NATIVE FORB AND SHRUB TOLERANCE TO MILESTONE® VM HERBICIDE

Mary B. Halstvedt and Daniel C. Cummings, Dow AgroSciences LLC, Billings, MT and Perry, OK; Travis Almquist, Luke Samuel, Rodney G Lym, North Dakota State University, Fargo; K. George Beck, Colorado State University, Ft. Collins; Roger L. Becker, University of Minnesota, St. Paul; Celestine A. Duncan, Weed Management Services, Helena, MT; Peter M. Rice, University of Montana, Missoula.

Milestone® VM herbicide (aminopyralid) is a broadleaf herbicide that has reduced risk to the environment compared with other commercially available herbicides, making it a desirable alternative for invasive weed control on rangeland and wildland sites. Effect of Milestone VM on desirable native forbs and shrubs is a consideration for land managers when making decisions about controlling invasive plants. Experiments were established at ten locations in four states to determine long-term response of native forbs and shrubs to Milestone VM applied in early summer or fall, and to develop a tolerance/susceptibility ranking for native plants. Studies were established within diverse native plant communities in western Montana, Boulder, Colorado, Theodore Roosevelt National Park (TRNP), North Dakota, and Glacial Ridge Preserve and restored prairies in Minnesota.

Experiments Established at 10 Locations

Field experiments were designed as randomized complete block with two to five replications and initiated from 2004 to 2007. Herbicide treatments were Milestone® VM at 5 or 7 fluid ounces/A. Broadcast ground applications were made with either a CO2 backpack sprayer, or pickup boom sprayer. At one Montana location a broadcast application was made with a helicopter. Treatments were made in September or October at six locations, June at two locations, and June and September comparisons at two Minnesota sites. Data collection across sites varied from either canopy cover or plant counts along a permanent transect, or plant density within each plot.

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First year post-application vegetation sampling was conducted in June and July the summer after treatment at all locations. Second year sampling was completed at eight study sites. There were a total of 118 native forbs across sites, with 20 species occurring at more than one location. Individual rankings of tolerance to Milestone® VM herbicide were established for 98 native forb species and 19 shrubs. Evaluations were based on individual species reduction in canopy cover or density compared to non-treated controls or baseline data.

Table 2: Four categories were developed for ranking tolerance of forbs and shrubs to Milestone VM herbicide:

<table>
<thead>
<tr>
<th>Code</th>
<th>Category</th>
<th>Symptoms</th>
<th>Injury Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>Tolerant</td>
<td>Minimal symptoms &lt;15% injury - may have slight cupping of leaves</td>
<td>&lt;15%</td>
</tr>
<tr>
<td>MT</td>
<td>Moderately tolerant</td>
<td>Symptoms include cupping/yellowing and can inhibit flowering, with recovery the first growing season after application</td>
<td>15 to 50% stand reduction</td>
</tr>
<tr>
<td>MS</td>
<td>Moderately susceptible</td>
<td>Injury could be significant the first year and may reduce stand</td>
<td>51 to 75% stand reduction</td>
</tr>
<tr>
<td>S</td>
<td>Susceptible</td>
<td>Severe injury the season of application and stand reduction the year after treatment with possible death of established plants. Some plants may regenerate from seed bank</td>
<td>&gt;75% stand reduction</td>
</tr>
</tbody>
</table>

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Figure 2: Results of 68 forb species with both 1 and 2 YAT data showing increase in species tolerance by the second year following treatment.

**All Forb Species Combined- 1 YAT**

![Pie chart showing species tolerance categories.]

Of the 98 forb species categorized, 28, 17, 25, and 28 were ranked susceptible, moderately susceptible, moderately tolerant, and tolerant, respectively.

Data were collected on 68 species approximately 2 years after treatment. Many forbs recovered by the second year following Milestone® VM application with only 14 of 68 native forbs ranked either moderately susceptible or susceptible. Forbs classified as tolerant and moderately tolerant increased from 51% in the first year after treatment to 77% in the second year after treatment showing excellent recovery of the forb community. Sunflower, yarrow, and lobelia were very susceptible to Milestone VM while lupine, golden Alexander and wild bergamot were very tolerant.

Figure 2: Results of 68 forb species with both 1 and 2 YAT data showing increase in species tolerance by the second year following treatment.

**Results of 68 Forbs Evaluated 2 YAT**

![Pie chart showing significant recovery.]

1 YAT

2 YAT
There were 29 plant families represented, with the greatest number of species (35%) in the Asteraceae family.

Table 3: Tolerance of forb species to Milestone® VM herbicide. Forbs are listed alphabetically by common name within plant family. Rankings include: T=tolerant; MT moderately tolerant; MS moderately susceptible; S= susceptible; and NA = data not available (see Table 2 for category description)

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Family</th>
<th>Genus</th>
<th>Species</th>
<th>1 YAT</th>
<th>2 YAT</th>
<th>Location</th>
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<tbody>
<tr>
<td>Golden Alexanders</td>
<td>Apiaceae</td>
<td>Zizia</td>
<td>aurea</td>
<td>T</td>
<td>T</td>
<td>Glacier Ridge Fall</td>
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<tr>
<td>Hearl-leaved alexanders</td>
<td>Apiaceae</td>
<td>Zizia</td>
<td>aptera</td>
<td>T</td>
<td>NA</td>
<td>MN: Summer/Fall</td>
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<tr>
<td>Nine-leaf lomatium</td>
<td>Apiaceae</td>
<td>Lomatium</td>
<td>iteratum</td>
<td>MT</td>
<td>T</td>
<td>MTRice-Fall</td>
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<tr>
<td>Wyeth's biscuitroot</td>
<td>Apiaceae</td>
<td>Lomatium</td>
<td>ambiguum</td>
<td>T</td>
<td>T</td>
<td>MTRice-Fall</td>
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<tr>
<td>Spreading dogbane</td>
<td>Apocynaceae</td>
<td>Apocynum</td>
<td>androsaemifolium</td>
<td>T</td>
<td>T</td>
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<td>Asclepias</td>
<td>syriaca</td>
<td>T</td>
<td>T</td>
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<td>Balsamorhiza</td>
<td>sagittata</td>
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<td>MT</td>
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<td>Black-eyed Susan</td>
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<td>aristata</td>
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<td>T</td>
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<td>ruderalere</td>
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<td>nuttalli</td>
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<table>
<thead>
<tr>
<th>Common Name</th>
<th>Family</th>
<th>Genus</th>
<th>Species</th>
<th>1 YAT</th>
<th>2 YAT</th>
<th>Location</th>
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<td>Tithymalus</td>
<td>brachyceras</td>
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<td>Lupinus</td>
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<td>purpurea</td>
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<td>Psoralea</td>
<td>lanceolata</td>
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<td>MT</td>
<td>CO-summer</td>
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<td>helvola</td>
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<td>alba</td>
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<td>fistula</td>
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<td>Lamiaceae</td>
<td>Monarda</td>
<td>fistulosa</td>
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<td>Mentha</td>
<td>arvensis</td>
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<td>venenosus</td>
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<td>pudica</td>
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<td>stellatum</td>
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<td>montanum</td>
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<td>howardii</td>
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<td>coccinea</td>
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<td>Tall annual willow-herb</td>
<td>Onagraceae</td>
<td>Epilobium</td>
<td>paniculatum</td>
<td>S</td>
<td>MS</td>
<td>MTRice-Fall</td>
</tr>
<tr>
<td>Common yellow woodsorel</td>
<td>Oxalidaceae</td>
<td>Oxalis</td>
<td>stricta</td>
<td>T</td>
<td>T</td>
<td>Glacier Ridge Fall</td>
</tr>
<tr>
<td>Narrow leaf collomia</td>
<td>Polemoniaceae</td>
<td>Collomia</td>
<td>linearis</td>
<td>S</td>
<td>MS</td>
<td>MTRice-Fall</td>
</tr>
<tr>
<td>Pink microseris</td>
<td>Polemoniaceae</td>
<td>Microsteris</td>
<td>gracilis</td>
<td>T</td>
<td>T</td>
<td>MTRice-Fall</td>
</tr>
<tr>
<td>Douglas sage knotweed</td>
<td>Polygonaceae</td>
<td>Polygonun</td>
<td>douglasii</td>
<td>T</td>
<td>T</td>
<td>MTRice-Fall</td>
</tr>
<tr>
<td>Pale dock</td>
<td>Polygonaceae</td>
<td>Rumex</td>
<td>alissimus</td>
<td>S</td>
<td>NA</td>
<td>MN: Summer/Fall</td>
</tr>
<tr>
<td>Water smartweed</td>
<td>Polygonaceae</td>
<td>Polygonum</td>
<td>amphibium</td>
<td>MS</td>
<td>T</td>
<td>Glacier Ridge Fall</td>
</tr>
<tr>
<td>Winged buckwheat</td>
<td>Polygonaceae</td>
<td>Pterogonum</td>
<td>alatum</td>
<td>S</td>
<td>S</td>
<td>CO-summer</td>
</tr>
<tr>
<td>Western androsace</td>
<td>Primulaceae</td>
<td>Androsace</td>
<td>occidentalis</td>
<td>MS</td>
<td>T</td>
<td>MTRice-Fall</td>
</tr>
<tr>
<td>Purple meadow rue</td>
<td>Ranunculaceae</td>
<td>Thalictrum</td>
<td>dasycarpum</td>
<td>MT</td>
<td>MT</td>
<td>Glacier Ridge Fall</td>
</tr>
<tr>
<td>Prairie cinquefoil</td>
<td>Rosaceae</td>
<td>Potentilla</td>
<td>arguta</td>
<td>S</td>
<td>NA</td>
<td>MN: Summer/Fall</td>
</tr>
<tr>
<td>Prairie smoke</td>
<td>Rosaceae</td>
<td>Geum</td>
<td>triflorum</td>
<td>MT</td>
<td>T</td>
<td>MTRice-Fall</td>
</tr>
<tr>
<td>Soft cinquefoil</td>
<td>Rosaceae</td>
<td>Potentilla</td>
<td>gracilis</td>
<td>S</td>
<td>MT</td>
<td>MTRice-Fall</td>
</tr>
<tr>
<td>Virginia strawberry</td>
<td>Rosaceae</td>
<td>Fragaria</td>
<td>virginiana</td>
<td>T</td>
<td>T</td>
<td>MTRice-Fall</td>
</tr>
<tr>
<td>Wild rose</td>
<td>Rosaceae</td>
<td>Rosa sp.</td>
<td></td>
<td>S</td>
<td>NA</td>
<td>MT Duncan-summer</td>
</tr>
<tr>
<td>Small flowered fringe cup</td>
<td>Saxifragaceae</td>
<td>Lithophragma</td>
<td>parviflora</td>
<td>S</td>
<td>MS</td>
<td>MTRice-Fall</td>
</tr>
<tr>
<td>Blue-eyed Mary</td>
<td>Scrophulariaceae</td>
<td>Collinsia</td>
<td>parviflora</td>
<td>T</td>
<td>T</td>
<td>MTRice-Fall</td>
</tr>
<tr>
<td>One-sided penstemon</td>
<td>Scrophulariaceae</td>
<td>Penstemon</td>
<td>secundiflorus</td>
<td>MT</td>
<td>MT</td>
<td>CO-summer</td>
</tr>
<tr>
<td>Clammy ground cherry</td>
<td>Solanaceae</td>
<td>Physalis</td>
<td>heterophylla</td>
<td>S</td>
<td>NA</td>
<td>MN: Summer/Fall</td>
</tr>
<tr>
<td>Stinging nettle</td>
<td>Urticaceae</td>
<td>Urtica</td>
<td>dioica</td>
<td>MT</td>
<td>NA</td>
<td>MN: Summer/Fall</td>
</tr>
<tr>
<td>Blue vervain</td>
<td>Verbenaceae</td>
<td>Verbena</td>
<td>hastata</td>
<td>T</td>
<td>NA</td>
<td>MN: Summer/Fall</td>
</tr>
<tr>
<td>Hoary vervain</td>
<td>Verbenaceae</td>
<td>Verbena</td>
<td>stricta</td>
<td>T</td>
<td>NA</td>
<td>MN: Summer/Fall</td>
</tr>
<tr>
<td>Nutalls violet</td>
<td>Violaceae</td>
<td>Viola</td>
<td>nuttallii</td>
<td>MS</td>
<td>T</td>
<td>CO-summer</td>
</tr>
</tbody>
</table>
Shrubs were more tolerant than forbs to Milestone VM. There were 19 shrub species, and 74% were ranked either MT or T. Shrubs in the Rosaceae Family were generally the most susceptible to Milestone.

Table 4: Tolerance of shrub species to Milestone® VM herbicide. Rankings include: T=tolerant; MT moderately tolerant; MS moderately susceptible; and S= susceptible (see Table 2 for category description)

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Family</th>
<th>Genus</th>
<th>Species</th>
<th>1 YAT</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yucca</td>
<td>Agavaceae</td>
<td>Yucca</td>
<td>glauca</td>
<td>T</td>
<td>CO-Summer</td>
</tr>
<tr>
<td>Dogbane</td>
<td>Apocynaceae</td>
<td>Apocynum</td>
<td>andro</td>
<td>MT</td>
<td>USFS MT</td>
</tr>
<tr>
<td>Big Sagebrush</td>
<td>Asteraceae</td>
<td>Artemisia</td>
<td>tridentata</td>
<td>T</td>
<td>Wyoming Summer</td>
</tr>
<tr>
<td>Fringe sage</td>
<td>Asteraceae</td>
<td>Artemesia</td>
<td>frigida</td>
<td>MS</td>
<td>CO-Summer</td>
</tr>
<tr>
<td>Louisiana sage</td>
<td>Asteraceae</td>
<td>Artemesia</td>
<td>ludovicia</td>
<td>MS</td>
<td>CO-Summer</td>
</tr>
<tr>
<td>Silver sagebrush</td>
<td>Asteraceae</td>
<td>Artemisia</td>
<td>cana</td>
<td>T</td>
<td>USFS ND Fall</td>
</tr>
<tr>
<td>White sagebrush</td>
<td>Asteraceae</td>
<td>Artemisia</td>
<td>ludoviciana</td>
<td>T</td>
<td>USFS ND Fall</td>
</tr>
<tr>
<td>Oregon Grape</td>
<td>Berberidaceae</td>
<td>Berberis</td>
<td>repens</td>
<td>T</td>
<td>USFS MT</td>
</tr>
<tr>
<td>Elderberry</td>
<td>Caprifoliaceae</td>
<td>Sambucus</td>
<td>racemosa</td>
<td>T</td>
<td>USFS MT</td>
</tr>
<tr>
<td>Western snowberry</td>
<td>Caprifoliaceae</td>
<td>Symphoricarpos</td>
<td>occidentalis</td>
<td>T</td>
<td>USFS ND Fall, USFS MT</td>
</tr>
<tr>
<td>Buffaloberry</td>
<td>Elaeagnaceae</td>
<td>Shepherdia</td>
<td>canadensis</td>
<td>MT</td>
<td>USFS MT</td>
</tr>
<tr>
<td>Silver Buffaloberry</td>
<td>Elaeagnaceae</td>
<td>Shepherdia</td>
<td>argentea</td>
<td>T</td>
<td>USFS ND Fall</td>
</tr>
<tr>
<td>Kinnikinnick</td>
<td>Ericaceae</td>
<td>Arctostaphlos</td>
<td>uvaursi</td>
<td>T</td>
<td>USFS MT</td>
</tr>
<tr>
<td>Buckbrush</td>
<td>Rhamnaceae</td>
<td>Ceanothus</td>
<td>velutinus</td>
<td>T</td>
<td>USFS MT</td>
</tr>
<tr>
<td>Chokecherry</td>
<td>Rosaceae</td>
<td>Prunus</td>
<td>virginiana</td>
<td>MT</td>
<td>USFS ND Fall, USFS MT</td>
</tr>
<tr>
<td>Nine-bark</td>
<td>Rosaceae</td>
<td>Physorcarpus</td>
<td>mon</td>
<td>S</td>
<td>USFS MT</td>
</tr>
<tr>
<td>Serviceberry</td>
<td>Rosaceae</td>
<td>Amelancheir</td>
<td>alnifolia</td>
<td>S</td>
<td>USFS MT</td>
</tr>
<tr>
<td>Wood's rose</td>
<td>Rosaceae</td>
<td>Rosa</td>
<td>woodsii</td>
<td>S</td>
<td>CO-Summer, USFS MT</td>
</tr>
<tr>
<td>Golden current</td>
<td>Saxifragaceae</td>
<td>Ribes</td>
<td>aureum</td>
<td>T</td>
<td>USFS ND Fall</td>
</tr>
</tbody>
</table>

Conclusions:
- Most native forb species and shrubs were moderately tolerant to tolerant, or recovered following treatment with Milestone VM herbicide.
- Historical data\(^1\) suggests that by the third or fourth year post-application, there would be little difference in non-target forb tolerance with only a few very sensitive forbs being adversely impacted in the long term.
- Land managers can use these data as a guideline to evaluate risk to native plant communities when using Milestone VM for invasive species management.
- Milestone® VM herbicide (aminopyralid) can be used to manage invasive plants in mixed plant communities and facilitate recovery of desirable forbs and shrubs.