 30 to 90 days, and degrades to carbon dioxide and organic matter.

Water:

Solubility: moderate to low
Potential For Leaching Into Ground-Water: The potential for leaching depends on the soil type, acidity and rainfall conditions. Triclopyr should not be a leaching problem under normal conditions since it binds to clay and organic matter in soil. Triclopyr may leach from light soils if rainfall is very heavy.
Surface Waters: Sunlight rapidly breaks down triclopyr in water. The half-life in water is less than 24 hours.

http://ace.ace.orst.edu/info/extoxnet/pips/triclopy.htm

E X T O X N E T

Extension Toxicology Network

Pesticide Information Profiles

Effects on aquatic organisms: The parent compound and amine salt are practically nontoxic to fish. Triclopyr has a LC50 (96-hour) of 117 mg/L in rainbow trout and 148 mg/L in bluegill sunfish [6]. The compound is practically nontoxic to the aquatic invertebrate Daphnia magna, a waterflea, with a reported LC50 for the amine salt of 1170 mg/L [136]. The ester formulation has reported 96-hour LC50 values of 0.74 mg/L and 0.87 mg/L in the rainbow trout and bluegill sunfish, respectively [6,137]. The compound has little if any potential to accumulate in aquatic organisms. The bioconcentration factor for triclopyr in whole bluegill sunfish is only 1.08.

Breakdown in water: Triclopyr is not readily hydrolyzed at pH 5 to 9. Hydrolysis of the ester and the amine salt occurs rapidly and results in formation of triclopyr [6]. Reported half-lives in water are 2.8 to 14.1 hours, depending on season and depth of water [137]. The ester formulation half-life is from 12.5 to 83.4 hours [137]. In water, the most important breakdown process is photolysis [137].

http://www.fs.fed.us/r6/nr/fid/pubsweb/tri.pdf

Forest Service
Pacific Northwest Region
November 1996
Triclopyr
Herbicide Information Profile
Potential for Leaching into Ground-Water:
The potential for triclopyr leaching increases as soil organic matter decreases, and as climatic conditions reduce soil microbial activity. Triclopyr has some characteristics conducive to leaching behavior. It is not strongly adsorbed to soil particles, and adsorbed molecules may later detach into water moving through the soil. Triclopyr exceeds the threshold for solubility used by EPA (30 ppm) when evaluating potential for leaching into groundwater (U.S. EPA 1986).
Long-term forest and pasture field studies found very little indication that triclopyr will leach substantially either horizontally or vertically in loamy soils (SERA, Inc. 1996c). A trace amount of the metabolite TCP was detected in groundwater at a golf course site. Chlorpyrifos, but not triclopyr, was also detected (Dupuy 1986). In soil leaching tests, little or no triclopyr has been found below surface layers. The metabolites of triclopyr were less mobile than triclopyr itself. Triclopyr contamination of groundwater has not been reported.

TRICLOPYR

Herbicide Basics

Chemical formula: [(3,5,6-trichloro-2-pyridinyl)oxy] acetic acid

Herbicide Family:
Pyridine (Picolinic acid)

Target Species: Broadleaf herbs and woody species

Forms: salt & ester

Formulations: EC, SL

Mode of Action: Auxin mimic

Water solubility: 430 ppm (acid), 23 mg/L (ester), 2,100,000 mg/L (salt)

Adsorption potential: Intermediate (higher for ester than salt)

Primary degradation mech: Microbial metabolism, photolysis, and hydrolysis

Average Soil Half-life: 30 days

Mobility Potential: Intermediate

Dermal LD50 for rabbits:
>2,000 mg/kg

Oral LD50 for rats:
713 mg/kg

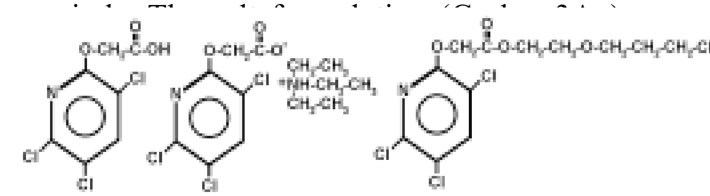
LC50 for bluegill sunfish:
148 mg/L

Trade Names: Garlon and Access

Manufacturer: Dow Agro-

Synopsis

Triclopyr is a selective systemic herbicide used to control woody and herbaceous broadleaf plants along right-of-ways, in forests, and in grasslands and parklands. It has little or no impact on grasses. Triclopyr controls target weeds by mimicking the plant hormone auxin, causing uncontrolled plant growth. There are two basic formulations of triclopyr - a triethyamine salt, and a butoxyethyl ester. In soils, both formulations degrade to the parent compound, triclopyr acid. Degradation occurs primarily through microbial metabolism, but photolysis and hydrolysis can be important as well. The average half-life of triclopyr acid in soils is 30 days. Offsite movement through surface or sub-surface runoff is a possibility with triclopyr acid, as it is relatively persistent and has only moderate rates of adsorption to soil particles. In water, the salt formulation is soluble, and with adequate sunlight, may degrade in several hours. The ester is not water-soluble and can take significantly longer to degrade. It can bind with the organic fraction of the water column and be transported to the sediments. Both the salt and ester formulations are relatively non-toxic to terrestrial vertebrates and invertebrates. The ester formulation, however, can be extremely toxic to fish and aquatic invertebrates. Because the salt cannot readily penetrate plant cuticles, it is best used as part of a cut-stump treatment or with an effective surfactant. The ester can be highly volatile and is best applied at cool temperatures on days with



Triclopyr acid Butoxyethyl ester Triethylamine salt

Herbicide Details

Chemical Formula: [(3,5,6-trichloro-2-pyridinyl)oxy]acetic acid

Trade Names: There are two basic formulations of triclopyr: a triethylamine salt (triclopyr amine or salt), and a butoxyethyl ester (triclopyr ester). The amine formulation is sold under the trade name Garlon 3A and is marketed in garden shops and hardware stores as Turflon Amine or as Brush-B-Gone . The ester formulation is sold under the trade name Garlon 4 and is marketed in garden shops and hardware stores as Turflon Ester . Other trade names include Access , Crossbow , ET , PathFinder II , Redeem , and Remedy . These products also may be mixed with picloram or 2,4-D to increase their versatility.

Manufacturers: Dow Agrosciences (formerly known as DowElanco or Dow Chemical), Platte

Use Against Natural Area Weeds: Triclopyr is used to control broadleaf herbs and woody species (WSSA 1994). It is particularly effective at controlling woody species with cut-stump or basal bark treatments. Susceptible species include the brooms (*Cytisus* spp., *Genista* spp., and *Spartium* spp.), the gorses (*Ulex* spp.), and fennel (*Foeniculum vulgare)*. Triclopyr ester formulations are especially effective against root- or stem-sprouting species such as buckthorns (*Rhamnus* spp.), ash (*Fraxinus* spp.), and black locust (*Robinia pseudoacacia*), because triclopyr remains persistent in plants until they die.

Even though offsite movement of triclopyr acid through surface or sub-surface runoff is a possibility, triclopyr is one of the most commonly used herbicides against woody species in natural areas. Bill Neil, who has worked extensively on tamarisk/saltcedar (*Tamarix* spp.) control, concluded that Pathfinder II , a triclopyr ester formulation by DowElanco, is the most cost effective herbicide for combating saltcedar. On preserves across the U.S., triclopyr has provided good control of tree-of-heaven (*Ailanthus altissima*), salt cedar (*Tamarix* spp.), glossy buckthorn (*Frangula alnus*), common *buckthorn (Rhamnus cathartica*), sweet fennel (*Foeniculum vulgare*), Brazilian peppertree (*Schinus terebinthifolius*), and Chinese tallow tree (*Sapium sebiferum*). TNC preserves in Hawaii have successfully used triclopyr to control blackwood acacia (*Acacia melanoxylon*), bush honeysuckle (*Lonicera maackii*), Chinese banyan (*Ficus microcarpa*), corkystem passionflower (*Passiflora suberosa*), eucalyptus (*Eucalyptus globulus*), Florida prickly blackberry (*Rubus argutus*), Mexican weeping pine (*Pinus patula*), Monterey pine (*Pinus radiata*), strawberry guava (*Psidium cattleianum*), tropical ash (*Fraxinus uhdei*), and velvet leaf (*Miconia calvescens*). Triclopyr can also be used in forest plantations to control brush without significant impacts to conifers (Kelpsas & White). Spruces (*Picea* spp.) can tolerate triclopyr, but some species of pine (*Pinus* spp.) however, can only tolerate triclopyr during the dormant fall and winter months (Jotcham et al. 1989).

Mode of Action: Triclopyr is an auxin mimic or synthetic auxin. This type of herbicide kills the target weed by mimicking the plant growth hormone auxin (indole acetic acid), and when administered at effective doses, causes uncontrolled and disorganized plant growth that leads to plant death. The exact mode of action of triclopyr has not been fully described, but it is believed to acidify and "loosen" cell walls, allowing cells to expand without normal control and coordination. Low concentrations of triclopyr can stimulate RNA, DNA, and protein synthesis leading to uncontrolled cell division and growth, and, ultimately, vascular tissue destruction. Conversely, high concentrations of triclopyr can inhibit cell division and growth.

Dissipation Mechanisms:

Summary: Both the ester and amine formulations are degraded by sunlight, microbial metabolism, and hydrolysis. In soils, both the ester and amine formulations will degrade rapidly to the parent compound, triclopyr acid. The acid and salt formulations bind well with soils, and therefore, are not likely to be mobile in the environment. The salt however, does not readily adsorb and can be mobile. The ester can be highly volatile (T. Lanini, pers. com.).

<u>Volatilization</u>

Ester formulations of triclopyr can be highly volatile, and care should be taken in their application. The potential to volatilize increases with increasing temperature, increasing soil moisture, and decreasing clay and organic matter content (Helling et al. 1971).

<u>Photodegradation</u>

Both the ester and salt formulations are degraded readily in sunlight to the parent compound, triclopyr acid, which is also photodegradable. A study of photolysis found the half-life of triclopyr acid on soil under midsummer sun was two hours (McCall & Gavit 1986). Photodegradation can be particularly important in water. Johnson et al. (1995) found triclopyr acid dissolved in water had a half-life due to photolysis of one to 12 hours.

<u>Microbial Degradation</u>

Microbial metabolism accounts for a significant percentage of triclopyr degradation in soils. In general, warm, moist soils with a high organic content will support the largest microbial populations and the highest rates of herbicide metabolism (Newton et al. 1990). Johnson et al. (1995a) found that microbial degradation of triclopyr was significantly higher in moist versus dry soils, and higher at 30º C than at 15º C (DT50 is 46 days versus 98 days in dry soils, and 57 days versus 199 days in moist soils, respectively. Additionally, the presence of sunlight plays a role in the rates of microbial metabolism of triclopyr. Johnson et al. (1995a) found that microbial metabolism was slowed when soil was deprived of light.

<u>Chemical Decomposition</u>

Hydrolysis of both the salt and ester to the acid form occurs readily in the environment and within plants (Smith 1976). McCall and Gavit (1986) reported that the ester was converted to an acid with a half-life of three hours, and that the rate of hydrolysis in water increased with an increase in pH.

Adsorption

Adsorption temporarily or permanently immobilizes triclopyr, but adsorption is not degradation. Adsorption is more important for the immobilization of the ester than of the salt formulation. The ester binds readily with the organic component of the soil, with adsorption rates increasing as organic content increases and soil pH decreases (Pusino et al. 1994; Johnson et al. 1995a). The salt form is soluble in water and binds only weakly with soil (McCall & Gavit 1986). The strong bond between the ester and soils accounts for the relatively low mobility of the ester in soils, whereas the salt form is much more mobile (McCall & Gavit 1986). In practice, however, both compounds are degraded rapidly to triclopyr acid, which has an intermediate adsorption capacity.

Behavior in the Environment

Summary: In soils, both formulations are degraded by photolysis, microbial metabolism, and hydrolysis to the parent compound, triclopyr acid. Triclopyr acid has an intermediate adsorption potential, limiting movement of the acid in the environment. The acid degrades with an average half-life of 30 days. In water, the salt will remain in the water column until it is degraded, which can occur in as little as a few hours under favorable conditions. The ester formulation, however, is not water-soluble and can take significantly longer to degrade in water. Within plants, both the salt and ester formulations are hydrolyzed to the acid form, and transported through the plant. Residues can persist in the plant until the tissues are degraded in the environment.

Soils

Both the ester and salt formulations degrade rapidly in soils to triclopyr acid, and thereafter, behave similarly in soils. Adsorption, photodegradation, microbial metabolism, and volatility, can all play a role in the dissipation of triclopyr from soils. The reported half-life of triclopyr in soils varies from 3.7 to 314 days, but averages 30 days, depending on the formulation applied and the specific soil and environmental conditions. If soil conditions are warm and moist, microbial metabolism can be the primary means of degradation (Newton et al. 1990).

Johnson et al. (1995a) reported an average half-life of triclopyr acid in four laboratory soils of 138 days, but this time varied significantly with soil temperature. At 15ºC half-lives ranged from 64-314 days, while at 30ºC half-lives were 9-135 days (Johnson et al. 1995). In Southwest Oregon, Newton et al. (1990) found 24-51% of triclopyr residues remained after 37 days in a dry and cool climate. Following an increase in warmth and moisture, however, dissipation increased dramatically and triclopyr residues exhibited a half-life of 11-25 days. In a study of triclopyr persistence in soil and water associated with rice production, triclopyr had a half-life of less than ten days in the three soil types tested (Johnson et al. 1995b). In a pasture near Corvallis, Oregon, the half-life of triclopyr acid was estimated to be 3.7 days (Norris et al. 1987).

Because of the importance of photodegradation and a decrease in the size of microbial populations with soil depth, triclopyr located deeper in the soil column (>15 cm) degrades more slowly than residues near the surface (Johnson et al. 1995a). Traces of triclopyr residues have been found at soil depths of 45 cm as late as 477 days after application (Newton et al. 1990). Sandy soils that are highly permeable may therefore, retain triclopyr longer. Most studies, however, found that triclopyr generally does not tend to move in significant quantities below the top 15 cm of soil (Norris et al. 1987; Newton et al. 1990; Stephenson 1990; Johnson et al. 1995a).

Water
In water, the two formulations can behave very differently. The water-soluble salt is degraded in the water column through photolysis and hydrolysis (McCall & Gavit 1985). The ester, however, is not water-soluble and can be persistent in aquatic environments. The ester binds to organic particles in the water column and precipitates to the sediment layers (McCall & Gavit 1986). Bound ester molecules will degrade through hydrolysis or photolysis to triclopyr acid (Smith 1976), which will move back into the water column and continue to degrade. The rate of degradation is dependent on the water temperature, pH, and sediment content.

Triclopyr acid has an intermediate soil adsorption capacity. Thus, movement of small amounts of triclopyr residues following the first significant rainfall are likely (McCall & Gavit 1986), but further leaching is believed to be minor (Newton et al. 1990; Stephenson et al. 1990; Thompson et al. 1991). Movement of triclopyr through surface and subsurface runoff in areas with minimal rainfall is believed to be negligible (Newton et al. 1990; Stephenson et al. 1990). In southwest Oregon, Norris et al. (1987) found that neither leaching nor long-distance overland water flow contributed significant amounts of the herbicide into a nearby stream, and concluded that the use of triclopyr posed little risk for non-target organisms or downstream water users. Triclopyr can, however, enter waterways via aerial drift and inadvertent overspray. When the acid was applied to rice paddy fields, residues remained in the water column and were not found in significant amounts in the soil (Johnson et al. 1995b). Degradation in water was rapid and showed a half-life of four days.

Vegetation
Both the ester and salt formulations are hydrolyzed to the acid after entering plant tissue. The acid tends to remain in plants until they die or dop leaves and begin to decay (Newton et al. 1990). Newton et al. (1990) reported that triclopyr in evergreen foliage and twigs showed remarkable persistence. Although concentrations of triclopyr in the soil will decrease quickly and remain low through the winter, levels can rise again in the spring if a new supply of contaminated foliage falls from defoliating crowns (Newton et al. 1990). The residues of some herbicides in fruit have been shown to persist up to one month (Holmes et al. 1994). There is therefore a potential for long-term exposure of triclopyr to animal species that eat wild fruit. In non-target plants, triclopyr soil residues can cause damage via root uptake (Newton et al. 1990).

Environmental Toxicity
Birds and Mammals
Triclopyr is regarded as only slightly toxic to birds and mammals. The oral LD50 for rats is 630-729 mg/kg. The LD50s for mallard ducks and bobwhite quail are 1,698 mg/kg and 2,935 mg/kg, respectively. Newton et al. (1990) predicted that triclopyr would not be present in animal forage in doses large enough to cause either acute or chronic effects to wildlife, and concluded that the tendency for triclopyr to dissipate quickly in the environment would preclude any problems with bioaccumulation in the food chain. Garlon 3A® can cause severe eye damage to both humans and

wildlife, due to the high pH of its water-soluble amine salt base. Care must be taken during mixing and application to prevent accidental splashing into eyes.

In a study of the potential effects of herbicide residues on forest songbirds, sub-lethal doses of triclopyr ester (500 mg/kg in the diet for 29 days) were found to cause weight loss and behavior alterations in zebra finches (Holmes et al. 1994). In a 1987 study of triclopyr metabolism using one cow, all traces of triclopyr were eliminated from the cow's urine within 24 hours, and no residues were detected in its milk or feces. This study, however, did not track whether any triclopyr was absorbed into the cow's tissues, or whether the triclopyr recovered in the urine was still active (Eckerlin 1987).

Aquatic Species

Triclopyr acid and the salt formulation are slightly toxic to fish and aquatic invertebrates. The LC50 of the acid and the salt formulation for rainbow trout are 117 mg/L and 552 mg/L, respectively, and for bluegill sunfish 148 mg/L and 891 mg/L, respectively. The ester formulation is highly toxic to fish and aquatic invertebrates, with an LC50 (96-hour) of 0.74 mg/L in rainbow trout and 0.87 mg/L in bluegill sunfish (WSSA 1994; EPA 1998). The hydrophobic nature of the ester allows it to be readily absorbed through fish tissues where is it rapidly converted to triclopyr acid. The acid can be accumulated to a toxic level when fish are exposed to sufficient concentrations or for sufficient durations.

The extent to which the toxic effects of the ester are reduced by degradation is poorly understood. Studies have shown that the ester formulation degrades rapidly to less toxic forms (Thompson et al. 1991). Kreutzweiser et al. (1994) however, has shown that there is a significant chance of acute lethal effects to fish exposed to low level residues for more than six hours. In addition, delayed lethal effects were seen in fish exposed to high concentrations for a short duration. Considering that Thompson et al. (1991) concluded that organisms subjected to direct overspray were exposed to a high level of herbicide for short periods of time while organisms downstream were exposed to low levels for longer periods, the findings of Kreutzweiser et al. (1994) are of concern.

Nevertheless, most authors including the authors of the fish mortality study have concluded that if applied properly, triclopyr would not be found in concentrations adequate to kill aquatic organisms. As a measure of precaution, however, Kreutzweiser et al. (1991) suggest that some water bodies remain at risk of lethal contamination levels including shallow and slow moving water bodies where dissipation is slow, and heavily shaded streams that experience reduced photodegradation.

Other Non-Target Organisms

Triclopyr inhibited growth of four types of ectomycorrhizal fungi associated with conifer roots at concentrations of 1,000 parts per million (ppm) and higher (Estok et al. 1989). Some evidence of inhibition of fungal growth was detected in bioassays with as little as 100 ppm triclopyr.

Typical usage in forest plantations, however, results in triclopyr residues of only four to 18 ppm on the forest floor (Estok et al. 1989).

Application Considerations:

Application Under Unusual Conditions:

Several natural area managers have found that Garlon 4® and 3A® are effective when applied in mid-winter as a cut-stump treatment against buckthorns (*Rhamnus cathartica* and *R. frangula*). It is often easier to get to these plants when boggy soils around them are frozen. Randy Heidorn, Deputy Director for Stewardship of the Illinois Nature Preserve Commission (INPC), recommends three protocols to increase the safety of triclopyr ester application in winter:

(1) use a mineral oil based carrier;

(2) make sure that at the time of application, no water is at or above the ground surface, and no snow or ice is present that might serve as a route to spread the herbicide following a thaw, and;

(3) initiate a monitoring program to assess ambient water concentrations of triclopyr ester in communities that seasonally have water at or above the ground surface with little or no discharge (i.e. bogs).

Safety Measures

The salt formulation in Garlon 3A® can cause severe eye damage because of the high pH of its water-soluble amine salt base. Care should be taken to prevent splashing or other accident contact with eyes.

Human Toxicology

Because studies into the carcinogenicity of triclopyr have produced conflicting results, EPA has categorized triclopyr as a "Group D" compound, or a chemical that is not classifiable as to human carcinogenicity. The salt formulation in Garlon 3A® can cause severe eye damage.

References

Eckerlin, R.H., J. E. Ebel, Jr., G. A. Maylin, T. V. Muscato, W. H. Gutenmann, C. A. Bache, and D. J. Lisk. 1987. Excretion of triclopyr herbicide in the bovine. Bull. Environ. Contam. Toxicol 39:443-447.

Estok, D., B. Freedman, and D. Boyle. 1989. Effects of the herbicides 2,4-D, glyphosate, hexazinone, and triclopyr on the growth of three species of ectomycorrhizal fungi. Bull. Environ. Contam. and Toxic., 42:835-839.

Helling, C. S., P. C. Kearney, and M. Alexander. 1971. Behavior of pesticides in soil. Adv. Agron. 23:147-240.

Holmes, S. B., D. G. Thompson, K. L. Wainio-Deizer, S. S. Capell, and B. Staznik. 1994. Effects of lethal and sublethal concentrations of the herbicide triclopyr butoxyethyl ester in the diet of Zebra finches. J. Wildlife Dis. 30(3):319-327.

Johnson, W. G., T. L. Lavy, and E. E. Gbur. 1995a. Persistence of triclopyr and 2,4-D in flooded and non-flooded soils. J. Environ. Qual., 24:493-497.

Johnson, W. G., T. L. Lavy, and E. E. Gbur. 1995b. Sorption, mobility, and degradation of triclopyr and 2,4-D on four soils. Weed Sci. 43:678-684.

Jotcham, J. R., D.E.W. Smith, and G.R. Stephenson. 1989. Comparative persistence and mobility of pyridine and phenoxy herbicides in soil. Weed Tech. 3:155-161.

Kelpsas, B.R. and D.E. White. no date. Conifer tolerance and shrub response to triclopyr, 2,4-D and clopyralid. Northwest Chemical Company, Salem, Oregon.

Kreutzweiser, D. P., S. B. Holmes, and D. C. Eichenberg. 1994. Influence of exposure duration on the toxicity of triclopyr ester to fish and aquatic insects. Archives of Environ. Contam. Toxic. 26:124-129.

McCall, P. J. and P. D. Gavit. 1986. Aqueous photolysis of triclopyr and its butoxyethyl ester and calculated environmental photodecomposition rates. Environ. Toxic. Chem. 5:879-885.

Newton, M., F. Roberts, A. Allen, B. Kelpsas, D. White, and P. Boyd. 1990. Deposition and dissipation of three herbicides in foliage, litter, and soil of brushfields of southwest Oregon. J. Agric. Food Chem, 38:574-583.

Norris, L., M. L. Montgomery, and L. E. Warren. 1987. Triclopyr persistence in western Oregon hill pastures. Bull. Environ. Contam. Toxic. 39:134-141.

Pusino, A. W. Liu, and C. Gessa. 1994. Adsorption of triclopyr on soil and some of its components. J. Agric. Food Chem 42:1026-1029.

Smith, A. E. 1976. The hydrolysis of herbicidal phenoxyalkanoic esters of phenoxyalkanoic acids in Saskatchewan soils. Weed Res. 16:19-22.

Stephenson, G. R., K. R. Solomon, C. S. Bowhey, and K. Liber. 1990. Persistence, leachability, and lateral movement of triclopyr (Garlon) in selected Canadian forestry soils. J. Agric. Food Chem. 38:584-588.

Thompson, D. G., B. Staznik, D. D. Fontaine, T. Mackay, G. R. Oliver, and J. L. Troth. 1991. Fate of triclopyr ester (Release®) in a boreal forest stream. Environ. Toxic. Chem. 10:619-632.

WSSA. 1994. Herbicide Handbook. Weed Society of America. Champaign, Illinois, 352 pp.