

Roadside Chemical Usage Guidelines



2007 Edition

Updated April 2007

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The Importance of Roadside Vegetation Management

Keeping Nebraska's highways safe for those who travel includes the careful management and control of roadside vegetation. (*"Vegetation" as referenced here includes grasses, wildflowers, shrubs, brush, and trees.*) This includes, but is not be limited to, vegetation in the "clear zone" area, that part of the right of way that must remain free of obstructions.

Some examples are:

- Vegetation that hinders the visibility of traffic approaching any intersection.
- Vegetation overhanging or encroaching upon a right of way.

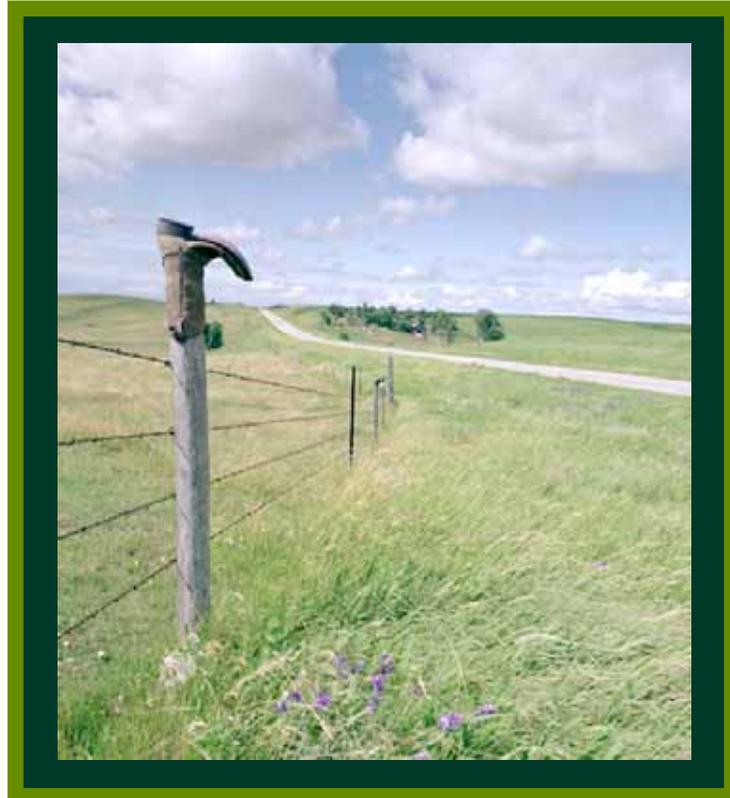
Note: *The State has the right to cut vegetation overhanging its right-of-way to protect the traveling public. In the event of a tree trunk on private property with limbs overhanging state right of way, this may be done without the consent of the private owner since one does not have the right to encroach upon State right-of-way in any manner.*

Safety is foremost in our landscape management and design. Common sense must prevail in the placement and/or maintenance of vegetation so safety hazards are not created or allowed to continue, once noted.

Safety of NDOR employees and the environment are other concerns that have influenced the choice of chemicals and methods recommended in this document. If an effective alternative to a restricted use pesticide is available, that is preferable to one of restricted use. Since many of the soils in Nebraska are porous and groundwater is a limited resource, pesticides least likely to contaminate groundwater or surface water are preferred to those that pose such a risk. NDOR also has a responsibility to make sure chemicals applied to the right-of-way stay there.

If you have concerns or questions about the treatments recommended in this document, please contact Alison Krohn with the Roadway Stabilization Unit: AlisonKrohn@dor.state.ne.us, (402) 479-3642.

Nebraska Weed Info



Questions about the information in this section should be directed to Alison Krohn at (402) 479-3642.

Email: AlisonKrohn@dor.state.ne.us

(ALWAYS READ AND FOLLOW LABEL DIRECTIONS)

Nebraska Noxious Weeds

1. Leafy Spurge..... Statewide
2. Musk Thistle Statewide
3. Canada Thistle Statewide
4. Plumeless Thistle Statewide
5. Diffuse Knapweed Statewide
6. Spotted Knapweed..... Statewide
7. Purple Loosestrife Statewide
8. Salt Cedar Statewide
9. BindweedBanner, Box Butte, Cheyenne, Deuel, Dundy,
Dawes, Garden, Morrill, Scotts Bluff, Sheridan Counties
10. Yellow Bedstraw.....Cherry County
11. Woolly Leaf Bursage Banner County
12. Bull Thistle..... Rock County
14. Scotch Thistle..... Dawes, Morrill
15. Houndstongue.....Dawes County
16. Common Reed Cass County
17. Sericea LespedezaPawnee, Johnson, Otoe, Gage Counties
18. Flodman Thistle..... Fillmore County
19. Tall Thistle..... Fillmore County

For information on noxious weeds in Nebraska or its counties contact:

Mitch Coffin, Program Manager
Nebraska Department of Agriculture
Bureau of Plant Industry
Noxious Weed Program
PO Box 94756, Lincoln, NE 68509
Office: 402-471-6844
Cell: 402-416-0603
FAX: 402-471-6892
mcoffin@agr.ne.gov

Most counties in the state are covered by a Weed Management District. They frequently sponsor workshops on noxious species found in that area and are a good resource. The county weed superintendents are also a good source of information.

Vegetation Management Websites

(for information, labels, and MSDS)

BASF.....	www.vmanswers.com/lib/
Becker-Underwood	www.beckerunderwood.com/
DowAgro	www.dowagro.com/prod/index.htm
Dupont	www.dupont.com/ag/vm/
Monsanto	www.monsanto.com/ito
PBI Gordon	www.pbigordon.com
Riverdale.....	www.riverdalecc.com
Syngenta.....	www.syngenta.com
UAP Timberland Supply Co.	www.uap.com
Van Diest Supply Co.....	www.vdsc.com
Labels and MSDS for all companies.....	www.cdms.net/manuf/manuf.asp
Invasive Species Info.....	www.invasivespeciesinfo.gov
County Extension Offices.....	www.extension.unl.edu/about.htm/About Us/County Offices/document view
UNL Institute of Agriculture & Natural Resources.....	http://ianrhome.unl.edu/
Nebraska Department of Agriculture.....	www.agr.state.ne.us/division/bpi/bpi.htm
Nebraska Weed Control Association	www.neweed.org
Pesticide Education Resources	http://pested.unl.edu/pesticide/pages/index.jsp

Guidelines & Forms



Questions about the information in this section should be directed to Alison Krohn at (402) 479-3642.
Email: AlisonKrohn@dor.state.ne.us

(ALWAYS READ AND FOLLOW LABEL DIRECTIONS)

Calendar

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Canada Thistle												
						Caution: seed spread						
Leafy Spurge											Plateau	
						Caution: seed spread				Plateau		
Biennial Thistles			Rosettes							Rosettes		
			Rosettes							Rosettes		
Knapweeds			Rosettes							Rosettes		
			Rosettes							Rosettes		
Purple Loosestrife										Contact wetland manager if found in mitigation site		
Salt Cedar												
	Apply seasonally recommended chemical to cut stump. Remove all woody debris.											
								Contact wetland manager if found in mitigation site				
Red Cedar	Priority given to hazard trees, seed bearing (blue berry), adjacent to rangeland & pasture											
Trees & Shrubs				No treatments 4/15 to 7/15								
	No snow on ground											
								After leaf drop, no snow				

- plant is flowering
- mechanical control
- chemical control

Certification of Chemical Applicators

- NDOR maintenance personnel who apply Pesticides should be certified by the Nebraska Department of Agriculture.
- Restricted Use Chemicals should only be used after all nonrestricted options have been tried, and failed, to control the problem. Maintenance personnel who apply Restricted Use Chemicals **must** be certified in Right-of-Way Pest Control to apply those chemicals.
- Maintenance personnel who apply a Restricted Use Chemical to treat for pocket gophers must be certified in Wildlife Damage Control.
- Maintenance personnel who apply any insect control, chemicals, including fertilizer, to lawns must be certified in ornamental and turf pest control.
- These rules also apply to the contractors that maintain any of our state operated rest areas, offices, maintenance yards, or apply chemicals on any NDOR right of way areas.

From: Nebraska Department of Agriculture

1. The Nebraska Pesticide Act, §2-2638(2), states in part that:

“Any person who applies lawn care for hire or compensation, shall apply to the Department for a commercial applicator license regardless of whether such business applies to any restricted use pesticides.”
2. Section 005.02A4 of the Nebraska Pesticide Act regulations defines that the Ornamental and Turf Pest Control category as:

“...including commercial and noncommercial applicators using or supervising the use of restricted use or general use pesticides to control pests in the maintenance and production of **ornamental trees, shrubs, flowers, and turf**, including in and around structures, greenhouses, plant nurseries, golf courses, athletic fields, public or private grounds and turf farms.”

Nebraska Department of Roads’ employees who apply pesticides, either general use or restricted use pesticides, in the maintenance of ornamental trees, shrubs, flowers, and turf on roadside rest areas are, therefore, required to be certified as either commercial or noncommercial pesticide applicators in Nebraska.

Pesticide Application Report

To be completed by Commercial Pesticide Applicators who apply Restricted Use Pesticides in Nebraska. Ref. 40 C.F.R. §171.11(c)(7).

Date Report Filed:

Pesticide Applied By: (Name of person and address of the maintenance yard)			Pesticide Applied For: Nebraska Department of Roads PO Box 94759 Lincoln Nebraska 68509-4759				
MONTH	DAY	YEAR	Time of Application A.M. <input type="checkbox"/> P.M. <input type="checkbox"/>		Location of Application: (Highway and Reference Post)		
Trade Name and EPA Registration Number of Pesticide Applied:							
Amount Applied:		% Active Ingredient :		Targeted Pest(s):			
COMPLETE THIS SECTION IF DISPOSAL IS REQUIRED							
Type of Pesticide:		Amount:					
Method:		Location:		Specific Crop or Commodity Applied To: Turf-Lawn <input type="checkbox"/> Roadside <input type="checkbox"/>			
Additional Comments:							

DR Form 187a, Oct 05

Nebraska Department of Roads

Pesticide Applications Document

(To be completed annually for each pesticide)

Distribution
Supervisor
Maintenance Engineer, Operations Division
Employee

Date:	Pesticide to be Applied:	Restricted Use: <input type="checkbox"/> Yes <input type="checkbox"/> No	
Supervisor:	Applicator:	Employee NIS No.	Certified: <input type="checkbox"/> Yes <input type="checkbox"/> No
<p>I have been given information on the use of the pesticide</p> <p>for application on <i>(Identify target species)</i></p> <p>I have been given the label and the Material Safety Data Sheets and have been given time to read them. Time was made for me to ask questions about the chemical.</p> <p style="text-align: right;">..... <i>(Signature of Applicator)</i></p>			
<p>Method of Application: <input type="checkbox"/> Backpack Sprayer <input type="checkbox"/> Tank Sprayer <input type="checkbox"/> Hand Spreader <input type="checkbox"/> Other</p> <p>Before being sent out to apply pesticides, the equipment to be used has been inspected and checked by</p> <p style="text-align: right;">..... <i>(Signature of Person Who Checked Equipment)</i></p>			

DR Form 187, Mar 07

Chemicals and Vegetation Control



Questions about the information in this section should be directed to Alison Krohn at (402) 479-3642.
Email: AlisonKrohn@dor.state.ne.us

(ALWAYS READ AND FOLLOW LABEL DIRECTIONS)

Chemical Additives and Accessories

Dye	Becker Underwood – Tablets – Liquid & Water Soluble Packets
Surfactant	Non-ionic - Premier 90, Liberate (surfactant & drift control) Methylated Seed Oil – Soy Stik Silicon – Silenergy, Silco
Drift Control	Gardian, Liberate (surfactant & drift control)

Insect Control

Insect Control – Lawns

Billbug & Webworm	Talstar One or Tempo SC Ultra
Spider Mites	Soapy Water, Avid, or Talstar One
Grubs	Merit or Mach II – <i>Apply June 10 to July 10</i>

Insect Control – Right of Way

Eastern Tent Caterpillar	Tempo SC Ultra – Sevin or Eight Non-chemical – Dipel
Grasshoppers	Tempo SC Ultra – Same as tent caterpillar
Mosquitoes	Adults – Talstar, Tempo WP on shrubs & trees Larvae – Non-chemical – Minnows, BTI briquettes

Weed Control – Lawns

Pre-emergent – Dimension or Barricade

Broadleaf Weeds – Trimec 992 or Vessel (2,4-D amine); Mecamine “D” or Speedzone (2,4-D ester)

General Weed Control – Right of Way

In Joints	Campaign, Journey, Stalker, Glyphosate (follow label instructions for spot spraying)
Wet Ditches	Rodeo, Habitat
Under Asphalt	Stalker, Journey, Arsenal
In Trees & Shrubs	Casoron 4G – November thru March, Pendulum
Grass in Trees & Shrubs	Poast, Over the Top with Fusilade 2000 during the growing season

General Vegetation Control

Guardrail Vegetation Chemicals

Chemical treatments must be rotated to minimize resistance development in annual weeds. Some weeds have already developed resistance to glyphosate (*Round-Up*) including Marestalk and Giant Ragweed. Guardrails set in pavement should only be treated after weeds appear.

1. All guardrails and signs set in pavement (**do not overspray**), treat after weeds emerge:
Glyphosate (example Round-Up): 6 oz. per gallon water
Journey 16 oz./gal or Arsenal 1.5 oz./gal + Nonionic Surfactant ½ oz. or Methylated Seed Oil 1-2 oz./gallon of water (*do not mix these chemicals with 2,4-D*)
2. Guardrails and signs (non-pavement set) approaching surface water (*bridges, culverts with water*), use treatments listed under pavement or the following:
Pre-emergence – Pendulum AquaCap 2 oz. + Arsenal 4 oz. + non-ionic surfactant ½ oz. per gallon of water. Pendulum may also be mixed with glyphosate for post-emergence residual control
Post-emergence – Escort XP 1 oz. + 2,4-D 24 oz. + 12 oz. non-ionic surfactant per **25** gallons of water. Always pre-mix Escort with some water to make a slurry that can be added to half-full tank. Escort can settle to the bottom of the tank without proper agitation and must be used the day it is mixed.
3. Other guardrails (not around water or in pavement) – mixes above or the following if resistance occurs:
1 gal. Tailspin + 2 oz. Escort XP + 6 oz. silicon surfactant per **100** gallons of water
4. If Kochia and/or Russian Thistle emerge and appear to be resistant to current treatment, use 0.75 oz. of Vista + 1-2 oz. Methylated Seed Oil per gallon of water. Spray to wet, not to run off.
5. Surfactants that work well:
A. Premier – 90+ Gardian Drift Control, Liberate
6. For non-selective, non-residual use:
A. Roundup Pro, Ranger Pro, Buccaneer + surfactant

Seasonal Brush Control

Spring – Summer

No treatment from March 15 to July 15

August 1 to September 15 Krenite-S – See Below

After leaf drop to March 15 See Trees & Stump Control p. 18

Use the following recipe for August to September brush control: Good Coverage = Good Control
100-Gallon Mix

1. 1 Quart Gardian
2. 1½ Gallons Krenite-S
3. Use Good Pressure (*50 to 80 psi*)

Noxious Weed Control

Spot Spraying for Thistle Control (Canada, Musk, Plumeless, Scotch, Bull)

<http://www.newweed.org/weeds.htm>: The best time to treat biennial thistles is the spring or early summer before they bolt and flower, but they are most visible when flowering. Check areas where control was applied or needed in previous years to scout for thistle rosettes.

1. To a 3-gallon back-pack sprayer, add 1 1/2 gallons of water and then the following:
 - A. 1 fluid ounce of Milestone
 - B. 3/4 to 1 ounce dye
 - C. Add water to 3 gallon level
2. Transline 1 oz./gallon water, requires good agitation
3. Cimarron 1 oz. + 4 pints non-ionic surfactant per 100 gallons of water
4. If unable to spot spray thistles, mow before seed sets (*while plants are flowering*).

Canada Thistle (<http://www.newweed.org/noxweeds/cana.htm>): One of our most serious weeds because it is a perennial that will spread if not controlled. Some colonies develop resistance to specific herbicides so switch to another active ingredient if suppression is not achieved after 3 years of treatment. Mow when the plant is blooming to prevent seed formation and dispersal.

1. Milestone: 0.05 oz. (1 Tablespoon) per gallon water
2. Transline: 1.5 oz./gallon water

Leafy Spurge (<http://www.newweed.org/noxweeds/leaf.htm>) is another serious, perennial pest that will spread if not treated.

1. When plant is budding, the following may be mixed up for a 100 gallon tank at a rate of 30 gallons per acre:
 - A. 3 qts. 2,4-D Low Volatile Ester + 16 oz. of Dye

Retreatment in the fall with Plateau will be needed for control. The mix above will slow its spread.

2. When plant is flowering, mow it to prevent seed formation and mark it for fall treatment.
3. Fall treatment: Plateau 1.5 oz. + 0.3 oz. methyl seed oil (0.25% of total volume) per gallon of water.

Knapweeds (Spotted, Diffuse [<http://www.newweed.org/weeds.htm>])

1. Milestone 0.05 oz./gallon water during rosette to flower bud stage
2. Transline: 0.5 oz./gallon water during rosette to flower bud stage
3. 2,4-D ester: 1 oz./gallon + drift agent water during rosette stage

Purple Loosestrife (<http://www.newweed.org/noxweeds/purp.htm>): Use aquatic label herbicide if the area to be treated has surface water. Do not mow. New plants can sprout from cuttings.

Biological Control: Galerucella spp. beetles have been released along the Platte, Niobrara, and Missouri Rivers in Nebraska to suppress the plant. Contact the county weed supervisor for information on the release of beetles to infested R.O.W., especially wetland mitigation sites.

1. 2,4-D amine per 1.5 oz. per gallon water
2. Rodeo (aquatic label) 1.5 oz. + 0.5 oz. non-ionic surfactant per gallon water
3. Habitat (aquatic label) 1-2 qt per 100 gallons water

Saltcedar (<http://www.newweed.org/noxweeds/salt.htm>): All vegetative material should be removed because new plants can sprout from cuttings.

Habitat 4-6 oz. + 4 oz. methylated seed oil per 3 gallons water applied to foliage when tree is flowering.

For cut stump application, mix 8-12 oz. Habitat per gallon of water and apply to outer quarter of cut surface.

County Declared Noxious Weeds

Bindweed: Banner, Box Butte, Cheyenne, Deuel, Dundy, Dawes, Garden, Morrill, Scotts Bluff, Sheridan Counties

1. Escort XP 1.5 oz. + 3 qts. 2,4-D ester + 1 gallon non-ionic surfactant per 100 gallons of water; requires good agitation
2. Plateau 1.5 oz. + 1.3 oz. methylated seed oil per gallon of water
3. Glyphosate 32 oz. + 2,4-D ester 0.5 pint/acre, apply late summer through fall

Sericea Lespedeza (<http://www.newweed.org/watchlist/serlez/slez.htm>) Pawnee, Johnson, Otoe, Gage Counties: 2,4-D is not effective against this plant.

1. Remedy 1.3 oz. per gallon water prior to bloom
2. Escort XP 1 oz. + 1 qt. non-ionic surfactant per **100 gallons** water late summer to fall application when plants are blooming; requires good agitation
3. Milestone 0.05 oz. per gallon water
Not affected by 2,4-D

Woolly Bursage Banner County

1. Round-Up Max 1-2 oz. per gallon water
2. 2,4-D ester 1.5 oz. per gallon water when plant is budding
3. Plateau 1 oz. + 1.3 oz. methylated seed oil per gallon water

Houndstongue (<http://www.newweed.org/watchlist/htong/htong.htm>) Dawes County

1. Plateau 1.5 oz. + 1.3 oz. methylated seed oil per gallon of water
2. Escort XP 1.5 oz. + 1 qt. non-ionic surfactant per **100 gallons** water; requires good agitation

Common Reed (Phragmites) (<http://www.newweed.org/watchlist/phrag/phrag.htm>) Cass County

Habitat 1 pint per 3 gallons water

Yellow Bedstraw (<http://plants.usda.gov/java/profile?symbol=GAVE>) Cherry County

Milestone 0.05 oz. per gallon water

Plateau 1.5 oz. + 1.3 oz. methylated seed oil per gallon of water

Wetlands Noxious Weed Control and Brush Control

The Department of Roads now owns many wetlands across Nebraska. The wetlands are not free from noxious weeds and invading Cottonwoods. The two noxious weeds that are the most common in the wetlands are Purple Loosestrife and Canada Thistle with an occasional patch of Leafy Spurge in the upland portion of the wetlands.

The County Weed Control Authorities may call your attention to these noxious weeds and want to spray them or urge you to get in there and spray these weeds or you may notice these weeds through your own vigilance.

Do not spray in the wetlands on your own. Call the Environmental Permits Unit at (402) 479-4418 and talk it over with the Manager or the Biologist in charge of that wetland.

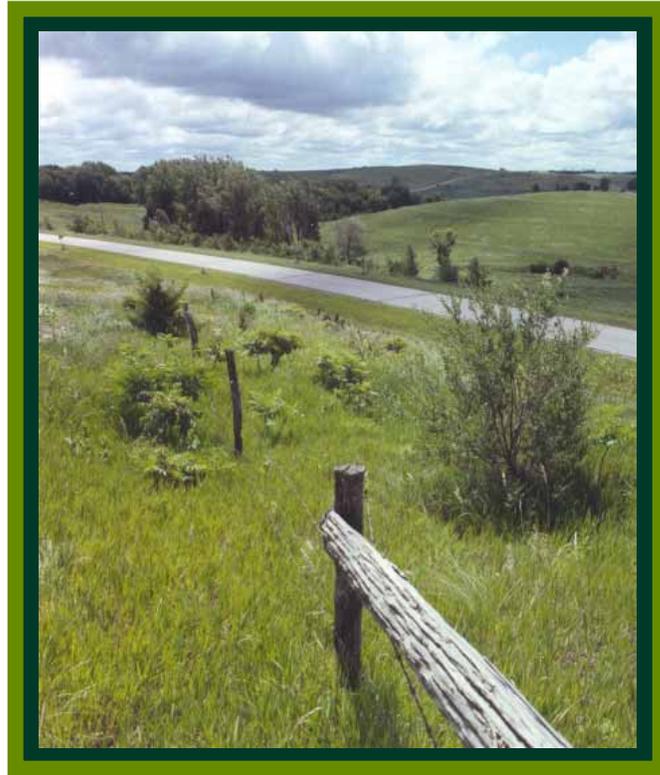
Wetland Volunteer Tree & Noxious Weed Control

Recipe for a three-gallon backpack sprayer applied after June 15.

1. For a three-gallon backpack sprayer, add the following:
 - A. 1 Gallon of Water
 - B. 6.25 fluid ounce of Rodeo
 - C. 2 Ounces Premier 90 Wetting Agent
 - D. 1 Ounce of Dye
 - E. Add 2 more Gallons of Water
2. Spray to wet the entire plant
3. The solution may also be made up in bulk.

This recipe is good for Volunteer Trees, and Purple Loosestrife in wetlands.

Tree & Stump Control



Questions about the information in this section should be directed to Alison Krohn at (402) 479-3642.
Email: AlisonKrohn@dor.state.ne.us

(ALWAYS READ AND FOLLOW LABEL DIRECTIONS)

Cut Stump Herbicides

During the growing season:

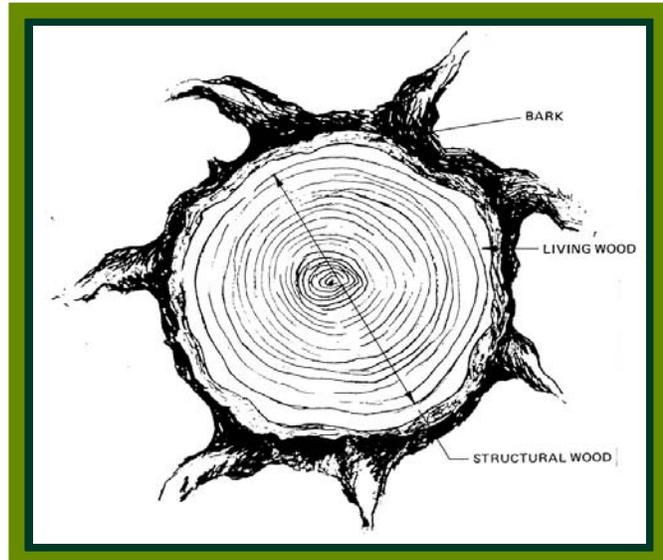
- A. 2-4-D Amine
- B. Roundup – Pro

During the dormant season:

- A. Pathfinder II
- B. Krenite – S
- C. Stalker or Remedy basal mixtures

Cut Stump Treatment for Stumps Over 3” in Diameter

- Treat the living wood only – Treat immediately after cutting
- Stumps that are 3” and under, cover the entire stump immediately



Red Cedar Control for Cedars Three Foot and Smaller

Cedars cut below live branches will not resprout and need no chemicals. Herbicides do not work well on trees larger than 6' and the potential for offsite drift is high. Eradication priority should be given to female trees bearing fruit (*blue berries*).

100 Gallon Mix

1. 2 Ounces of Escort XP
2. 1 Pint of "Silenergy"
3. Spray to Wet – from Spring greenup to first frost
4. Symptoms are slow to appear – may take the entire growing season for a complete kill.

Call if you have questions, (402) 479-3642, or email AlisonKrohn@dor.state.ne.us.

Tree Control with Dormant Basal Treatment (*cannot be used in snow cover or standing water*)

- Spray entire trunk from knee high to the ground.
- Spray to wet only – we do not want runoff.
- Wear appropriate clothing:
- Rubber Boots
- Plastic Gloves
- Disposable Coveralls



1. Pathfinder II is a ready to use product and requires no mixing
2. Remedy 1 qt. per 3 qts crop oil or penetrating oil makes 1 gallon of spray
3. Stalker 8-12 oz. per gallon of penetrating oil; do not use around desirable woody plants

Penetrating or basal oil is carried by Van Diest or UAP Timberland as J.L.B. oil plus.

The recipe says the basal treatment should be made to the lower 12 to 18 inches of the tree trunk – approximately **knee high down to the ground**. Spray to wet – runoff is not necessary and only wastes the mix.

Areas that are treated with this basal method will have dead brush next year and can be a scheduled cleanup event.

Herbicide Restrictions Table

Haying Restrictions, Minimum Rainfast Time, Surfactant Recommendations:

Product	Chemical	Hay Restriction	Rainfast (Hours)	Surfactant
numerous	2,4-D amine or ester	30 days	4 hrs	
Arsenal	Imazapyr	7	not specified	non-ionic
Campaign	Glyphosate & 2,4-D	30	6 hrs	
Cimarron <i>(not including Cimarron Max, X-tra or Plus)</i>	Metsulfuron Methyl	0	4 hrs	non-ionic
Escort XP	Metsulfuron Methyl	0-3 *	4 hrs	non-ionic
Garlon 3A	Triclopyr amine	14	6 hrs	
Journey	Imazapic & glyphosate	7	1 hr	
Krenite	Fosamine	NA	not specified	
Milestone	Aminopyralid	0	4 hrs	
Overdrive	Diflufenzopyr	0	4 hrs	
Pathfinder II	Triclopyr ester	365*	not specified	drift control
Payload	Flumioxazin	365	1 hr	non-ionic
Pendulum Aquacap	Pendimethalin	NA	not specified	
Plateau	Imazapic	7	1 hr	methylated seed oil
Remedy	Triclopyr ester	365*	not specified	
Rodeo	Glyphosate	0-56	6 hrs	
Round-Up	Glyphosate	0-56	2-6 hrs	
Transline	Clopyralid salt	0	2 hrs	
Stalker	Imazapyr	7	not specified	
Vista	Fluroxypyr	7	not specified	

* see label

Calibration of Sprayers

Calibrating spray equipment is critical to the proper application of herbicides. The University of Nebraska Lincoln has published a NebGuide (G1511) that provides guidance on calibrating broadcast and hand sprayers: <http://www.ianrpubs.unl.edu/sendlt/g1511.pdf>

The same information is provided in the UNL *Guide for Weed Management in Nebraska* (EC 130), p. 30: <http://www.ianrpubs.unl.edu/sendlt/ec130.pdf>

The NebGuide below has been reprinted with permission from the University of Nebraska-Lincoln Extension.

v:\operations\chem-guide-final.doc

G1511

Calibration of Sprayers (Also Seeders)

Robert N. Klein, Extension Cropping Systems Specialist

Various methods for calibrating sprayers and seeders and related application information.

Applying the correct rate of a product is an important part of obtaining good results with both seeders and pesticide sprayers. With seeders too little seed reduces crop yields and increases weeds while too much seed increases costs and may reduce yields. With a pesticide application, too little product can mean poor control, while too much can mean crop injury, extra costs, and possible residue on the crop and/or carryover.

Many methods can be used to calibrate sprayers, including the ounce calibration and formula-based methods. With the ounce calibration method, 1/128 of an acre is sprayed and the spray is collected. When measured in ounces the amount collected would be equal to the number of gallons applied per acre since there are 128 ounces in a gallon. (For further information on this method, see NU NebGuide, *Fine Tuning a Sprayer with the "Ounce" Calibration Method*, G88-865.) Other methods involve using formulas which need to be remembered or recorded for easy use. These methods also may require converting some of the information you have.

The methods discussed in this NebGuide are simple relationships and do not require remembering formulas. However, you do need a general understanding of cross multiplication. The important thing is to be consistent: if you put an item on top of an equation on one side, the same item also goes on the top on the other side.

Three factors determine sprayer application rate:

1. Speed
2. Nozzle spacing
3. Nozzle output (determined by orifice size, pressure, and density of spray solution)

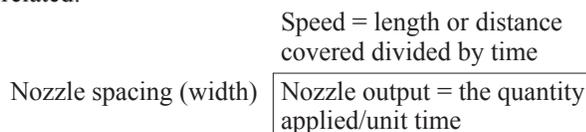
Where:

Speed = Length or distance covered divided by time

Nozzle spacing = Width

Nozzle output = The quantity applied/unit time

The following diagram shows how these three factors are related:



For example, to determine speed:

1 mile per hour (mph) is:

1 mile (5,280 ft) in 1 hour (60 minutes)

$$\text{Or } 1 \text{ mph} = \frac{5,280 \text{ ft/hour}}{60 \text{ min/hour}} = 88 \text{ ft/min}$$

Problem 1. Determine speed in mph.

If we travel 440 feet (ft) in 30 seconds (sec), what is our speed in mph?

The objective is to determine the distance traveled in 60 seconds (1 minute) and divide by 88 (88 feet/minute is equal to 1 mph).

$$\frac{30 \text{ sec}}{440 \text{ ft}} = \frac{60 \text{ sec}}{D} \quad (\text{D is the distance we are solving for in the equation})$$

We cross multiply to find the value of D

$$30 D = 60 \times 440$$

$$30 D = 26,400$$

$$D = \frac{26,400}{30}$$

$$D = 880 \text{ ft}/60 \text{ sec}$$

Since every 88 ft traveled/60 sec (1 min) is equal to 1 mph, we divide 880 by 88 to get 10 mph

Problem 2. Determine speed in mph.

If we travel 297 feet in 27 seconds, what is our speed?

$$\frac{27 \text{ sec}}{297 \text{ ft}} = \frac{60 \text{ sec}}{D}$$

$$27 D = 60 \times 297$$

$$27 D = 17,820$$

$$D = \frac{17,820}{27}$$

$$D = 660 \text{ ft}/60 \text{ sec}$$

Divide by 88 since 1 mph = 88 ft/60 sec (1 min)

$$\frac{660}{88} = 7.5 \text{ mph}$$

Problem 3. Determine speed in mph.

If we travel 660 feet in 1 minute and 15 seconds, what is our speed?

First, convert 1 minute and 15 seconds to seconds: 60 + 15 = 75 seconds

$$\frac{75 \text{ (sec)}}{660 \text{ (ft)}} = \frac{60 \text{ (sec)}}{D}$$

$$75 D = 39,600$$

$$D = 528$$

$$\frac{528}{88} = 6 \text{ mph}$$

Problem 4. Determine rate/acre.

If the sprayer is moving at 6 mph, the distance covered in one minute is 528 feet (6 mph x 88 ft/min = 528 feet).

To determine the area you cover with one nozzle in one minute if your sprayer has a 30-inch nozzle spacing:

Distance traveled 6 x 88 = 528 ft/min

30 in (2.5 ft)

Area sprayed = 1,320 sq. ft. (2.5 ft x 528 ft/min)

Collect the output of several nozzles and determine the average output per nozzle. All nozzles should be within 10 percent of the manufacturer's rating for that nozzle. For example an XR11003 delivers 0.3 gpm at 40 psi. If it delivers more than 0.33 gpm or 42.24 (128 x .33) ounces/min at 40 psi, the nozzle should be replaced. Any nozzle delivering 5 percent above or below the average delivery rate for all the nozzles should be replaced.

For this example, the average nozzle output is 32 oz per minute or

$$32 \text{ (oz/min)} \div 128 \text{ (oz/gallon)} = 0.25 \text{ gpm}$$

What is the rate per acre? One way to calculate application rate without remembering a formula is to use a relationship: The amount applied and the area sprayed per minute are the same as the amount applied and the area sprayed per acre. R = gals/acre

	Minute Box		Acre Box
	Distance 6 x 88 = 528 ft		
Nozzle Spacing 30 in ÷ 12 = 2.5 ft	0.25 gpm	=	R
	528 x 2.5 = 1320 sq ft		43,560 sq ft

From minute box $\frac{0.25}{1320} = \frac{R}{43,560}$ From acre box

$$1320R = 10,890 \text{ (} 0.25 \times 43,560 \text{)}$$

$$R = 8.25 \text{ gals/acre}$$

Problem 5. Determine the acres sprayed per minute.

Travel distance in one minute = 616 ft
 Nozzle spacing = 30 in (20 nozzles on sprayer)
 Nozzle output = 64 oz/minute
 What is travel speed? $616 \div 88 = 7 \text{ mph}$ (Remember 88 ft/min = 1 mph)

What is sprayer width? 20 nozzles x 2.5 ft (30-inch spacing) per nozzle = 50 ft

What is application rate? $\frac{64 \text{ oz/minute}}{128 \text{ oz/gallon}} = 0.5 \text{ gpm}$

	Minute Box		Acre Box
	Distance 616 ft		
30-inch nozzle spacing (2.5 ft)	64 oz or 0.5 gpm	=	R
	1,540 sq ft		43,560 sq ft

$$\frac{0.5}{1,540} = \frac{R}{43,560}$$

$$1540R = 21,780$$

$$R = 14.14 \text{ gals/acre}$$

To determine the area covered the sprayer in one minute:
 1,540 sq ft/nozzle/minute
 20 nozzles 1,540 x 20 ÷ 43,560 sq ft/A = 0.71 acre/minute

Problem 6. Determine nozzle size needed to achieve the operational goal.

Sprayer speed = 7 mph
 Nozzle spacing = 20 inches
 Application rate desired = 17 gpa
 Nozzle flow rate = F

	Minute Box		Acre Box
	7 x 88 = 616 ft		
Nozzle Spacing $\frac{20 \text{ in}}{12 \text{ in/ft}} = 1.67 \text{ ft}$	F = gpm	=	17 gpa
	1,029 sq ft		43,560 sq ft

$$\frac{F}{1,029} = \frac{17}{43,560}$$

$$43,560 F = 17,493$$

$$F = 0.40 \text{ gpm} \quad \text{or XR8004* at 40 psi}$$

If we need 0.40 gpm, by design an XR8005* will give 0.5 gpm at 40 psi. Output varies by the square root of the pressure.

For example: $\sqrt{40 \text{ psi}} = 6.32 \text{ psi}$

$$\frac{\sqrt{40 \text{ psi}}}{\sqrt{10 \text{ psi}}} = 2$$

$$\sqrt{10 \text{ psi}} = 3.16 \text{ psi}$$

Raising the pressure from 10 to 40 psi (4 times $\sqrt{4} = 2$) doubles output.

Therefore we need to reduce output to 0.40 gpm which is 80 percent of the 0.5 gpm that an XR8005 puts out at 40 psi.

$$\sqrt{40} = 6.32 \times 0.8 = 5.056$$

$$\sqrt{P}$$

To solve for "P" take the result multiplied by itself.
 5.056 x 5.056 = 25.6 psi
 an XR8005 at 25.6 psi will give you 0.40 gpm

*Selected from TeeJet Nozzle Booklet by Spraying Systems.

Problem 7. Calibrating a hand sprayer.

First fill sprayer with water to a known level, a mark you can later refill to accurately. (Tip: It's best to spray a test area over concrete so you can see the evenness of application.)

Spray test area 100 sq ft = 10 ft x 10 ft
 or 250 sq ft = 10 ft x 25 ft
 or 500 sq ft = 10 ft x 50 ft or 20 ft x 25 ft

Refill sprayer to same level as before, measuring amount of water it takes to refill sprayer.

If the pesticide recommendation is for 2 liquid ounces of product per 1,000 sq ft, the amount to include per 1,000 sq ft would be 1/4 cup or 4 tablespoons or 12 teaspoons. (See Weights and Measures Conversions on page 4.)

If during the test, 28 oz of water were applied over 250 sq ft, how much water and pesticide should be added to a 3 gallon sprayer?

The amount of water you applied in test area	$\frac{28 \text{ oz}}{250 \text{ sq ft}} = \frac{V \text{ for volume}}{1,000 \text{ sq ft}}$	How much water you will apply per 1,000 sq ft
--	--	---

$$250 V = 28,000$$

$$V = 112 \text{ ounces or } \div 32 \text{ (ounces/qt)} =$$

3.5 qt of water per 1,000 sq ft

This indicates that 2 oz of pesticide should be added for every 3.5 qt of sprayer capacity.

With a 3-gallon sprayer, 12 qt (3 x 4 qt/gal) of water should be added to the sprayer tank.

$$\frac{2 \text{ oz}}{3.5 \text{ qt}} = \frac{P \text{ for Pesticide}}{12 \text{ qt}}$$

$$3.5 P = 24$$

$$P = 6.86 \text{ oz or } 0.86 \text{ cup (8 oz/cup)}$$

6.86/8 = 0.86 cup The amount of pesticide to add to a 3-gallon sprayer

Problem 8. Determining the density of spray solution.

The rate at which a fluid flows through a spray orifice varies with its density. Since all the tabulations are based on spraying water, which weighs 8.34 lbs per U.S. gallon, conversion factors must be used when spraying solutions which are heavier or lighter than water. To determine the proper size nozzle for the solution to be sprayed, first multiply the desired GPM or GPA of solution by the water rate conversion factor. The conversion factors are the square root of specific gravity. (See Weights and Measures Conversion chart on page 4 for some common fertilizers).

For example, the specific gravity of 28% nitrogen, which weighs 10.65 lbs/gal, is:

$$\frac{10.65 \text{ (Wt of 28-0-0/gal)}}{8.34 \text{ (Wt of water/gal)}} = 1.28 \text{ specific gravity}$$

Conversion factor for 28-0-0 fertilizer or 28% nitrogen is

$$\sqrt{1.28} = 1.13$$

<i>Weight of Solution</i>	<i>Specific Gravity</i>	<i>Conversion Factors</i>
7.0 lbs per gallon	0.84	0.92
8.0 lbs per gallon	0.96	0.98
8.34 lbs per gallon - Water	1.00	1.00
9.0 lbs per gallon	1.08	1.04
10.0 lbs per gallon	1.20	1.10
10.65 lbs per gallon - 28% nitrogen	1.28	1.13
11.0 lbs per gallon	1.32	1.15
11.06 lbs per gallon - 32% nitrogen	1.33	1.15
12.0 lbs per gallon	1.44	1.20
14.0 lbs per gallon	1.68	1.30

Example of using the conversion factor:

Desired application rate is 20 GPA of 28% N.

$$\text{GPA (solution)} \times \text{Conversion factor} = \text{GPA (water)}$$

$$20 \text{ GPA (28\%)} \times 1.13 = 22.6 \text{ GPA (water)}$$

A nozzle size should be selected to supply 22.6 GPA of water at the desired pressure, speed, and nozzle spacing.

Problem 9. Determining the density of a spray solution.

In this example, the following has been recommended for an ecofallow corn field:

75 lbs of nitrogen from 28% UAN

Density of 28% N = 10.65 lbs/gal

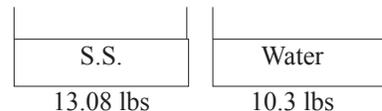
$$10.65 \times .28 = 2.982 \text{ lbs N/gal}$$

$$\frac{75 \text{ lbs N}}{2.982 \text{ lbs N/gal}} = 25.15 \text{ gal of 28\% solution}$$

<i>Ingredient</i>	<i>Amount</i>	<i>Gallons</i>
28% Nitrogen	75 lb N	25.151
Balance Pro	2.0 oz	0.016
Fultime	2.25 qt	0.563
Gramoxone Extra	2 pt	0.250
Crop Oil Concentrate	1 qt	0.250
2,4-D 6 LVE	1/2 pt	0.063
		26.293 or 26.3 gal/acre

To determine how this will spray out and what gallonage of water is needed to get 26.3 gal/acre of this spray solution, three steps are required:

1. To determine specific gravity weigh an equal amount of the spray solution and an equal amount of water.



Determine specific gravity weight of spray solution:

$$\frac{13.08 \text{ lbs (wt of spray solution)}}{10.3 \text{ (wt of water)}} = 1.27 \text{ specific gravity}$$

2. Determine conversion factor $\sqrt{1.27} = 1.13$
3. Determine the quantity of water to calibrate sprayer:
 Spray Rate x Conversion Factor = Water Amount Equivalent
 $26.3 \text{ gal/acre} \times 1.13 = 29.6 \text{ gal/acre}$
 Now you need to calibrate the equipment to apply 29.6 gallons of water per acre.

Problem 10. To calibrate a seeder.

How many pounds of seed are needed to plant 18 seeds/ft in a row with 10-in spacing. Seed size is 15,000 seeds/lb and seed is collected for 500 ft.

To determine pounds of seed needed per acre:

$$\frac{12 \text{ in/ft}}{10 \text{ in/row}} = 1.2 \quad 1.2 \times 43,560 \text{ ft}^2/\text{A} = 52,272 \text{ ft of row/acre}$$

$$52,272 \times 18 \text{ seeds/ft row} = 940,896 \text{ seeds/acre} \div 15,000 \text{ seeds/lb} = 62.7 \text{ lb/A}$$

NOTE: Reference to commercial products is made with the understanding that no discrimination is intended and no endorsement by University of Nebraska Cooperative Extension is implied.

Determine area seeded with one opener on one acre:

	Test Box	Acre Box
10 in per row or	500 ft long	
$\frac{10 \text{ in}}{12 \text{ in/ft}} = 0.83 \text{ ft}$	Wt for weight of seed calibrated	62.7 lb seed/acre
	415 sq ft (500 x .83)	43,560 sq ft

Then cross multiply:

$$\frac{\text{Wt}}{415} = \frac{62.7}{43,560}$$

$$43,560 \text{ Wt} = 26,020.5 \quad (62.7 \times 415)$$

$$\text{Wt} = 0.6 \text{ lb/opener or } 9.6 \text{ oz/opener}$$

Weights and Measures Conversion

Weight

- 16 ounces = 1 pound = 453.6 grams
- 1 gallon water = 8.34 pounds = 3.78 liters
- 1 short ton = 2,000 lbs
- 1 long ton = 2,240 lbs
- 1 cubic foot water = 62.4 lbs

Liquid Measure

- 1 fluid ounce = 2 tablespoons = 29.57 milliliters
- 1 tablespoon = 3 teaspoons = 14.79 milliliters
- 1 cup = 16 T = 8 oz = 236.583 milliliters
- 16 fluid ounces = 1 pint = 2 cups
- 8 pints = 4 quarts = 1 gallon

Dry Measure

- 1 ounce = 28.3495 grams

Length

- 1 inch = 2.54 centimeters
- 3 feet = 1 yard = 91.44 centimeters
- 16.5 feet = 1 rod
- 5,280 feet = 1 mile = 1.61 kilometers
- 320 rods = 1 mile

Area

- 9 square feet = 1 square yard
- 43,560 square feet = 1 acre = 160 square rods
- 1 acre = 0.405 hectare
- 640 acres = 1 square mile
- 1 hectare = 2.47 acres

Speed

- 88 feet per minute = 1 mph
- 1 mph = 1.61 km/h
- 1 mph = 0.477 meter/sec

Volume

- 27 cubic feet = 1 cubic yard
- 1 cubic foot = 1,728 cubic inches = 7.48 gallons
- 1 gallon = 231 cubic inches
- 1 cubic foot = 0.028 cubic meters
- Volume of sphere = $D^3 \times 0.5236$

Common Abbreviations and Terms Used

- GPM = gallons per minute
- GPA = gallons per acre
- psi = pounds per square inch
- mph = miles per hour
- RPM = revolutions per minute
- GPH = gallons per hour
- FPM = feet per minute
- T = Tablespoon
- t = teaspoon

Circles

- Diameter x 3.1416 = circumference
- Radius² x 3.1416 = area

Spraying Systems Droplet Size in Microns

- Very Fine = 153 and less
- Fine = 154 - 241
- Medium = 242 - 358
- Coarse = 359 - 451
- Very coarse = 452 - 740
- Extensively coarse = 741 +

Fertilizer Facts

Pounds per gallon of liquid fertilizer at 60°F

10-34-0	11.40
11-37-0	11.60
7-21-7	11.00
28-0-0	10.65
28-0-0	10.65
32-0-0	11.06
82-0-0	5.15
12-0-0-26	11.50

- 1 ppm = 1 second in 12 days or 0.013 ounces in 100 gallons
or about 8/10 of 1 teaspoon in 1,000 gallons
- 1 ppb = 1 second in 32 years or 0.013 ounces in 100,000 gallons
or about 8/10 of 1 teaspoon in 1,000,000 gal
- 1 ppt = 1 second in 320 centuries
- 1 pint of water in ocean = 5,000 molecules in any pint of water
- 1 psi = 2.31 ft
- 1 foot of lift of water = 0.433 psi
- 452 gpm = 1 in/1 acre/1 hr

	<i>Lbs/bu</i>	<i>Moisture %</i>
Corn	56	15.5
Soybeans	60	13.0
Grain sorghum	56	14.0
Wheat	60	13.5
Sunflower	25	10.0

- Cu ft x 0.8 = bushel of grain
- Cu ft x 0.4 = bushel of ear corn

- 1 horsepower = 550 ft lbs/sec
- = 33,000 ft lbs/min
- = 746 watts

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