



Suggested Herbicide Mixtures for Roadside Vegetation Management

This publication provides examples of herbicide mixtures for different vegetation concerns along roadsides. It is intended to be illustrative, not exhaustive. We have limited the discussion to commonly used products, or products we feel could be commonly used. Listed rates represent one point in a possible range of rates.

The product label is the authoritative document on the use of an herbicide. Read it, and follow it.

Trade names are provided for information, not as a recommendation. Many of the herbicides described in this document are available in identical formulations from multiple manufacturers. When applicable, the products listed are on the current Pennsylvania state herbicide contract, administered by the PA Department of General Services. Table 1 provides a list of the herbicides mentioned in this document.

Table 1. These are examples of herbicides used for roadside vegetation management. They are listed by trade name, active ingredient, concentration (% for dry, lb/gal for liquids), primary application (preemergence or postemergence), and most common use in a roadside setting (TVC is 'total vegetation control').

trade name	active ingredients	concentration	application	common use
AquaNeat	glyphosate	4 lb/gal (5.4 lb ai/gal)	POST	nonselective
Arsenal	imazapyr	2 lb/gal	PRE, POST	brush
Edict IVM	pyraflufen-ethyl	0.2 lb/gal	POST	broadleaf
Escort XP	metsulfuron	60%	POST	broadleaf, brush
Garlon 3A	triclopyr	3 lb/gal	POST	broadleaf, brush
Tahoe 4E	triclopyr	4 lb/gal	POST	brush
Journey	glyphosate imazapic	1.5 lb/gal 0.75 lb/gal	PRE, POST	TVC
Karmex XP	diuron	80%	PRE	TVC
Krenite S	fosamine	4 lb/gal	POST	brush
Krovar I	bromacil diuron	40% 40%	PRE	TVC
Milestone VM	aminopyralid	2 lb/gal	POST	broadleaf
Oust Extra	sulfometuron metsulfuron	56% 15%	PRE, POST	TVC
Oust XP	sulfometuron	75 %	PRE, POST	TVC
Overdrive	dicamba diflufenzopyr	50% 20%	POST	broadleaf
Payload	flumioxazin	51%	PRE, POST	TVC
Pendulum AquaCap	pendimethalin	3.8 lb/gal	PRE	TVC
Plateau	imazapic	2 lb/gal	PRE, POST	TVC
Sahara DG	diuron imazapyr	62% 8%	PRE, POST	TVC
Throttle XP	sulfentrazone sulfometuron chlorsulfuron	48% 18% 9%	PRE, POST	TVC
Tordon 101M	2,4-D picloram	2.0 lb/gal 0.54 lb/gal	POST	broadleaf, brush
Tordon K	picloram	2 lb/gal	POST	broadleaf, brush
Triplet SF	2,4-D MCP dicamba	2.4 lb/gal 0.63 lb/gal 0.23 lb/gal	POST	broadleaf
Vanquish	dicamba	4 lb/gal	POST	broadleaf, brush
Velpar DF	hexazinone	75 %	PRE, POST	weeds in crownvetch

By Art Gover, Jon Johnson, and Larry Kuhns, 2007. This work was sponsored by the Pennsylvania Department of Transportation. The contents of this work reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of either the Commonwealth of Pennsylvania or The Pennsylvania State University, at the time of publication. This work does not constitute a standard, specification, or regulation.
 Penn State College of Agricultural Sciences research programs are funded in part by the Commonwealth of Pennsylvania and the U.S. Department of Agriculture.

Several treatments include the herbicide *glyphosate*. The *glyphosate* product *AquaNeat* mentioned within these recommendations contains 5.4 lb active ingredient (ai)/gal (equivalent to the product *Rodeo*). If you are using a *glyphosate* product with 4 lb ai/gal (equivalent to the product *Roundup*) use 1/3 more product. For example, instead of 48 oz/ac of *AquaNeat*, you would use 64 oz/ac of *GlyPro Plus*.

When treatments are targeting foliage, a surfactant should be included in the mixture. Consult the herbicide labels for surfactant recommendations.

Integrated Vegetation Management

Our focus here is the specifics of herbicide mixtures for a range of roadside vegetation issues. However, herbicides are just one tool available to vegetation managers. Responsible management relies on a broad-based program including establishing and preserving desirable groundcovers, judicious mowing, tree trimming and brushing. These activities are only truly effective as part of a pre-planned program.

To cover the spectrum of treatments you may use during the season in a roadside program, we have categorized the treatments as total vegetation control, selective weed and brush control, 'non-selective' weed and brush control, and control of problem species.

Total Vegetation Control (TVC)

TVC applications provide bare ground under guiderrails, around signposts, and along concrete barriers and traffic islands (*Figure 1*). The herbicide components of a TVC treatment usually consist of broad-spectrum residual (BSR), preemergence, and postemergence ingredients. BSR herbicides provide control of existing vegetation, as well as soil residual activity. BSR herbicides are potentially more prone to off-site movement, and are applied at rates to provide 'just enough' activity while minimizing the application rate. Preemergence herbicides are generally highly insoluble and immobile in the soil, remain near the soil surface, and less likely to move off-site. These products are applied at higher rates to prevent establishment of weeds from seed for the entire growing season. Postemergence herbicides are effective at controlling actively growing weeds that are already established. Relatively low rates of a postemergence herbicide can substitute for increasing the rates of the BSR component of the mix.

Commonly used BSR herbicides include *sulfometuron*, *bromacil*, and *imazapyr*.

Examples of preemergence herbicides include *diuron*, *pendimethalin*, *imazapic*, *flumioxazin*, and *sulfentrazone*.

Table 2: Product suggestions to illustrate different approaches to assembling a total vegetation control treatment. Abbreviations: BSR-broad spectrum residual, MOA- mode of action, PRE-preemergence, POST-postemergence. Costs are approximate, based on the 2006 Pennsylvania state herbicide contract (PA Dept. of General Services).

mix no.	products	product/ac	comments	cost/ac
1	Oust XP + Karmex XP + AquaNeat	3 oz 8 lb 48 fl oz	Arguably the industry standard. Excellent preemergence and postemergence activity at a low cost. If emerged vegetation is not present, the <i>glyphosate</i> treatment is not needed for any treatment listed (subtract \$8 per acre).	\$62
2	Oust Extra + Karmex XP + AquaNeat	4 oz 8 lb 48 fl oz	'Oust Extra' increases foliar activity, particularly against woody species that may be present, such as vines.	\$62
3	Krovar I AquaNeat	8 lb 48 fl oz	The <i>bromacil</i> in 'Krovar I' replaces <i>sulfometuron</i> in 'Oust Extra' as the BSR component. Can be used as a rotation option for Mix 1 or 2.	\$90
4	Oust Extra + Krovar I AquaNeat	3 oz 5 lbs 48 fl oz	Also provides a rotation option to Mix 1 or 2, and the <i>bromacil</i> in the 'Krovar I' should provide additional activity against well-established perennials.	\$92
5	Sahara DG AquaNeat	10 lb 48 fl oz	The 10 lb/ac rate of 'Sahara DG' is equivalent to 'Arsenal' plus 'Karmex XP' at 3 pints plus 8 lbs/acre. <i>Imazapyr</i> increases activity against perennials and woody vines that may be present. <i>Imazapyr</i> has the same MOA as <i>sulfometuron</i> , so this is not a viable rotation treatment to 1 or 2.	\$ 88
6	Throttle XP AquaNeat	12.5 oz 48 fl oz	'Throttle XP' was developed to provide control of weeds that have developed resistance to <i>sulfometuron</i> or <i>diuron</i> by relying on <i>sulfentrazone</i> as the preemergence component. 'Throttle XP' will become available during 2007.	\$90
7	Oust Extra + Payload AquaNeat	4 oz 8 oz 48 fl oz	Payload has a MOA similar to <i>sulfentrazone</i> in Throttle XP. This is another tank mix to consider as a rotation option for kochia control.	\$87
	Karmex XP	8 lb	This list compares the costs of PRE herbicides that would be added to a BSR. 'Karmex XP' is widely used because it is effective and inexpensive. 'Payload' provides improved control of resistant kochia. 'Pendulum AC' is very effective against annual grasses. 'Journey' or 'Plateau' is effective against grasses but weak on legumes.	\$24
	Payload	8 oz		\$48
	Pendulum AC	134 fl oz		\$38
	Journey	32 fl oz		\$28
	Plateau	12 fl oz		\$26

The most commonly used postemergence herbicide is *glyphosate* (see Table 1 for trade names for herbicide active ingredients).

Examples of herbicide mixtures for TVC applications are listed in Table 2. These mixtures are intended to provide bare ground for the entire growing season. These treatments have a high material cost per acre, but typically manpower and equipment are the most expensive elements of this application. Doing it twice with a cheaper mix costs more than doing it once with the right mix.

An increasingly important issue with TVC treatments is *herbicide resistance*. Many weeds are genetically variable, and some of the genetic strains (biotypes) within a species are less susceptible to certain herbicides. If this

herbicide is applied repeatedly, the susceptible biotypes are eliminated and resistant biotypes become dominant. When this occurs, the treatment is no longer effective. This is occurring throughout Pennsylvania with kochia (*Kochia scoparia*). It is important to rotate herbicide mixtures every season or two and change the *mode-of-actions* within the mixture to reduce the onset of herbicide resistance. The herbicides *Oust XP*, *Arsenal*, and *Plateau* have the same mode-of-action. Substituting among these materials is not a viable rotation.

TVC treatments are applied early-season to prevent the establishment of vegetation. However, applying later within this window provides two advantages - your treatment has to provide residual activity for a shorter time, and the postemergence activity of your treatment increases as the leaf area of the target vegetation increases.



Figure 1. Most total vegetation control applications to roadsides are fixed-pattern, truck-based treatments to guiderails, concrete barriers, and shoulders. Signposts and traffic islands are treated with a handgun application.

Selective Weed and Brush Control

Many herbicide combinations for weed and brush control are intended to selectively control herbaceous broadleaf weeds, as well as encroaching brush without injuring roadside turf. In general, controlling woody plants requires a more potent treatment than controlling herbaceous weeds. If you are targeting only broadleaf weeds in mowed, roadside turf, a common 'three-way' turf weed control product such as 'Triplet SF' (2,4-D, MCPP, dicamba) will be effective and economical. When targets include brush or herbaceous species that are not subject to mowing, you need to use more potent herbicides.

Table 3 provides examples of herbicide mixtures that will control broadleaf weeds and brush while limiting injury to grasses. Mixes that include 'Escort XP' will cause discoloration and temporary growth inhibition of many grasses. growth regulator. Where this is unacceptable, use the mixes that do not include 'Escort XP'.

Table 3: Examples of herbicide combinations for a selective broadleaf weed and brush application. Costs are approximate, based on the 2006 Pennsylvania state herbicide contract (PA Dept. of General Services).

products	product/ac	comments	cost/ac
Garlon 3A + Escort XP	64 fl oz 0.5 oz	Probably the most commonly used combination on PA roadsides. Controls a wide spectrum of herbaceous and woody species. 'Escort XP' can injure cool season grasses. 'Garlon 3A' rates will range from 32 to 64 oz/ac, and 'Escort XP' rates are typically 0.5 to 1.0 oz/ac.	\$32
Garlon 3A + Vanquish + Escort XP	32 fl oz 32 fl oz 0.25 oz	By adding 'Vanquish' and reducing the 'Escort XP' rate, turf safety is improved. 'Overdrive' at 8 oz/ac could be substituted for 'Vanquish'.	\$35
Garlon 3A + Vanquish	48 fl oz 48 fl oz	Removing 'Escort XP' from the mixture improves safety to grasses, but the rates of 'Garlon 3A' and 'Vanquish' should be increased to maintain the same activity against woody species.	\$48
Garlon 3A + Tordon 101M	64 fl oz 64 fl oz	A common mix in utility settings. 'Tordon 101M' is a Restricted Use Pesticide. Substituting 'Tordon K' at 16 oz/ac for the 'Tordon 101M' would provide the same dose of <i>picloram</i> .	\$45

'Non-selective' Weed and Brush Control

Herbicide mixtures that include *glyphosate* or 'Krenite S' are commonly used to target brush, but these mixtures will injure all vegetation that is contacted. These mixtures are useful against dense stands of brush and weeds where there is no desirable groundcover present (Figure 2), or for targeting encroaching branches (sidetrimming) on narrow rights-of-way. When targets are scattered, apply these treatments selectively to preserve desirable vegetation.

An advantage of a *glyphosate*-based mixture is that any undesirable species can be targeted during the application, whether grass, broadleaf, or woody.

Table 4 lists treatments that include *glyphosate* or 'Krenite S'.

'Problem Species' Mixtures

Herbicide programs for roadside vegetation management are intended to address a broad range of species. However, some species 'escape' the normal program and become very problematic. Often, these species require specific applications, and multiple applications within a growing season.

Table 5 illustrates suggested herbicide mixes and sequences for tree-of-heaven, or ailanthus (*Ailanthus altissima*), Japanese knotweed (*Polygonum cuspidatum*), Canada thistle (*Cirsium arvense*), and poison hemlock (*Conium maculatum*) and other biennial weeds growing in crownvetch areas.

Our Japanese knotweed recommendations include a treatment early in the season to 'burn down' or defoliate roadside knotweed. This is not the best time to treat knotweed, but it is often necessary to prevent the knotweed from reducing sight distance and encroaching into the roadway. The early-season application on roadsides serves as a 'chemical mowing' prior to a late-season *glyphosate* application.



Figure 2. A non-selective mixture of the herbicides *glyphosate* plus *imazapyr* is applied to a dense stand of tree-of-heaven (*Ailanthus altissima*) using a handgun.

Ailanthus is another species that should be treated twice in the same growing season, particularly tall, dense colonies. We recommend a foliar treatment in July using *glyphosate* mixed with 'Arsenal' or 'Escort XP' (Figure 2). After the effects of this treatment are clear, we make a follow-up application using a basal bark treatment, targeting the missed stems. The initial foliar treatment greatly reduces the stem number, and the follow-up treatment very selectively eliminates the remaining targets.

The recommendations for Canada thistle address turf or crownvetch areas. In turf areas, or areas you are converting to turf, a late season application of 'Milestone VM' maximizes injury to thistle. In crownvetch, an early

Table 4: Herbicide combinations for broad-spectrum brush and weed control. These mixtures must be applied selectively to prevent injury to non-target vegetation. Costs are approximate, based on the 2006 Pennsylvania state herbicide contract (PA Dept. of General Services).

products	product/ac or product/100 gal	comments	cost/ac
AquaNeat	96 fl oz	Broad spectrum, inexpensive, and no residual activity. <i>Glyphosate</i> alone will miss some species, such as autumn olive (<i>Elaeagnus umbellata</i>) and red maple (<i>Acer rubrum</i>). Tank mixing with other herbicides is recommended.	\$15
AquaNeat + Arsenal + Escort XP	96 fl oz 8 fl oz 1 oz	This three-way mix is (highly) non-selective and has significant soil residual activity. We have used 'Arsenal' or 'Escort XP' in two-way combinations with <i>glyphosate</i> with good success on mixed brush species.	\$44
Krenite S + Arsenal	192 fl oz 3 fl oz	'Krenite S' is the standard treatment to sidetrim brush. <i>Fosamine</i> is a bud-inhibitor and mostly stays in the part of the plant where it was applied. 'Arsenal' increases the species spectrum, but also increases the translocation beyond the contacted branches.	\$70

June application of 'Velpar DF' will selectively burn down the thistle and prevent seed set.

Poison hemlock and other biennial weeds usually occur in crownvetch areas. An early April application of 'Velpar DF' plus *glyphosate* allows you to target the weeds while they are still small, and take advantage of a window prior to the start of the TVC program. Waiting until June with 'Velpar DF'-only (no *glyphosate*) provides better control of Canada thistle, but the 'skeletons' of the treated biennials will be 5 to 8 ft tall.

A key to managing any problem species is vigilant follow-up and a dedicated maintenance program after you have achieved initial control.

For More Information

Don't make a treatment if you are unsure of it.

Always consult the product labels for application and safety information. The manufacturer's representative and your herbicide distributor are good sources of information.

You can reach us through the contact information at the bottom of this page. Our website (<http://rym.cas.psu.edu>) features several publications addressing vegetation management in non-crop areas.

Table 5. Herbicide mixtures and sequences for Japanese knotweed (*Polygonum cuspidatum*), ailanthus (*Ailanthus altissima*), Canada thistle (*Cirsium arvense*), and poison hemlock (*Conium maculatum*). Costs are approximate, based on the 2006 Pennsylvania state herbicide contract (PA Dept. of General Services).

timing	products	product/ac	species and comments	cost/ac
spring	Garlon 3A + Escort XP + Edict IVM	64 fl. oz + 1 oz + 2.75 fl. oz	Japanese knotweed - a late-season (September) application of <i>glyphosate</i> has proven to be economical and effective. However, knotweed grows early in the season and needs to be treated in the spring to maintain sight distance and reduce encroachment. 'Edict IVM' is a contact herbicide that provides rapid burndown. 'Vanquish' can be substituted for 'Garlon 3A'. The <i>glyphosate</i> treatment is applied late in the summer to knotweed regrowth.	\$51
followed by late summer	followed by AquaNeat	followed by 96 fl oz		\$ 15
July	AquaNeat + Arsenal	96 fl. oz 4 fl. oz	Ailanthus - well established (tall) stands should be treated twice during the same growing season, between July 1 and fall color. A high-volume application of <i>glyphosate</i> and <i>imazapyr</i> provides effective control and minimal residual activity, allowing quicker revegetation. 'Arsenal' can be replaced by 0.5 oz/ac of 'Escort XP', which is very active against ailanthus but has more soil residual activity. The Garlon 4 basal bark application (at least 30 days later) addresses the larger stems not adequately treated by the foliar treatment as well as misses.	\$28
Aug/Sep	followed by Garlon 4 basal oil	25 % v/v 75 % v/v		\$24/gal
in turf Sep/Oct	Milestone VM	7 fl. oz	Canada thistle - In turf, or areas you are converting to turf, fall applications of 'Milestone VM' have provided excellent reduction, and will also eliminate crownvetch. If mustard species are present, tank-mix with an herbicide such as 'Garlon 3A', 'Vanquish', 'Overdrive' or 'Triplet SF'. In crownvetch, a Velpar DF treatment will burn down thistle and most other weeds.	\$17
in crownvetch June	Velpar DF	20 oz		\$24
April	AquaNeat Velpar DF	12 fl. oz 20 oz	Poison hemlock and other biennials - these species typically infest crownvetch areas where regular mowing or weed control is not practiced. Treating poison hemlock in early April allows you to complete this program prior to starting the bareground program. 'Velpar DF' is safe to crownvetch, and the low rate of <i>glyphosate</i> applied early in the season causes minimal injury. If Canada thistle is also a target, delay the application to early June and don't add <i>glyphosate</i> . Poison hemlock in turf areas is readily controlled with the treatments listed in Table 3.	\$26
or June	Velpar DF	20 oz		\$24

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