Crater Lake National Park
Natural Resources Division
March 2007

St. Johnswort at Crater Lake National Park

Integrated Pest Management Plan

BACKGROUND

Crater Lake National Park's most prolific and visible exotic plant is St. Johnswort (*Hypericum perforatum*), also known as "Klamath weed." This species is the most widely distributed and abundant non-native plant in the Park. It is most abundant along the Highway 62 corridor. At some locations it forms yellow-flowered swaths 2-3 meters wide extending for a quarter mile or more along the road margin. Patches tend to be denser and more abundant closest to the Park boundaries on Highway 62 South (Figure 1), and then get progressively sparser as one continues up road towards Munson Valley Road. In smaller patches, St. Johnswort can be found in many areas (Munson Valley Road, South Pole Quarry, South Yard, Headquarters area, Mazama Campground, Rim Village).

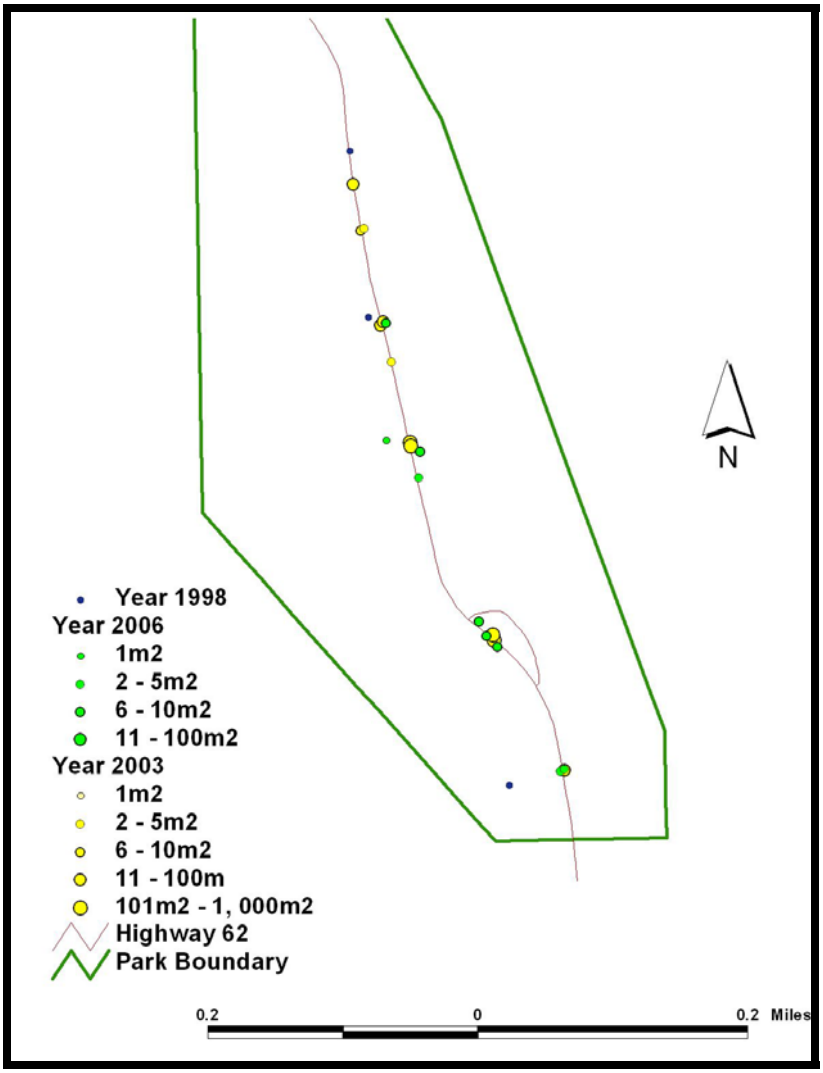

Figure 1. Approximate spread of St. Johnswort in the 'Panhandle' area of Crater Lake NP (1998-2006).

The first record of St. Johnswort in the Park dates to1960 (Zika 2003). Park survey records indicate that St. Johnswort has spread considerably. In 1997, the number of St. Johnswort patches along Highway 62 between the South Boundary and Munson Valley Road intersection was about 18 patches. In 2003, staff detected 47 patches along the same highway interval. By 2006, all patches supporting more than 100 individual plants were found along this corridor.

Established patches are difficult to eradicate, and although efforts have been made over the years to hand-pull individuals, total extent continues to increase. Plants threaten to invade new territories. St. Johnswort is a designated noxious weed by state authorities in Oregon, California, Washington, and four other western states.

OBJECTIVE

The objective of this plan is to significantly reduce the extent of St. Johnswort within Crater Lake National Park through prevention and control measures. This goal may be considered achieved when populations are so isolated and small, that hand-pulling by a single seasonal employee will be sufficient to keep populations from spreading.

ST. JOHNSWORT ECOLOGY

A native of Europe, St. Johnswort was first recorded in California in the early 1900s. In dense stands, St. Johnswort displaces native plant species and reduces wildlife foraging sites. St. Johnswort depletes soil moisture, thus competing with natives. It is likely to delay establishment of native species in disturbed sites. In late summer, the dry stalks of St. Johnswort may constitute a fire hazard, especially along roads where careless travelers may toss cigarettes.

The response of St. Johnswort to fire is varied, from no response; to immediate increases in cover and/or density; to immediate decreases in cover and/or density, followed by increases several postfire years later (Zouhar 2004).

A perennial herb, it can grow to five feet tall. Stems are erect and woody with multiple branchings. Leaves are opposite, sessile, and have the notable feature of small holes resembling pin prick perforations (hence, *perforatum*). Flowers are bright yellow with raised black glands along petal margins. St. Johnswort reproduces both by seed and by short underground rhizomes.

St. Johnswort reproduces by both seeds and runners below ground. An individual plant is capable of producing up to 30,000 seeds each year

(Rutledge and McLendon 1996; Parsons 1957). The seeds are very small (~ 1mm long) and have a gelatinous coating that enables seed to adhere to animals and vehicles. They are also transported by wind and in mud and debris into previously uninfested areas by vehicles (Parsons 1957). Seeds can remain viable in the soil for at least 10 years (Tisdale et. Al. 1959; Clark 1953).

It is the combination of the two methods of reproduction that make control difficult. Hand-pulling tends to inevitably leave behind parts of these underground runners which are then often stimulated into greater reproduction.

SITE DESCRIPTION

St. Johnswort has been detected in Crater Lake NP from the lowest elevations (ca. 4,200') to Rim Village (7,000'). The vast majority of the Park's St. Johnswort plants occur along the margins of Highway 62. Sparse populations are found regularly on Munson Valley Road and developed areas. Plants occur primarily at the edges of paved or disturbed substrate. These sites tend to be gravely, well-drained, and lacking of tree canopy at the immediate site. Within the region, St. Johnswort has readily invaded the periphery of highways and roads. For example, along Dead Indian Memorial Road, large fields can be observed extending hundreds of feet back from the road edge. These may be associated with logging and/or livestock. In California, good habitat equals rangeland areas and pastures (especially when poorly managed), fields, roadsides, and forest clearings with cool, moist winters and dry summers. Overall St. Johnswort grows best in open, disturbed sites and on slightly acidic to neutral soils. It does not tolerate saturated soils (CDFA 2007).

CONTROL OPTIONS

Control strategies commonly applied to exotic plants in western North America include physical/mechanical (hand-pulling, cutting/mowing), biological agents, fire, and chemicals. This section highlights the effectiveness, feasibility, and drawbacks of these measures.

Fire

While experimental evidence is varied regarding St. Johnswort's response to fire, much of the available literature suggests that fire increases frequency and density of St. Johnswort (Zouhar 2004). Most St. Johnswort at Crater Lake NP is in sparse ground cover unable to carry a fire. Therefore, fire is not a feasible tool for control.

Mowing

Based on local experience, hand-pulling tends to be effective for young plants and very small populations, but impractical and ineffective on larger, older infestations (Table 1). Similar limitations are noted elsewhere (Washington 2007; Moser and Crisp; Sampson and Parker 1930). It is extremely difficult to remove the entire root system from most soils, leaving behind small rhizome fragments from which new stems develop. The disturbed/compacted roadside soils that nurture much of our St. Johnswort plants do not allow us to extract the entire root systems effectively.

Cutting/mowing appears to have varied effects. When carefully timed, mowing will theoretically reduce St. Johnswort. Fitzsimmons and Burrill (1999) suggest applications can be repeated during the summer to prevent seeding (see also Moser and Crisp). Repeated mowings in one season may also "starve" the roots (Zouhar 2004). However, field documentation that mowing actually reduces St. Johnswort is not available in the literature.

Mowing has been implicated as a cause in the expansion of St. Johnswort populations (Harris and Gill 1997). The California Department of Food and Agriculture (2007) warns that mowing promotes vegetative spread from rhizomes. Overall, most agencies do not recommend mowing (Zouhar 2004; Krueger and Sheley 2002). An additional drawback of mowing is injury to native plants. Natives, especially grasses, can limit growth of St. Johnswort through competition (Buckley and others 2003).

Biological

With biological controls, one introduces a natural predator to control an established exotic plant. In the mid-1940s, two species of *Chrysolina* beetles were collected and shipped from Australia, then released in North America to great success: in the grasslands of northern California, St. Johnswort populations dropped to less than 1% of their former numbers, and in northern Idaho, St. Johnswort abundance hovers around 3% of its former stature. It seems that these beetles require milder winters than those found at Crater Lake, and in general, *Chrysolina spp.* populations haven't been seen locally in the last 10 years

The root boring beetle (*Agrilus hyperic*i). Photo: courtesy ODA.

above 3,500 feet, making the successful use of this biocontrol in Crater Lake unlikely.

The boring beetle (*Agrilus hyperici*) is favored in Australia (Cullen and others 1997). However, the effectiveness of the beetle in North America is not readily documented but its failure to establish populations is (AAFC 2007; ODA 2007).

Although insects are unlikely to succeed in establishing themselves at Crater Lake National Park's mountain climate, if any were to succeed there would likely be impacts on native insects and possibly non-target plants.

Chemical

Local land managers find that chemical control for larger, well-established St. Johnswort populations works best in the long run for roadside St. Johnswort infestations. The most effective controls in the local area appear to be the herbicides which contain picloram or glyphosate (Table 1). The most favored chemical in Australia is fluroxypyr which has been shown to be more effective than picloram, glyphosate, 2,4-D, and metsulfuron (Campbell and Nicol 1997).

Herbicides have a high potential of impacting non-target organisms. Relevant properties of the three most effective herbicides are highlighted here and Table 2.

Table 1. Comparison of control methods for St. Johnswort.

Method	Benefits	Information Source or Citation	Risks	Information Source or Citation
Hand-removal	May only be feasible on small patches or young plants and applied at least once per year. Has generally not been effective at controlling medium-large patches or mature plants.	BLM (Klamath Falls) Crater Lake NP Winema NF	It is difficult to pull entire belowground rootmass. Remaining root parts can sprout.	Crater Lake NP Sampson and Parker (1930)
Bio Control (insects)	Beetles (*Chrysolina* spp.) not effective in our local area. But have been very useful in warmer climates. Root Boring Beetle (*Agrilus hyperici*) introductions have failed to establish in western Oregon and southern BC but present in Eastern Washington. Effectiveness has not been documented. Fly (*Zeuxidiplosis giardi*) has had many attempts to introduce in Oregon fail. Moth (*Aplocera plagiata*) common in E. Oregon and Washington but ineffective, disperses 50 miles.	BLM (Klamath Falls) ODA (Klamath Falls) ODA (2007) AAFC (2007) Fitzsimmons and Burrill (1999) USFS 2007 USFS 2007	Overall risk of any biocontrol species impacting native insects, plants, etc.	(Lynch and others 2002)

Mowing	Ineffective Two or more cuttings prior to seed formation may reduce St. Johnswort. Reduces seed production but promotes vegetative spread.	Krueger and Sheley 2002 Moser and Crisp CDFA (2007)	Impacts native plants. Can promote sprouting if not mowed frequently enough. Can spread weed seeds if not carefully timed.	Crater Lake NP Rice and Randall (2004)
Fluroxypyr (Vista)	Most Effective but not tested in local area.	Campbell and Nicol (1997)	Harmless to grasses & legumes if applied in early season. Impacts broadleafs & woody species.	
Metsulfuron (Escort)	Effective	Moser and Crisp	Impacts broadleaf & woody species but safe on grasses.	
Picloram (Tordon)	Very effective. Very effective. Benign on grasses but can kill tree saplings and broadleafs.	BLM (Klamath Falls) ODA (Klamath Falls)	Impacts broadleaf, legume & woody species. May leach out of roots and damage non-target species. Can move offsite through surface or subsurface water.	
Glyphosate (Roundup)	Great Success. Repeat applications necessary on individual plants. Best used when in bloom. Kills grasses. Not as affective as Picloram.	ODA (Klamath Falls) Winema NF	Can kill grasses. May require more than one treatment/season.	
2,4-D	Repeat applications in one season are required.	Moser and Crisp	Requires more than one treatment/season.	

Table 2. Environmental risks of the most effective chemicals.

Chemical	Ecotoxicity	Selectivity	Persistence (half-life in days)	Mobility	Effects on Aquatic Organisms
Fluroxypyr	Low	Selective to broadleaf weeds and woody brush.	36	Intermediate	Slightly and Practically Non-toxic
Glyphosate	Low – Very Low	Non-selective	47	Low	Slightly and Practically Non-toxic
Picloram	Low	Selective to woody plants and a wide variety of broadleafs.	90	Intermediate	Practically non-toxic to moderately toxic

Toxicity
Toxicity can be measured against both target and non-target organisms. There can be both acute and chronic effects. The acute effects listed include the LD50 (the amount of chemical ingested that causes 50% mortality in test animals). Of the three herbicides currently used at Death Valley, none have any documented long-term (chronic) health effects.

- Fluroxypyr – LOW TOXCITY: Oral LD_{50} (500-5,000 mg/kg in most species tested including birds. Dermal LD_{50} (2,000-5,000 mg/kg).
- Glyphosate – LOW-VERY LOW TOXICITY: Oral LD_{50} (500-5,000 mg/kg in most species tested including birds. Dermal LD_{50} (>5,000 mg/kg).
- Picloram – LOW TOXICITY: Oral LD_{50} (500-5,000 mg/kg in most species tested including birds. Dermal LD_{50} (2,000-5,000 mg/kg).

Human Health Risks
Scientists estimate non-cancer health risks by generating a hazard quotient (HQ). This number is the exposure divided by the toxicity. When the HQ is less than 1, exposures are unlikely to cause any adverse health effects. When the HQ is greater than 1, the potential for non-cancer health effects should be considered. Risk assessments for chemicals that cause cancer (carcinogens) estimate the probability of an individual developing cancer over a lifetime. Cancer risks estimated in this way are very conservative, and actual cancer risks are likely to be much lower. Cancer risk estimates of less than 1 in 100,000 are within the range considered negligible by most regulatory agencies. A summary is provided in Table 3.

Table 3. Human risk for average exposure scenarios of fluroxypyr, glyphosate, and picloram (WSDOT 2006)

Hazard Quotient (Non-cancer Risk)	Cancer Risk	Potential Risks and Management Priority
Less than 1	Less than 1 in 100,000	Negligible

Selective/Non-Selective
Some herbicides are selective; that is, they only kill certain species or plants, or groups of species. Others are non-selective – they are designed to be effective on all types of plants.

- Fluroxypyr is SELECTIVE. It kills annual and perennial broadleaf weeds and woody brush but is relatively harmless to most monocots (grasses and other linear leafed plants) plus legumes.
- Glyphosate is NON-SELECTIVE. It kills a wide variety of weeds, brush, and plants.
- Picloram is SELECTIVE. It kills woody plants and a wide variety of broadleafs but not mustards or grasses.

Persistence
Persistence is a measure of how long it takes for a chemical to breakdown in the environment. It is usually measured in terms of a half-life. A shorter half-life is better. The chemicals break down primarily through microbial activity (bio-degradation), although UV radiation, oxidation, and other chemical actions also play rolls.

- Fluroxypyr has an average half-life of 36 days.
- Glyphosate has an average half-life of 47 days.
- Picloram has an average half-life of 90 days.

Mobility
Mobility is a measure of how much a chemical moves around in the environment. We are usually concerned with movement in soil, but "drift" can also be an issue. Drift is when the herbicide is carried on the wind away from where it is intended. High mobility is bad –the herbicide can end up where it isn't intended to be.

- Fluroxypyr's potential to leach to groundwater is intermediate; surface runoff potential is high, and potential for loss on eroded soil is low. Fluroxypyr has moderate volatility and the potential for loss to the atmosphere is moderate.
- Glyphosate is not mobile and has a very low potential to contaminate groundwater.
- Picloram is moderately to highly persistent in soils and has the potential to contaminate groundwater.

Effects on Aquatic Organisms
Some herbicides are considered "safe" to use in water, some are not. This refers to their effect on the natural environment (primarily fish), and does not consider the potential effects of herbicide as a drinking water contaminant. No herbicide of any type will be applied within 200ft of water in this project.

- Fluroxypyr's acute toxicity tests evaluated by U.S. EPA indicate that fluroxypyr is slightly toxic to practically non-toxic to freshwater fish. For rainbow trout, 96-hour LC50 values ranged from 13.4 mg/L to >100 mg/L. Tests with the invertebrate, *Daphnia magna* indicate that fluroxypyr is practically non-toxic to this species. The 48-hour EC50 for this toxicity test was >100 mg/L.
- Glyphosate is practically non-toxic to moderately toxic to fish. It does not bioaccumulate (build up) in the bodies of fish. It is slightly toxic to practically non-toxic to aquatic insects. It does not bioaccumulate (build up) in these organisms.
- Picloram is moderately toxic to fish. The LC50 concentrations for various fish species are 19.3 mg/L for rainbow trout. Picloram ranges from practically non-toxic to moderately toxic in aquatic (water) insects. The LC50 for Daphnia magna (water fleas) exposed for 48

hours is 68.3 mg/L and for Gammarus lacustris (crustaceans) exposed for 96 hours is 27 mg/L.

Restricted Use Classification

All pesticides are categorized into two (2) groups for regulatory purposes by the EPA. These are Unclassified (General Use) and Restricted Use (RUPs). Restricted Use Pesticides may only be purchased and used (used in the broad sense to include opening the container, mixing, loading, applying, and rinsing empty containers) by Certified Applicators or persons under their direct supervision.

- Fluroxypyr (Vista brand) = General Use Pesticide
- Picloram (Tardon K brand) = Restricted Use Pesticide
- Glyphosate (RoundUp Pro brand) = General Use Pesticide

PREVENTION MEASURES

This objective is primarily concerned with the deterrence of new establishments of St. Johnswort populations as caused by human activities. Without effective prevention, subsequent control measures will be never-ending since new populations will always be appearing. Although it is impractical to directly curtail the importation of seed to the Park, measures can be taken to reduce the transport of seed between locations within the Park.

1. Wash all Highway 62 Heavy Equipment and Vehicles at the Wash Station (Maintenance Building) before using anywhere else in the Park. This applies only to equipment/vehicles which have been fully or partially driven off the paved road edge of Hwy 62 and are leaving this corridor – and driving further into the interior of the Park (up Munson Valley Road).

2. Time Roadside Mowing to Closely Follow Snowmelt as feasibly possible. This would precede emergence of St. Johnswort and native non-woody vegetation. This is typically in May - early June.

3. Keep Heavy Equipment & Vehicles within Designated Use Area at South Yard. The periphery of the South Yard is a transition between a developed site and native vegetation. Weeds are common in this zone due to periodic disturbance. A boundary should be designated and barriers installed. This will prevent disturbance-caused weed establishment and vehicle contact with seeds in this zone.

4. Wash All Non-park Owned Earth-moving Equipment before entering Park. Accommodations to wash Contractor, Concession, and Park-

rented equipment should be made in town where equipment comes from.

5. Crater Lake NP Natural Resource Staff Provides Weed Refresher to CRLA Road, Trail and Sign Crews Every Summer. This includes a refresher of the approved IPM Plan and may also include weed identification handouts and a presentation (e.g. USDA 2005).

6. Minimize Use of Gravel for Highway Maintenance. The preferred habitat of St. Johnswort is a well-drained coarse soil.

CONTROL STRATEGY

Based on the preceding review of control techniques and their efficacy, it is likely that no single control method will sufficiently meet the objectives of this plan. The literature indicates that hand-pulling alone is inadequate in controlling moderate or large populations of St. Johnswort. This knowledge is further supported by the field experiences of land managers in and around Crater Lake NP.

Although mowing theoretically can reduce seeding, this technique has not been documented to reduce or curtail spread of St. Johnswort. Furthermore, mowing would need to adhere to a strict schedule with repeated applications each season to increase chances of success. The mowing of associated native plants could not be avoided and thus would constitute a considerable impact.

Biocontrols are arguably the most risky of control strategies. Although they can be very effective in controlling St. Johnswort, such as in California, there is a good probability that the insects will not thrive at Crater Lake's mountain climate. If insects were to survive, they would likely have a negative impact on non-target organisms.

The use of herbicides is the only method proven effective on moderate-large populations of St. Johnswort in the local area. However, if applied improperly, herbicides may have acute impacts on non-target organisms. Thus, use must be carefully applied by qualified personnel in accordance with label instructions.

Small Populations (< 10 individual plants)

These small patches will be hand-pulled. Much care in removing all below-ground plant parts will be taken.

Moderate – Large Populations (> 10 individual plants)

These patches are primarily along the Highway 62 corridor with several additional populations along the North Entrance Road, Munson Valley Road, and Highway 138. These corridors are the primary occupied habitat of St. Johnswort in the Park. Because most patches are greater than 100 individuals, hand-pulling would not be effective. Therefore, chemical control should be applied to St. Johnswort at these sites until populations sizes are reduced significantly. Of the three most effective chemicals, fluroxypyr has the least number of risks (Table 2) and is therefore the preferred chemical for use. Spot-spraying is the preferred treatment method to be applied only once in a growing season. Treatments will only occur at sites greater than 200 ft from surface waters. Because documentation of the use of fluroxypyr specifically on St. Johnswort in the western U.S. is not readily available, there is a slight possibility that its effectiveness may not be adequate. In the unlikely event this scenario is realized, the second choice for chemical use is picloram which is more effective, and environmentally comparable to glyphosate (Tables 1 and 2).

To limit potential exposure of humans and surface water to chemicals, applications will not be permitted at the following locations:

- Campgrounds
- Rim Village
- Within 200 ft. of Caldera edge, or inside Caldera
- Within 200 ft. of surface water
- Within 200 ft. of any building

A significant threshold occurs when an individual population declines to less than 10 individual plants. At this point, chemicals are no longer used and hand-pulling becomes the preferred method.

<u>NPS Administrative Procedures for Restricted Use Pesticide (RUP):</u>
Personnel who are Oregon state-certified applicators will be used for any herbicide treatments. All three chemicals are registered with EPA. Thus:

1) label must be followed as with the application of all pesticides;
2) purchase of a RUP by a certified applicator can only be done through a dealer licensed to sell RUPs;
3) application of a RUP must be done by a licensed private, public, or commercial applicator or directly supervising a non-licensed applicator;
4) annual reporting requirements must be met (both through PUPs and to the state); and
5) final approval to use a RUP comes from WASO-IPM.

MONITORING

Early detection is a critical component of pest management. Thus, select Park Field Staff will attend a refresher every June where they are informed about St. Johnswort identification and reporting procedures (See Prevention #5).

Formal surveys will be conducted every summer. This field effort is led by a seasonal Biological Technician experienced with weed ecology and management who is supervised by the Park Terrestrial Ecologist. Disturbance corridors (roads, trailheads, parking areas) will be emphasized for inventory because this is the optimal habitat for establishment of St. Johnswort. It is important to stress that safety measures be taken when working near traffic. The ODOT guidelines (short-term work zones) for shoulder work and minor road encroachment apply. Data recording will follow methods applied at CRLA in 1998 (CRLA 1998) and include the following fields: species name, date, location name, type of disturbance, plant community, phenology, abundance, and extent. Information will be stored on the Park network at k:\rm\ter.bio.stuff\ter.res.data\flora.data. Combined with GPS coordinates, this information will be incorporated into a GIS map, updated annually.

The priority for monitoring sites will be:

1. Highway 62 (S=9.66miles, W=7.79miles, N entrance Rd=9miles, Lost Crk. Rd=5.5miles, Munson Vly=6.7miles, Grayback=5miles)
2. Road Segments Bordering Research Natural Areas
3. Developed Sites on Munson Valley Hwy (Mazama Village, HQ, turnouts)
4. Highway 138
5. Developed Sites in Sand Ck. Valley (Lost Ck CG and Pinnacles)
6. Grayback Road
7. Developed Sites on Rim Drive (Rim Village, turnouts, trailheads, picnic areas, Cleetwood Trail)
8. Boundary segments that abut roads (USFS and State lands)
9. Trailheads

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APPENDIX

Labels for proposed herbicides