ENVIRONMENTAL ASSESSMENT

Use of Integrated Pest Management to Control Leafy Spurge Occurrences along the Klamath and Scott Rivers and in the Quartz Valley Watershed

April 29, 2013

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Chapter 1: Purpose and Need for Action

Purpose

The purpose of the proposed action, to control or eradicate Leafy spurge (*Euphorbia esula*) occurrences on private lands along the Klamath and Scott rivers and private and tribal lands along Quartz Valley tributaries to the Scott River, is to reduce the size of existing populations and prevent Leafy spurge from dispersing along these water courses. Due to the persistence of this species, there remains a small window of opportunity to control incipient occurrences before they become unmanageable. The use of an Integrated Pest Management (IPM) strategy is being considered in order to curtail the environmental degradation caused by Leafy spurge and to allow the passive restoration of riparian vegetation. Promoting healthy and functioning riparian habitats would improve water quality and habitat for anadromous fish and riparian associated terrestrial wildlife.

Need

The need for the proposed action resulted from a dramatic increase in Leafy spurge occurrences. Surveys conducted by the Siskiyou County Department of Agriculture (SCDA) over the last decade indicate Leafy spurge sporadically infests over sixty miles of the Klamath and Scott rivers and their tributaries and that the number of Leafy spurge sites have increased by over 100 percent along the Klamath River and over 200 percent along the Scott River since 2001. Taken together, these occurrences represent the only large Leafy spurge infestation in California. Because Leafy spurge can adapt to a variety of environmental conditions the observed rate of spread is expected to continue. Unconstrained spread of this species is likely to further degrade riparian ecosystems in Siskiyou County and increase the likelihood for infestations in neighboring counties through which the Klamath River flows.

Decision to be Made

The U.S. Fish and Wildlife Service (Service) is responsible for ensuring that the project portion funded with federal support is in compliance with the National Environmental Policy Act. The Yreka Field Office Supervisor would select one of the alternatives analyzed in detail and would determine, based on the facts and recommendations contained herein, whether this Environmental Assessment (EA) is adequate to support a Finding of No Significant Impact or whether an Environmental Impact Statement is required.

Background

Leafy spurge is native to Europe and Asia and was introduced to northeast North America in the early 1800s. It is an erect, branching, perennial plant with smooth stems and showy yellow flower bracts. The leaves of Leafy spurge are small (0.25 to 0.5 inches), somewhat frosted, and slightly wavy along their margins. The flowers are inconspicuous and are borne on greenish-yellow structures surrounded by yellow modified leaves called bracts. All parts of the plant contain a white milky juice called latex that is poisonous to humans and wildlife.

Leafy spurge is an aggressive invader that can adapt to a variety of environmental conditions. It can grow in light-sandy to heavy-clay soils and on a wide variety of terrain from flood plains and river banks to grasslands and mountain slopes (Lym 2005). Its rhizomatous branching root

system can spread up to 30 feet per year in width and depth from the parent plant. Since its introduction to North America, it has doubled in acreage every 10 years, and currently infests 5 million acres in 35 states in the United States alone.

Leafy spurge can reproduce both by seeds and by vegetative means. Seeds are borne in pods that contain three gray-brown, seeds. After the seeds mature, seed capsules open explosively, dispersing seeds up to 15 feet from the parent plant. Seeds that land in water can germinate while floating, giving Leafy spurge the ability to root as soon as it makes land fall. Thus, rivers and streams are effective vectors of seed dispersal. Vegetative buds along roots can also grow into new shoots. If the root is tilled or cut, each part of the root may grow into a new, independent plant.

Because Leafy spurge is extremely prolific and has such a complex root system, it can readily displace native vegetation through shading, out-competing, and usurping available water. Leafy spurge also contains plant toxins that slow or stop the growth of other nearby plants. For these reasons Leafy spurge infestations can significantly alter the composition of native vegetation and reduce floral biodiversity, affecting the abundance and distribution of rare plants. Research conducted by Butler and Cogan (2004) indicated that Leafy spurge infestations reduced species richness by an average of 51 percent across eleven plant associations in North Dakota. Similarly, Belcher and Wilson (1989) reported that cover values of all common native species were negatively correlated with cover of Leafy spurge in a Canadian mixed-grass prairie. These authors also found that four common native grasses were absent at sites where Leafy spurge was most abundant. Leafy spurge infestations can also displace native bank stabilizing vegetation, increasing the potential for erosion and sediment delivery to adjacent rivers and creeks.

Changes in plant species composition resulting from Leafy spurge infestations can affect community composition and habitat utilization patterns of wildlife. Scheiman et al. (2003) discovered that densities of two species of grassland sparrow were lower in areas with high Leafy spurge cover than areas with low to medium cover. Conversely, meadowlark nesting success increased with amount of Leafy spurge cover. Leafy spurge infestations reduced habitat utilization of three large ungulates including elk (*Cervus elaphus*) and deer (*Odocoileus spp.*) by up to 32 percent in the Theodore Roosevelt National Park (Trammel and Butler 1995). A more recent study conducted at the Theodore Roosevelt National Park found Leafy spurge seeds in deer feces (Wald et al. 2005). However, due to the limited amount of seeds found the authors concluded that deer seldom forage on Leafy spurge. Leafy spurge pollen and nectar is attractive to many insect pollinators including bees, flies, and butterflies (Larson 2008) and seeds are consumed by some birds (Blockstein et al. 1987; Wald et al. 2005).

Information regarding soil moisture uptake by Leafy spurge is limited. However, Geronimo et al. (2008) reported that Leafy spurge acquired water from deeper soils than native forbs and grasses in Southeastern Idaho. They also found the depletion of soil moisture at depths between 19 and 60 inches was greater where Leafy spurge occurred compared to areas where only native forbs and grasses occurred. Consequently, large areas of Leafy spurge infestations adjacent to rivers and streams may reduce water yields to these systems.

If it enters fish-bearing waters, the latex in Leafy spurge may also be poisonous to fish. While the toxicity of Leafy spurge latex to fish in the Klamath Basin is not understood, research

indicates that the latex from plants in the *Euphorbia* genus are toxic to some fish species (Ross and Steyn 2004) and in some cases comparable to synthetic pesticides (Prasad et al. 2011).

The continued expansion of Leafy spurge can also result in direct economic losses by reducing grazing and forage production, recreational opportunities, and jobs and secondary economic impacts by reducing water conservation benefits and increasing commodity prices (Leitch et al. 1994). The economic impacts of Leafy spurge on grazing lands in Montana, North Dakota, South Dakota, and Wyoming were estimated in 1994 to be $37.1 million in direct losses and $82.6 million in secondary economic impacts. By 2002, this estimate of economic loss had risen to $186 million (Lym 2005).

Leafy spurge is persistent and difficult to control. Control strategies must be conducted regularly and persistently over many years to be successful (Lym and Zollinger 1995; Beck 2008). Because Leafy spurge can re-infest rapidly, it is recommended that treatments be applied annually until control reaches 90 percent or more (Lym and Messersmith 2006). When implementing treatments it is also recommended that infestations be periodically monitored to evaluate treatment effectiveness. If control objectives are not being met, it may signal inadequate treatments, at which point changes in techniques and strategies should be considered (Goodwin et al. 2006).

Several control options are available and most successful attempts at controlling Leafy spurge have used an IPM strategy in which different treatment methods, suited to site specific conditions, were used. Most control options, when used singly, take several years to be effective. During this time seed production and dispersal continue, perpetuating the spread of the infestation. Therefore, leading authorities on Leafy spurge management have concluded that eradication or even effective control in some situations cannot be achieved by biological agents, grazing, or manual controls without coupling these treatments with an herbicide treatment (Goodwin et al. 2006).

Siskiyou County

The first report of Leafy spurge in Siskiyou County was from Quartz Valley in the 1940s. In 1960 Leafy spurge was listed as a California Department of Food and Agriculture A-Rated invasive noxious weed. That year the SCDA began eradication efforts on 152 acres spread over six thousand acres in Butte Valley, Scott Valley, Quartz Valley, and one small infestation in Shasta Valley. By 1975 infested acres had been reduced to 10.5 acres. In the mid-to-late 1970s, land containing the majority of the remaining Leafy spurge infested acres changed ownership and subsequently land management practices. This spread Leafy spurge into non-infested areas and acres treated by SCDA increased to 55 in 1979. By 1989, infested acres were once again reduced to 6.7. However, over the better part of the next two decades, SCDA's funding for weed control was greatly reduced, inhibiting their ability to treat Leafy spurge. From 2007 through 2011 funding for Leafy spurge inventory and treatment increased substantially and extensive Leafy spurge surveys were cooperatively conducted by the SCDA and the Klamath National Forest (KNF). This inventory indicated that Leafy spurge had increased to 95.65 acres by 2009. The dramatic increase in Leafy spurge was primarily attributed to the SCDA's inability to treat a large percentage of existing occurrences due to budget shortfalls over the previous two decades, which left abundant sources of seed production unmanaged, and the ineffectiveness of certain treatments. The increased funding of the mid-to-late 2000s, also allowed for treatment of many

more acres than had been possible in the past 20 years. By 2011, the SCDA had reduced infested acres to 70 or a 27 percent decrease since the 2009 inventory.

Based on SCDA surveys and site specific treatment reports there are approximately 569 discrete occurrences of Leafy spurge along the Klamath and Scott rivers and Quartz Valley tributaries (J. Aceves pers. comm.) (Map 1). These occurrences are distributed over 60 river miles and range in size from one plant up to 0.16 acres. Approximately 55 percent of total inventoried acres occur on private land, 42 percent occur on lands managed by the KNF, and 3 percent occur on Tribal land. Taken together, all of the discrete occurrences on private lands and tribal lands in the Quartz Valley total approximately 72 acres. The majority of infested private land acres (64.7 percent) occur along the Scott River and its tributaries. Density of Leafy spurge occurrences along the Klamath River decreases from the mouth of the Scott River downstream to the Siskiyou County border. Less than one percent of the infested acres on private land occurs below Happy Camp, CA.

Most occurrences are located on rocky river bars and floodplains or in dense riparian vegetation where treatment options are limited. Because these occurrences are currently confined to small, well defined areas, they can still be readily controlled or even eradicated with persistent, adaptive management that uses knowledge gained from previous and ongoing control attempts to derive new management approaches and strategies. If not treated promptly, however, these small patches would likely expand into large infestations and eradication would become physically or economically unattainable (Lym and Messersmith 2006; Goodwin et al. 2006). Therefore, the Service is partnering with the SCDA to actively control existing Leafy spurge occurrences on private and tribal lands. Currently more than 99 percent of the private landowners and tribal representatives in the Quartz Valley have granted permission to the SCDA to enter and treat Leafy spurge on their property. Therefore, this project combined with ongoing efforts by the KNF on public lands, would result in the treatment of approximately 69 percent of the known Leafy spurge occurrences along the Klamath and Scott rivers and Quartz Valley tributaries to the Scott River.

The issue of production and downstream dispersal of seeds from unmanaged public lands to non-infested areas or previously treated sites is not disputed. The possibility that this could occur exists. However, by continuing to treat the majority of Leafy spurge infested acres, the annual production of seed will decrease, and monitoring of treated sites on private land will determine if seed dispersal by water movement is occurring.

For this project the SCDA would determine and implement the appropriate site specific treatments while the Service would provide funding to support implementation of selected treatments. Federal funds for this project were provided by the Service's Partners for Fish and Wildlife Program. Funds provided by this program can only be used to enhance or restore habitat on private or tribal lands. Therefore, federal lands were not considered for treatment in this project. Because repeated treatments over several years may be necessary to control or eradicate some occurrences, this EA evaluates five years of treatments.

Public and Agency Involvement

The project draft EA was made available to the public in order to provide background information to interested parties who wished to review and provide comments. A public scoping notice for this project was posted on the Yreka Fish and Wildlife Office website on January 20, 2011, and on the front page of the Siskiyou Daily News on January 23, 2011. The scoping notice provided a project summary and information on how to view or obtain the draft EA. Additionally, the same notice was mailed to over 30 recipients including local environmental groups, Resource Conservation Districts, Watershed Councils, and State, Federal, and local government agencies. Fifteen comment letters or emails were received in response to the scoping notice.

A meeting between the Karuk Tribe, the SCDA, and the Service occurred on 10/23/12. The purpose of this meeting was to clarify and discuss issues, and concerns raised during scoping.

On 6/29/11, the Yreka and Fish and Wildlife Office received a letter from its Regional Archeologist concurring that this project is consistent with the programmatic agreement between the Service and the California State Historic Preservation Officer and that is in compliance with section 106 of the National Historic Preservation Act. In that letter it was determined that the project "is not an undertaking that has the potential to affect cultural resources".

On 4/20/12, the SCDA received concurrence by email from the State Water Resources Control Board that this project did not require a National Pollutant Discharge Elimination System (NPDES) permit.

Based on analyses completed for the EA the Service determined on 1/14/13 the project would have No Effect on federally listed wildlife species or their critical habitat.

On 2/11/13, a letter of concurrence was received from the National Marine Fisheries Service (NMFS) concurring with the Service's determination that the project is not likely to adversely affect Southern Oregon/Northern California Coast coho salmon and their critical habitat. In that letter NMFS determined that the project would adversely affect Essential Fish Habitat (EFH) for Chinook salmon and coho salmon. However, NMFS also stated that "the anticipated adverse effects of the project are minimal and the project contains adequate protection measures" thus "no additional EFH conservation recommendations are necessary to avoid, minimize, mitigate, or otherwise offset the adverse effects to EFH".

Chapter 2: Alternatives

Alternatives, Including the Proposed Action

Over the past decade the SCDA has been treating Leafy spurge using a variety of control methods. All of the following alternatives represent a continuation of these ongoing control efforts and are consistent with the SCDA IPM strategy, which includes evaluating progress and modifying actions as necessary to meet control objectives. Only control methods that have been previously tested by local agencies or organizations or described and analyzed in peer reviewed journals or other scientific papers were considered for inclusion in the following alternatives.

This assessment considers three alternatives for treating Leafy spurge occurrences on private lands along the Klamath and Scott rivers and private and tribal lands along Quartz Valley tributaries to the Scott River. Alternative 1 (no action) proposes no additional management actions. Alternative 2 proposes the use of a control strategy using manual treatments only. Alternative 3 proposes the use of a control strategy including manual and herbicide treatments.

Alternative 1: No Action

The No Action Alternative refers to no additional County actions being taken to control Leafy spurge along the Klamath and Scott rivers and Quartz Valley tributaries. Given the natural history of the plant described throughout this document, this alternative would allow the continued growth of Leafy spurge and expansion of its range on private lands in Siskiyou County, unless private landowners address their infestations.

Alternative 2: Manual Control

Because there are often public concerns with the use of herbicides, Alternative 2 would use a variety of manual methods to reduce or eradicate Leafy spurge occurrences. The proper control method(s) for a given occurrence would be selected after considering site specific conditions. Specific manual methods considered in this alternative include tarping, hand pulling and digging, and manual defoliation.

Tarping consists of removing all vegetative material, including the Leafy spurge plants, and placing a protective cover (usually plastic or a geotextile) over the bare ground. Over time this reduces the population by preventing light from reaching the soil, effectively preventing seed germination and growth under the tarp. In areas subject to annual high water, tarps would be removed annually. Because all vegetation under the tarp may be killed, surveys would be conducted to ensure that rare or sensitive species do not occur in areas proposed for tarping. Where possible, tarping would extend 15 feet or more beyond the perimeter of the occurrence to prevent recently dispersed seeds from sprouting and to keep the roots from growing to the edge of the tarp and then producing plants.

Sites conducive to tarping include flat, sandy areas without large rocks or dense vegetation. These areas allow for the tarp to lay flat on the ground and minimize the potential for obstacles to poke through the tarp. Where these environmental conditions exist, tarping can be effective at controlling Leafy spurge as shown in Figure 1.

However, sites containing boulders, dense vegetation, or other obstacles can preclude effective tarping as shown in Figure 2. Attempts to control Leafy spurge by tarping at these sites have proven to be ineffective. Notice the tarp bulging with boulders and vegetation underneath and the Leafy spurge growing up and around the tarp.

Figure 1. Example of a site conducive to traping.

Figure 2. Examples of sites not conducive to tarping.

Additionally, even at sites with suitable conditions, tarping is not always effective at controlling Leafy spurge. The tarp in Figure 3 was pulled back several months after it was placed. Although the other vegetation under the tarp is dead, Leafy spurge is green and re-growing by vegetative shoots from the extensive rhizome root system.

Over the past seven years the KNF has tarped and hand pulled Leafy spurge at a variety of sites to determine the effectiveness of this method (M. Knight pers. comm. 2012). Results of these treatments and observations by KNF staff are summarized below:

- In 2011, 35 sites totaling 13.95 acres were treated with tarping and hand pulling. In 2012, 24 locations totaling 8.96 acres were treated with the same methods. A recent evaluation of these sites found the efficacy of these methods at controlling Leafy spurge is highly variable.
- In flat, sandy, dry areas with limited obstructions of vegetation or boulders, tarps that have been in place for 3 years have resulted in no above ground production of stems under the tarps, just adjacent to tarps. Leafy spurge stems adjacent to tarps appear spindly, and can be easily pulled.
- Tarps that have been in place for three years show much wear, and appear to be compromised with vegetation growing up through them.
- Tarped areas nearer water, as along ditches, has limited success, as water availability enhances spread to beyond tarp dimensions.
- Pulling sprouts adjacent to tarps does aid in under-tarp control.
- Pulling above ground plant material with the basal sprouts in spring reduces vigor and seed production.
- Dense patches of spurge are easier to control with tarps than scattered small patches. The theory is that the small patches are already connected underground, and tarping these small patches only re-directs resources to other non-tarped rhizomes.
- Areas of large boulders, willows, and dense vegetation such as blackberries are not suitable for tarping.
- The time and physical demands of hauling tarp material to and from sites that are inundated on an annual basis provides challenges in terms of the timing and availability of personnel to conduct this work, and the storage of used tarps.
- Tarping methods were ineffective where Leafy spurge plants were not removed before tarping.

Figure 3. Leafy spurge growing under a tarp.

As part of SCDA's watershed-wide Leafy spurge inventory process, infested sites were evaluated for suitability to treatment by tarping. Sites were considered tarpable if they occurred in sand or sand/gravel substrates lacking dense vegetation, large boulders, or other obstacles that would prohibit tarping. Additionally, sites with more than 50 plants were not deemed tarpable unless they occurred in sand. Results of this process indicate 27 sites totaling approximately 0.7 acres are tarpable on private lands.

Hand pulling and digging are most effective where there are only a few plants and they are in their first year of growth (Drlik et al. 1998; Goodwin et al. 2006). Over time, repeated pulling and digging of seedlings would exhaust the root system. However, because Leafy spurge is a deep-rooted, rhizomatus species, hand pulling, particularly of older plants, usually results in breaking the root system a few inches below the ground and both methods are only effective if the entire root system is removed. Because vegetative buds along roots can grow into new shoots and Leafy spurge seeds can germinate anytime during the growing season, repeated annual visits are necessary to ensure seedlings are removed in their first year of growth. For these reasons hand pulling and digging would be limited to new shoots emerging from tarped areas and newly discovered occurrences that are in their first year of growth.

The remaining Leafy spurge occurrences would be treated using a manual defoilation method. Manual defoliation consists of hand-stripping the leaves and removing the top five centimeters of Leafy spurge stems. Manual defoliation can reduce flowering, seed yield, and stem densities when plants are defoliated two to three times per growing season (Al-Rowaily et al. 1995; Kirby et al. 1997). Kirby et al. (1997) found that defoliating Leafy spurge twice in a growing season for four consecutive years reduced stem densities by 55 percent over non-defoliated controls.

Project treatment cost per acre, including personnel, materials, and operating costs, are estimated to be approximately $8,556.00 for tarping, and $4,320.00 for hand pulling and manual defoliation. These estimates are based on three site visits per year to implement tarping treatment and two site visits per year to implement hand pulling and manual defoliation treatments. Therefore, estimated annual project cost to treat all known occurrences on private lands would be approximately $314,000.00 for manual treatments. Project cost estimate for manual treatment was based on the assumption that one acre would be tarped and the remaining acres would be treated by hand pulling or defoliation. While the cost per acre will not likely change over time, the annual project cost will decrease over time as individual occurrences are reduced in size.

Alternative 3: Manual and Herbicide Control

This alternative would use the same manual control methods described in Alternative 2 as well as the use of herbicides. The proper control method(s) for a given occurrence would be selected after considering site specific conditions. For this alternative glyphosate would be the herbicide used due to its efficacy at controlling the target species, low toxicity to non-target organisms, and chemical properties that limits its movement in, and potential adverse impacts to the environment.

Glyphosate is a non-selective systematic herbicide. It is applied directly to plant foliage where it is absorbed across leaves and stems and subsequently translocated throughout the plant. Glyphosate disrupts the shikimic acid pathway by inhibiting enzymes and reducing production of aromatic amino acids that are vital for protein synthesis and plant growth (Miller et al. 2010). Research using similar herbicide formulations and application rates to those proposed for this project, suggest glyphosate can provide up to 80 to 90 percent control (stem reduction) of Leafy spurge 12 months after initial treatment (Lym and Messersmith 1985; Goodwin et al. 2006). Absorption and translocation of glyphosate by Leafy spurge is dependent on the growth stage of the plant (Maxwell et al. 1987; Lym 2000). Studies investigating glyphosate absorption during the same growth stages that Leafy spurge would be treated in this project, suggest that 55 and 77 percent of glyphosate would be absorbed three days and five days after treatment, respectively (Maxwell et al. 1987; Lym 2000). These same studies reported 21.4 and up to 45 percent of applied glyphosate had been translocated to Leafy spurge roots three and five days after treatment, respectively. Glyphosate is highly adsorptive, binding strongly to most soils (Tu et al. 2001; Mamy and Barriuso 2005). Once adsorbed to soil, glyphosate is resistant to desorption (Mamy and Barriuso 2007) rendering it highly immobile in the environment (EPA 1993; Feng and Thompson 1990). It is readily degraded by soil microbes to aminomethyl phosphonic acid (AMPA) which is degraded to carbon dioxide (EPA 1993). The median half-life of glyphosate in soils ranges from 2 to 197 days with 47 days being typical (Giesy et al. 2000). However, the adsorptive qualities of glyphosate can slow microbial degradation and increase its persistence in soils (Tu et al. 2001). Reported half-lives of glyphosate on foliage range from one to 26 days (Sandberg et al. 1980; Newton et al. 1984; Mortensen et al. 2008). Glyphosate is highly water soluable but solubility varies depending on the type of glyphosate salt in the active ingredient (Messersmith 2007). Half-life in fresh water ranges from a few days to several weeks depending on system properties (SERA 2011a). If glyphosate reached surface water, it would not be broken down readily by water or sunlight (EPA 1993). However, glyphosate would likely dissipate rapidly from natural water bodies through adsorption to suspended particles and bottom sediments where they are subsequently broken down by microbes (Feng et al. 1990; Newton et al. 1994; Goldsborough and Brown 1993).

Surfactants are often added to glyphosate formulations to increase the effectiveness of the herbicide. For this project the nonionic surfactant R-11 would be used. Nonionic surfactants reduce surface tension so that more rapid penetration of the herbicide into the plant is possible. The principal functioning chemical agents in R-11 are Alkylphenol ethoxylate, butyl alcohol, and dimethylpolysiloxane, which constitute 90 percent of the compound (Wilbur Ellis 2011). R-11 is grouped in a class of compounds called nonylphenol polyethoxylates (NPE) (Chen et al. 2010). Upon entering the environment, NPEs readily degrade into nonylphenol (NP) (EC 2002). NP is moderately water soluble and adsorbs strongly to soils and sediments (EC 2002; EPA 2005). Under aerobic conditions, nonylphenol compounds in soil initially biodegrade readily with half-lives as short as seven days. This initial phase is then followed by a secondary phase of prolonged degradation with half-lives as long as 110 days (EC 2002). On foliage, NP appears to degrade rapidly. Sundaram et al. (1980) found only three percent of the total NP applied in their study was present in spruce foliage 30 days after application. In water, NPE and NP are moderately resistant to degradation and are therefore considered persistent in aquatic environments (EPA 2005; EPA 2010). Bioaccumulation of NP in fish is considered to be low (EPA 2005).

Herbicide treatment would consist of spot spraying individual plants by hand using backpack-mounted sprayers. Herbicide application would occur only at low nozzle pressure and within 2.5 feet of the ground. Application would be halted when wind speeds exceed five miles per hour (mph). Using these best management practices, herbicide drift or the movement of spray from the intended target, is expected to be less than one foot (see Appendix A). As such the potential for overspray and drift would be minimized and approximately 80 percent or more of the applied herbicide mix would come in contact with the target species and be absorbed by the plant (J. Aceves pers. comm.). When treating plants within 10 feet of water, herbicides would be applied using a wick applicator. A wick application consists of painting or brushing the herbicide formula directly on the foliage of target plants. Therefore, no drift of the herbicide formula is expected at sites where the wick application method is used. Application would also be halted when there is greater than 30 percent chance of rain within six hours. Treated plants would be left on site.

Maximum application rate for glyphosate under its EPA approved label is 4.0 lbs a.i./ac (active ingredient per acre). However, the SCDA has found that an herbicide formulation containing significantly less active ingredient can effectively control Leafy spurge. For this Project, the SCDA would use an herbicide formulation that contains approximately 98.62 percent water, 1.13 percent glyphosate, and 0.25 percent surfactant (R-11). This equates to approximately 126.23 ounces of water, 1.45 ounces of glyphosate, and 0.32 ounces of R-11 per gallon of herbicide. The SCDA estimates that it takes 25 gallons of the herbicide formulation, which contains approximately 2.15 lbs of glyphosate and 8 ounces of R-11, to treat a full acre of Leafy spurge using a broadcast treatment. Given that the current occurrences of Leafy spurge are small and would be spot treated by hand, the actual amount of herbicide formulation applied per acre of treatment is expected to be considerably less than 25 gallons per acre. Therefore, it is expected that a maximum of 2.15 lbs of glyphosate may be applied per acre of treatment.

All SCDA treatment personnel have been trained by a Qualified Applicator Certificate holder, which is issued by the California Department of Pesticide Regulation. Specifically, treatment personnel are trained on appropriate application techniques including; how to use, calibrate, and maintain all application equipment; how to properly store tanks and backpack sprayers in field vehicles; and appropriate safety precautions. Additionally, all treatment personnel are required to review and follow all herbicide label requirements. Equipment used for transportation, storage, or application of chemicals shall be maintained in a leak proof condition at all times. Herbicides would be mixed at the SCDA yard in Yreka and backpack sprayers would be filled off-site to minimize spills and the potential to contaminate any water source. In the field, herbicides are applied by a two person crew consisting of a crew leader and a technician. All crew leaders for this project are returning SCDA employees that have experience in herbicide application.

As part of the initial treatment, herbicides may be applied to an estimated 72 acres infested with Leafy spurge. The optimal time for applying glyphosate is after full flower, during seed fill to fall regrowth (Lym and Messersmith 2006). For these reasons, the majority of herbicide treatments would occur during the months of July through September. Individual occurrences may be treated twice in a given year depending on the efficacy of the initial treatment. If a second treatment is necessary, it would occur before October 1st. Discrete occurrences to be treated range in size from one plant up to .16 acre patches and are spread out over 60 river miles.

Due to the size of the occurrences and their spatial distribution only one to two acres would be treated per day. Thus, it would take two to three months to complete the herbicide treatment. Because many years of treatment would be necessary before Leafy spurge is completely controlled or eradicated, follow-up herbicide treatments may be applied for up to five years. During follow-up treatments up to 72 acres could be treated with herbicides annually. However, because each treatment is expected to reduce the number of plants in an occurrence, the number of treated acres is expected to decline annually.

Project treatment cost per acre, including personnel, materials, and operating costs, are estimated to be approximately $1,666.00 for herbicides. This estimate is based on one visit per year to implement this treatment. Therefore, estimated annual project cost to treat all known occurrences on private lands with herbicides would be approximately $120,000.00. While the cost per acre will not likely change over time, the annual project cost will decrease over time as individual occurrences are reduced in size.
All acres proposed for treatment occur on private or tribal lands where the landowner or a tribal representative authorizes permission for the SCDA to enter and agrees to the treatment of Leafy spurge either verbally or in writing using a Noxious Weed Consent Agreement (see Appendix B). All of the private landowners and tribal representatives have been advised of the environmental hazards of a growing Leafy spurge infestation and the potential positive and negative aspects of proposed treatment efforts, including the use of herbicides. Upon request, private landowners and tribal representatives have also been provided with a copy of the herbicide label. Landowners within the project area are free to purchase over the counter herbicides containing glyphosate and treat Leafy spurge at their discretion without supervision. Alternative three proposes to treat Leafy spurge on private lands using the same herbicides that can be purchased over the counter. However, this Alternative allows for the application of the herbicide by trained vegetation management professionals, ensuring that the proper amount of herbicide would be applied and that applications would occur at the time of year when treatment would be most successful.

Alternatives not considered for detailed analysis: **Grazing, Burning, Cultivating, and Biological Controls**

Grazing: Sheep and goats can control Leafy spurge by grazing on the topgrowth of the plant. Grazing is best suited to control Leafy spurge on large infestations, primarily in pasture and rangelands. Where Leafy spurge occurrences are small and discontinuous, fencing may be required to concentrate foraging. Fencing may also be needed at sites to prevent animals from moving to neighboring properties or grazing in areas with other resource concerns. Because the majority of occurrences are small and widely dispersed, occur in inaccessible areas, or require fence construction, grazing was not considered a practical method to meet the purpose of controlling Leafy spurge along the Klamath and Scott rivers and Quartz Valley tributaries.

Burning: Research suggests that prescribed fire is ineffective at depleting the root system of Leafy spurge and may actually stimulate vegetative growth from root buds (Goodwin et al. 2006). When used in conjunction with other methods, prescribed fire has resulted in some success in reducing Leafy spurge seed viability. Prescribed burning requires trained professionals and permits which would limit the potential treatment times to early spring or late fall, which are not optimal treatment times for controlling Leafy spurge. Additionally the small size, wide distribution, and location of existing occurrences, limits the number of sites where fire

can be safely and effectively implemented. Spot-burning with a propane torch has proven to be effective on some weeds and provides a less expensive and easier to implement option to prescribed fire (Tu et al. 2001). However, the efficacy of this method in controlling Leafy spurge has not been tested and documented. For these reasons, burning was not considered practical to meet the purpose and need of this project.

Cultivating: Cultivating or tilling the soil at a depth of three to four inches every two weeks during the growing season and every three weeks when plant is dormant has proven to be an effective method for controlling Leafy spurge. However, this technique has primarily been tested in pasture and rangelands and is not suitable for rocky terrain, areas containing dense vegetation, or areas where access for large machinery is difficult, which are conditions along the Klamath and Scott rivers and Quartz Valley tributaries.

Biological Controls: Biological control uses natural enemies of weed species, including insects. While many insect species (beetles, moths, gall midge) have been released in the United States to manage Leafy spurge, the flea beetle (*Apthona sp*.) has proven to be the most successful control agent (Goodwin et al. 2006). Attempts by the SCDA to establish flea beetles indicate they are sensitive to the environmental conditions in which they are released. Beetles released at sites containing Leafy spurge growing in loamy soil have survived for five years whereas beetles released at sites containing Leafy spurge growing in shallow, sandy soils did not survive. It is believed that shallow, sandy soils do not provide adequate over-wintering habitat (J. Aceves pers. comm.). Because the Leafy spurge occurrences to be treated in this project occur in shallow, sandy or rocky soils the introduction of biological controls to new sites are not proposed in any of the alternatives.

Affected Environment

The specific areas to be treated include the Mill and Shackleford Creek drainages which originate in Quartz valley; the Scott River from Shackleford Creek downstream to its confluence with the Klamath River; and the Klamath River from the Scott River downstream to the Siskiyou County border.

Chapter 3: Environmental Consequences

Alternative 1: No Action

Under Alternative 1, Leafy spurge along the Klamath and Scott rivers and Quartz Valley watershed would remain unmanaged and would likely continue to spread at rates equal to or greater than those observed over the last decade. Not treating these occurrences would also increase the risk of the establishment of new sites downstream of the existing occurrences, threatening native plants and habitats.

Ecological Impacts

Soil Quality: Continued expansion of Leafy spurge can increase the potential for soil erosion by reducing plant diversity. Additionally, preliminary data from a study investigating soil properties suggests Leafy spurge can affect the function of soil microbes which could impact recruitment or reestablishment of native species (Larson 2011).

Botanical: Potential consequences of not controlling Leafy spurge to plant communities are well documented. Leafy spurge has the ability to overtake plant communities, dramatically changing their composition. Potential effects of not controlling Leafy spurge include a reduction in native grasses, forbs, and woody plants, including rare and endangered species. There are 19 plants that meet the California Native Plant Societies rare or endangered criteria within 0.5 miles of the main stem Klamath River between Iron Gate Dam and the Siskiyou County border.

Invasive plants can also attract pollinators away from native flowers. Larson et al. (2006) reported that native species received fewer visits in areas infested with Leafy spurge. A burgeoning Leafy spurge population may therefore depress pollination of native species. This would be of particular concern in areas where rare or sensitive species are located.

Water quality: There are no anticipated direct effects to water quality from Alternative 1. Indirect effects may occur as Leafy spurge displaces native vegetation. Over time this could affect water quality by reducing instream shading and increasing erosion and sediment delivery to adjacent creeks and rivers. Additionally, by depleting late summer deep soil moisture, Leafy spurge could impact water yields to adjacent streams and rivers.

Fish and Wildlife: Uncontrolled Leafy spurge may have an adverse effect to fish in the project areas over time by reducing shade vegetation, increasing the potential for erosion, and decreasing water yield. The Klamath and Scott rivers support a variety of anadromous fish including the federally listed coho salmon (*Oncorhyncus kisutch*) as well as Chinook salmon (*Oncorhyncus tshawytscha)*, steelhead trout (*Oncorhyncus mykiss*), and Pacific lamprey (*Lampetra tridentata*). These species have similar life histories including the need for cold water and coarse gravel for spawning. In their 2009 report to Congress, the National Oceanic and Atmospheric Administration identified altered sediment supply and impaired water quality as threats to anadramous salmonid populations in the Klamath River (National Oceanic and Atmospheric Administration 2009).

Similar to aquatic species, impacts to terrestrial wildlife would be expected over time as Leafy spurge displaces native vegetation. Forage for ungulates and suitable nesting habitat for some ground nesting birds would likely decline. However, Leafy spurge produces seeds that are eaten by a variety of birds and provide a pollen and nectar source for some bees.

Human Health and Safety:

Because actions are not proposed Under Alternative 1, this alternative does not pose a risk to human health or safety.

Cumulative Impacts:

If actions are not undertaken to control Leafy spurge, it is anticipated that this species would continue to expand, eventually becoming the dominant plant in many riparian areas. Expanding Leafy spurge occurrences would continue to degrade watershed health and function by impacting water quality, altering native plant distribution and abundance, and reducing wildlife forage. Taking no action now could lead to needing to undertake a larger control effort in the future or render future control unattainable.

Alternative 2: Manual Control

Under Alternative 2, the appropriate control method(s) for a given occurrence would be selected after considering site-specific conditions. All of the control methods proposed for this alternative require a time frame of several years to decades to control Leafy spurge. While these methods may control individual occurrences over time, they may be ineffective at preventing the spread of Leafy spurge due to the length of time required to obtain control. Additionally, the rocky terrain and dense vegetation characteristic of many Leafy spurge sites, may prohibit implementation of certain treatments in some areas.

Ecological Impacts

Soil Quality: Direct effects to soil quality under Alternative 2 are expected to be minimal or short term. Tarping can initially reduce beneficial microorganisms in the soil but their populations quickly recolonize soils once tarps are removed (Pokharel 2011). Additionally, tarping can control some pathogens and increase availability of plant nutrients. Hand pulling and digging would disturb soils but this would only occur in small discrete patches. Manual defoliation is not expected to affect soil quality.

Botanical: Hand pulling, digging, and manual defoliation, would likely have an immediate benefit to botanical species within the treated areas by reducing competition with Leafy spurge while minimizing impacts to non-target species. However, these methods may take several years to control an individual occurrence of Leafy spurge. During this time, seeds would continue to be dispersed. Therefore, these methods may not be effective at controlling the spread of Leafy spurge to non-infested areas, which may impact rare or endangered plants. While tarping would likely kill or suppress all vegetation within the treated area, surveys of proposed tarping sites would be conducted to ensure that rare or endangered plants are not affected. Therefore, impacts to rare or endangered plants are not expected.

Water quality: There are no anticipated direct effects to water quality from Alternative 2. Indirect effects from ground disturbing activities such as digging and hand pulling may be short-term increases in erosion and sediment delivery to the streams. However, because the majority of Leafy spurge sites occur in rocky or sandy soils on low to moderate sloping terrain, any increase in erosion is expected to be minimal. Because treatments may take several years to control and individual occurrence, Alternative 2 may be ineffective at controlling the spread of Leafy spurge to non-infested areas. Therefore, water quality issues associated with the displacement of native vegetation by Leafy spurge as discussed under Alternative 1 may occur over time.

Fish and Wildlife: Alternative 2 is not expected to have direct impacts on fish or other aquatic species. However, ground disturbing activities such as hand pulling and digging could increase short-term erosion and sediment delivery to the streams following rain events. An increase in sediment delivery can adversely affect coho salmon and steelhead by interfering with the development of eggs and larvae. Hand pulling and digging would be limited to new shoots emerging from tarped areas and newly discovered occurrences that are in their first year of growth, and soils at treated sites are resistant to erosion. For these reasons, any increases in sediment delivery are expected to be minimal and not impact anadromous fish.

Control methods that only remove or kill Leafy spurge such as hand pulling, digging, and manual defoliation, would benefit species that utilize native vegetation for foraging or nesting. Tarping would result in a short term reduction of foraging and nesting habitat as they would likely kill or suppress all vegetation within the treated area. However, these impacts are not expected to be significant due to the size and distribution of the tarping treatments.

Due to the time required to obtain control, Alternative 2 may be ineffective at controlling the spread of Leafy spurge to non-infested areas. Therefore, potential indirect effects to fish and wildlife from Leafy spurge infestations would be the same as described in Alternative 1.

Human Health and Safety:

Under Alternative 2, there is some risk of injury due to the extensive use of manual treatments. However, all treatments would be implemented by experienced field staff and all field staff receive extensive training by the SCDA before implementing any control actions. Therefore, the risk to human health or safety from this alternative is expected to be minimal.

Cumulative Impacts:

Because the impacts of tarping, digging, hand pulling, and manual defoliation, are expected to be short term or negligible, they are not expected to have a significant cumulative impact to plants, fish, or wildlife. While this alternative would likely have localized benefits, it may not be effective at controlling the spread of, and environmental degradation caused by, Leafy spurge.

Alternative 3: Manual and Herbicide Control

Under Alternative 3, Leafy spurge would be controlled by utilizing the most effective IPM option available at each specific site. Leading authorities on Leafy spurge control have concluded that eradication and in some situations effective control cannot be achieved without herbicide treatment (Goodwin et al. 2006). Most of the Leafy spurge along the Klamath and Scott rivers and Quartz Valley tributaries occur in inaccessible or rocky terrain or dense vegetation, which limits the applicability of certain treatment methods. Additionally, other methods have proven to be ineffective or require several years to decades to control individual occurrences. For these reasons, tarping would occur on the 0.7 acres deemed tarpable by the SCDA, otherwise herbicides would be the primary treatment unless other IPM methods are determined to be more suitable. Other potential treatment methods include hand pulling and digging and manual defoliation as described in Alternative 2. Because the environmental consequences of these manual treatments have been previously analyzed and would be the same for Alternative 3, the following analyses only address the environmental consequences associated with herbicide application.

Ecological Impacts

Soil quality: As a result of dripping from treated plants and over-spray during applications up to 20 percent of the applied herbicide may make contact with the ground. Glyphosate applied to soil can affect microbial communities which are responsible for increasing the availability of soil nutrients. Results of research on this topic suggest glyphosate applied at recommended field application rates in natural environments has little effect on microbial activity and communities (Tu 1994; Haney et al. 2000; Ratcliff et al. 2006). Tu (1994) also found that affected populations

of microorganisms recovered rapidly after treatment suggesting that glyphosate did not pose a threat to long-term microbial activity.

Due to the small amount of herbicide anticipated to make contact with soil, the size and distribution of treated areas, and the limited and short-term impacts to soil microbes, impacts to soil quality are expected to be minimal.

Botanical: Glyphosate is a non-selective herbicide. Most plants that come into direct contact with glyphosate are killed or damaged but uptake and plant response varies depending on application method, rate, and frequency (Dill et al. 2010). For this project, herbicides would be applied by hand using backpack sprayers at low nozzle pressure. Applications would be made in late summer when many of the grasses and other plants have become dormant. Project best management practices for wind speed would minimize drift, effectively minimizing exposure to non-target plants. Therefore, direct effects to non-target plant species are expected to be minimal. California State rare or endangered plant populations are not known to occur within proposed treatment areas.

Upon making contact with soil, glyphosate adsorbs quickly and tightly, and is highly immobile (EPA 1993; Feng and Thompson 1990). For this reason glyphosate is not readily taken-up by plant roots and has little or no herbicidal activity once it touches soil (Sprankle et al. 1975; Giesy et al. 2000; Dill et al. 2010). Consequently, indirect effects to non-target plants are expected to be negligible.

Water Quality: Direct effects to water quality would include application of herbicides directly into water or accidental spillage. Herbicides would not be applied directly to vegetation emerging from water or directly over water. There is the possibility that glyphosate could travel through the air to adjacent water. However, herbicides would be applied by hand using backpack sprayers at low nozzle pressure and application would be halted when wind speeds exceed 5 mph, ensuring that drift would be negligible (see Appendix A). Additionally, when treating plants within 10 feet of water, herbicides would be applied using a wick applicator, eliminating the potential of drift at sites adjacent to water. Therefore, applied herbicides are not expected to make direct contact with water.

During herbicide treatments there is always the potential for the applicator to trip or fall. However, spray tanks are constructed of durable plastic that is resistant to these types of impacts. As an emergency precaution all crews would carry spill equipment and would follow prescribed spill emergency procedures. Backpack sprayers would also be filled off-site to minimize spills and the potential to contaminate any water source.

Indirect effects to water quality would result from the movement of glyphosate from a treated area into a water source through erosion, runoff, or percolation. As a result of dripping from plants and over-spray a small amount of herbicide would reach the soil. Additionally, a small amount of glyphosate may reach soil through exudation from roots and from decomposition of treated plant residues (Rodrigues et al. 1982; Tesfamariam 2009). However, due to its adsorptive qualities, glyphosate is unlikely to move vertically into groundwater (EPA 1993). In arid areas with rocky, sandy soils, such as those found along the Klamath and Scott rivers, glyphosate typically would only penetrate the top 4 to 8 inches of soil (SERA 2011a). Comes et al. (1976) found that glyphosate sprayed directly into a dry irrigation canal was not detectable in

the first irrigation water flowing through the canal even though glyphosate residues were still persistent in the soil, suggesting that flowing water does not readily extract glyphosate from soils.

Although glyphosate is unlikely to leach into ground water or be extracted by flowing water, it can enter water sources when adsorbed to soil particles suspended in runoff (EPA 1993; Tu et al. 2001). Soil properties, topography, and rainfall are the primary factors controlling runoff events (Brady 1974; Huddleston 1996). Most of the proposed treatment would occur on river bars and floodplains characterized by low slopes ($\leq$ 20 percent) and well drained sandy or rocky soils. Average rainfalls for the months of July through September are 0.3, 0.7, and 1.0 inches for the Klamath River (Happy Camp) and 0.3, 1.3, 1.3 inches for Scott River (Fort Jones). As such, it is unlikely that typical summer rainfall would generate runoff events that would transport glyphosate into adjacent water sources. However, intense thunderstorms can occur in the Klamath and Scott River areas during the summer months. These storms can have significant rainfall and represent the greatest likelihood of transporting glyphosate from the treatment area to a water source, especially if they occur immediately following an herbicide application. Due to the size and spatial distribution of the Leafy spurge occurrences to be treated, only one to two acres would be treated per day, effectively minimizing the number of recently treated acres exposed to random thunderstorm events. As stated above, treated areas are characterized by well drained soils with high infiltration rates and occur on shallow slopes that are resistant to erosion. Therefore, even in the worst case scenario it is unlikely that summer thunderstorms would generate enough erosion and runoff to measurably affect water quality.

To quantify this assumption a worst case scenario was modeled using the Groundwater Loading Effects of Agricultural Management Systems (GLEAMS). Originally designed by U. S. Department of Agriculture to simulate water quality events on agricultural fields, recent versions of GLEAMS have incorporated parameters to address complex hydrology-erosion-herbicide interactions in other ecological systems (Knisel and Davis 2000). For this exercise, the worst case scenario consisted of a three inch rainfall occurring on the same day that two acres of Leafy spurge were treated with glyphosate. The maximum value for the rainfall parameter in the model was set to three inches because historical weather data compiled by the Weather Warehouse (http://weather-warehouse.com) for Happy Camp, CA, indicates that 3.04 inches is the maximum 24 hour rainfall recorded within the months (July through September) that herbicides are proposed to be applied. The two acres to be treated were distributed in a 25 foot wide strip to simulate a riparian corridor treatment. Results of this modeling exercise suggest that no detectable levels of applied herbicide would be transported by runoff or sediment yield outside of the treated area under the above scenario (See Appendix C for model results and model assumptions). These model results are very similar to the Syracuse Environmental Research Associates 2011 USDA Forest Service Glyphosate Risk Assessment GLEAMS model outputs for potential runoff and sediment loss from arid, sandy soils (SERA 2011a).

The onset of consistent, heavy fall rains also increases the potential for runoff and erosion. In the Klamath and Scott River areas, consistent fall rains typically begin in late October or early November which would be one to three months after treatment. Due to its short foliar and soil half-lives and adsorptive properties there is a low probability that glyphosate would enter water after the fall rains commence. A study conducted by the California Environmental Protection Agency (Wofford et al. 2003) in the Lower Klamath Basin failed to detect measurable

concentrations in a forest stream below an experimental 13 acre glyphosate treatment following the first fall rain which occurred 37 days after the treatment.

High water events following fall and winter rains and spring snowmelt also have the potential to wash decomposing treated Leafy spurge plants into rivers and streams. Data from the United States Geological Service's (USGS) surface water statistics for the Klamath and Scott rivers indicate annual high flows occur between December and June. Thus, high water events would likely occur two or more months after herbicide treatments have been implemented. Although the degradation of glyphosate in decaying plants varies according to species, typical half-lives for glyphosate on foliage range from 1 to 26 days (Sandberg et al. 1980; Newton et al. 1984; Mortensen et al. 2008). Once applied to the foliage, glyphosate is rapidly translocated to the roots of Leafy spurge plants (Maxwell et al. 1987) which are not subject to being washed into streams or rivers during high water events. Thus, negligible amounts of glyphosate are expected to be present in the portions of decaying plants susceptible to high water events. Once absorbed, glyphosate is not readily extracted from dead or decaying vegetation by water (Rampoldi et al. 2011). For these reasons, any glyphosate introduced into rivers and streams from decaying vegetation during high water events is expected to be below EPA's minimum detection limit (the minimum concentration of a substance that can be measured with 99 percent confidence that the analyte concentration is greater than zero) using standard laboratory methods and procedures (EPA 1990; EPA 2007). See Appendix D for assumptions and calculations used to estimate the potential of decaying vegetation to transport glyphosate to water.

The surfactants used in herbicide formulations can be toxic, and in some cases more toxic than the herbicide. Herbicides and surfactants can also have joint action where one or more of the components in a mixture impact the toxicity of other components in the mixture (SERA 2011a). Research on R-11 and the specific joint action of glyphosate and R-11 is limited but suggests R-11 is more toxic than glyphosate and increases the toxicity of glyphosate when combined in formulations (Trumbo 2005; SERA2011a). However, surfactants typically constitute a small percentage of the herbicide formulation. For the proposed treatments, a maximum of 0.25 percent of the formulation would be R-11. Herbicide formulations would not be applied directly to emergent vegetation or directly over water and project best management practices would ensure the herbicide formulation would not make direct contact with water through drift. The adsorptive qualities and short soil half-life of NP (a degradation byproduct of R-11), the stability of soils and shallow slopes in the treated areas, and lack of summer rains, also make it unlikely R-11 or its degradation products would enter water sources through runoff or erosion. Because R-11 constitutes a small percentage of the herbicide formulation, any NP introduced into rivers and streams from decaying vegetation during high water events is not expected to reach the minimum detection level used by other researchers (0.002mg/L) (Sundaram et al. 1980; Trumbo 2005) assessing the environmental impacts of R-11 (see Appendix D). Therefore, the use of the surfactant R-11 is not expected to measurably affect water quality.

Fish and other Aquatic Species: The potential effects of glyphosate to fish and the effect of pH on toxicity have been well documented (Appendix E. Table 1). Research indicates that increasing pH decreases the toxicity of glyphosate to fish (Wan et al. 1989). Data from the USGS National Water Information System suggest that the pH of the Klamath (Seiad Valley) and Scott Rivers (west of Fort Jones) during the months when treatments are proposed are neutral to slightly basic (7-8.6). Based on EPA toxicity classifications, glyphosate would

therefore be considered slightly toxic to practically nontoxic to salmonids and other fishes (Appendix E. Table 2). While some studies reported that sublethal concentrations of glyphosate had little effect on salmonids (Folmar et al. 1979; Morgan and Kiceniuk 1992), other studies indicate sublethal concentrations can result in erratic swimming, rapid respiration, temporary loss of olfaction, and avoidance behavior (Morgan et al. 1991; Tierney et al. 2006; Tierney et al. 2007). Glyphosate would also be considered slightly-to-practically nontoxic to other aquatic species including tadpoles, frogs, midges, and crustaceans (Appendix E. Table 3). Mussel larvae and juveniles appear to be the most sensitive and glyphosate would be considered moderately toxic to these species and life forms. Glyphosate is highly water soluble and it does not readily bioaccumulate in the tissues of fish (Wang et al. 1994; Giesy 2000). Bioaccumulation of glyphosate in other aquatic species is not well understood.

The surfactant R-11 can be more toxic than glyphosate. Although data on the toxicity of R-11 is limited, it suggests that R-11 is more toxic to fish and other aquatic species than glyphosate (Appendix E. Table 4). Bioaccumulation of R-11 in aquatic species is not well understood.

As stated above under water quality, herbicides are not expected to make direct contact with water during application or be transported to water through erosion, runoff, or percolation. Also, if decaying plants are transported to rivers and streams they are not expected to result in detectable levels of glyphosate or R-11within these water courses. For these reasons, the proposed application of herbicides is not expected to directly impact any aquatic species or result in accumulation of glyphosate or R-11 in bottom sediments.

Because glyphosate is a non-selective systemic herbicide it could indirectly impact aquatic habitat by killing riparian vegetation. However, project best management practices would ensure herbicide drift and contamination of non-target plants is minimized. Additionally, treated areas would range in size from one plant to 0.16 acres, would be spread out over 60 river miles, and predominately occur in well drained soils on low to moderately sloping terrain. Based on surveys conducted by the SCDA, only eight sites totaling approximately 1.25 acre would be treated within 10 feet of water. At these sites a wick application method would be used, further reducing the potential to impact shade-producing riparian vegetation. For these reasons, potential impacts to riparian habitat are expected to be minimal and not be concentrated in any area. Therefore, impacts to shade-producing vegetation or potential increase in erosion are expected to be negligible and not measurably impact water quality.

Wildlife: Direct effects to terrestrial wildlife and birds include exposure to glyphosate from direct spray. As workers would have to access each treatment area by foot, it is expected that most wildlife would vacate the immediate area of an application. Exceptions to this assumption would likely include species of low mobility including terrestrial-phase amphibians and avian nestlings. Despite the fact that amphibian skins are highly permeable to glyphosate (Quaranta et al. 2009), research indicates that glyphosate has low toxicity to amphibians (Mann and Bidwell 1999; Dinehart et al. 2008). However, numerous studies suggest that surfactants used in glyphosate formulations are toxic to amphibians to varying degrees (Mann and Bidwell 1999; Reylea 2005; Howe et al. 2004). Because the majority of the areas to be treated are small and dispersed and project best management practices would minimize drift, it is unlikely that amphibians would be sprayed directly. Additionally, herbicide treatments would occur after the breeding season for most avian species and during the warmest and driest months of the year when lungless salamanders such as the State listed Siskiyou Mountains (*Plethodon stormi*) and

Scott Bar (*Plethodon asupak*) salamanders retreat to more favorable climatic conditions underground (Nussbaum 1974; DeGross and Bury 2007). Thus, direct effects to wildlife are not expected.

Indirect effects would include the ingestion of contaminated vegetation or prey, contact with contaminated vegetation, or herbicide-induced changes in vegetation. Due to their life histories and habitat requirements, small mammals would likely have the greatest exposure to these effects. A large body of information exists regarding the toxicity of glyphosate to small mammals. McComb et al. (2008) reported high intraperitoneal LD_{50} values (dose of a material that results in mortality of 50 percent of test organisms) ranging from 800 to 1370 millligrams/kilogram of body weight (mg/kg-bw) across the small mammal community in the Oregon Coast, indicating that glyphosate has a relatively low toxicity to small mammals. Several studies report little to no adverse effect on small mammal populations over time under various application methods and exposure rates (Ritchie et al. 1987; Sullivan 1990; Sullivan et al. 1997; Cole et al. 1998) other than those attributed to herbicide-induced changes in vegetation (D'Anieri et al. 1987; Santillo et al. 1989), suggesting the potential effects of ingestion and contact with contaminated vegetation or prey are insignificant or short term. Additionally, because treated areas are dispersed and range in size from one plant to 0.16 acres and best management practices would reduce drift to non-target plants, impacts to vegetation providing habitat for small mammals are expected to be minimal and not concentrated in any one area.

Research on the effect of glyphosate to large mammals, summarized in International Programme on Chemical Safety (1994), indicates that net oral LD_{50} of technical grade glyphosate is greater than 5000 mg/kg of body weight in rats and goats. Orally ingested glyphosate is also poorly biotransformed in animals and is rapidly excreted unchanged in urine and feces (Williams et al. 2000). Because plants do not readily uptake glyphosate from the soil and project best management practices would minimize drift, contamination of non-target plants is expected to be minimal. Additionally, treated areas are small ranging from one plant up to 0.16 acres and are distributed over 60 river miles. Therefore, it is unlikely feeding beavers would chew on contaminated woody vegetation and consume glyphosate at levels shown to be adverse to other mammals. As such, beavers function in creating or enhancing coho habitat should not be affected. Because Leafy spurge is not regularly consumed by ungulates and contamination of non-target plants is expected to be minimal, impacts to ungulates are also expected to be insignificant.

R-11 is a nonylphenol polyethoxylate (NPE) (Chen et al. 2010). In the environment NPE's readily degrade in to nonylphenol (NP)(Environment Canada 2002). Repeated dose toxicity studies have indicated NP can affect liver, kidneys, and growth rates in different mammal species, reproductive function in male rats, and weak estrogenic effects in female rats (de Jager et al. 1999; Laws et al. 2000; Environment Canada 2001; Nagao et al. 2000; EPA 2009). In these studies LD_{50} values ranged from > 200 to 4,000 mg/kg-bw/day for oral exposure to > 1000 mg/kg-bw/day for dermal exposure suggesting that acute toxicity to mammals is low for oral and dermal routes (EPA 2009). The lowest observable adverse effect level (LOAEL) for these studies also varied but a 43mg/kg-bw/day LOAEL would be inclusive of all studies.

Given that oral and dermal toxicity is low, R-11 constitutes a small percentage of the herbicide formulation, and treated areas are small and dispersed it is unlikely that terrestrial mammals

would be exposed to enough contaminated vegetation to surpass the LOAEL values reported for R-11.

The EPA classifies glyphosate as slightly toxic to birds (EPA 2008) (Appendix E. Table 5). While studies indicate that high concentrations of glyphosate (>4500 ppm) in ingested foods can cause weight loss in birds, concentrations up to 833 ppm of technical grade glyphosate in ingested foods had no effect on growth and reproduction of bobwhite quail and mallard ducks (EPA 2008). Avian species such as bank swallows that do not use vegetation to build nests and whose diet is almost entirely insects (Garrison 1998) are unlikey to be exposed to glyphosate. As with other terrestrial species, the major impact to birds appears to be herbicide-induced changes in habitat (Santillo et al. 1984; Easton and Martin 1998). Because the majority of the areas to be treated are small and dispersed and project best management practices would minimize drift, impacts to avian species and their habitats are expected to be negligible.

Available data on honey bees and other arthropods indicates that there is a low potential for glyphosate to cause direct toxic effects. However, glyphosate has been shown to impact food consumption, behavior and reproductive capacity (Benamu et al. 2010; Schneider et al. 2009).

Proposed treatment areas are small and distributed over 60 river miles. Therefore, any adverse effects to terrestrial wildlife and birds would not be concentrated and the potential for direct contact is reduced. Additionally, project best management practices would limit the exposure to non-target flora, which would minimize impacts to habitat and forage. Consequently, any impacts of the proposed treatments to wildlife are expected to be insignificant.

Human Health and Safety: Glyphosate is of relatively low oral and dermal acute toxicity and has been placed in Toxicity Category III for these effects (Toxicity Category I indicates the highest degree of acute toxicity and Toxicity Category IV the lowest) (EPA 1993). Exposure to concentrated product and inhalation of spray mist can cause eye and skin irritation and oral or nasal discomfort. However, any permanent ocular or dermal damage is very rare (Williams et al. 2000; Bradberry et al. 2004). EPA has also categorized glyphosate as a Group E oncogen – one that shows evidence of non-carcinogenicity for humans (EPA 1993).

Individuals potentially exposed to glyphosate would include workers and possibly the general public if present on private lands. All SCDA treatment personnel are trained by a Qualified Applicator Certificate holder on appropriate application techniques, safety precautions, and herbicide label requirements. To protect workers and minimize exposure, all treatment personnel would be required to wear personal protective clothing and eyewear and complete a “Pesticide Safety Training Program” prior to working with equipment, mixing and loading, and treatment activities. Therefore, potential exposure to workers applying glyphosate would be effectively minimized.

All proposed treatments would occur on private, or tribal, lands and only with landowner or tribal representative consent. All landowners have been briefed on the herbicides to be used, application methods, and necessary or prudent precautionary measures during and following treatment. Upon request, landowners are provided with a copy of the herbicide label. All treatments would occur on lands which are not accessible to the general public without consent from the landowner. Therefore, exposure to the general public is not expected to occur. However, in the unlikely event that a member of the general public has incidental contact with

recently sprayed vegetation the following analysis was conducted to evaluate the potential impacts to human health and safety.

To assess the risk to human health and safety of the general public, potential effects were evaluated using a hazard and exposure analyses. Hazard was measured in terms of a hazard quotient (HQ) which compares potential doses of glyphosate to an established reference dose of glyphosate. The hazard and exposure analyses were then combined in a risk analysis to predict the health effects to the general public from the proposed action. This methodology is widely accepted by the scientific community and regulatory agencies for conducting risk assessments (National Resource Council 2009; SERA 2011a; EPA 2012).

Hazard analysis: This hazard analysis focused on the toxic properties of glyphosate. Toxic levels of glyphosate to humans are derived primarily from results on animal models, supplemented with information from accidental or intentional human poising incidents, and data on chemical structure. Glyphosate is of relatively low oral and dermal acute toxicity and has been placed in Toxicity Category III for these effects (Toxicity Category I indicates the highest degree of acute toxicity and Toxicity Category IV the lowest) (EPA 1993). LD_{50} values in experimental animals range from approximately 1,500 to over 6,000 mg/kg-bw (SERA 2010). Research has also indicated excessive exposure can cause liver and kidney damage and weight loss in some mammals (summarized in SERA 2011a) while lower doses can cause a reduction in testosterone in rats (Claire et al. 2012). In vitro studies indicate glyphosate formulations may cause cellular damage depending on the period and length of exposure, the concentration of glyphosate and adjuvant in the formulation, and bioaccumulation potential of the formula ingredients (Benachor et al. 2007; Benachor and Seralini 2009). Definitive studies that defined both a NOAEL and a lowest observed adverse effect level (LOAEL), suggest a systemic NOAEL of 175 mg/kg-bw/day for glyphosate (SERA 2011a).

Exposure analysis: The general public could potentially be exposed to herbicides through several means from ingesting contaminated food or water to direct dermal contact. Due to its adsorptive qualities, glyphosate is highly immobile in the environment. The worst case scenario modeled above, suggest that glyphosate would not be transported to water from runoff or erosion. In arid areas with rocky, sandy soils, such as those found along the Klamath and Scott rivers, glyphosate typically would only penetrate the top 4 to 8 inches of soil (SERA 2011a). Thus, glyphosate is not expected to reach groundwater. Additionally, this project would not occur adjacent to any municipal water supply. While a recent study by Sanchis et al. (2012) found detectable levels of glyphosate in 41percent of the wells tested in Catalonia Spain, areas studied with one exception, “presented a high impact from intensive agriculture and they were qualified as high risk areas”. Although Sanchis et al. (2012) did not quantify the amount of glyphosate applied in their study areas it is reasonable to assume that the amount of herbicide applied in areas of “intensive agriculture” are very different from the treatments proposed in this project.

Glyphosate would not be sprayed over water. Best management practices for backpack spray applications would reduce potential drift to less than one foot. Leafy spurge occurrences within 10 feet of water would be treated with a wick application. Because the herbicide formulation is applied directly to the target plant, no drift is expected with the wick application. Therefore, glyphosate is not expected to enter fish bearing streams through drift. Additionally, all treatments would occur on private or tribal lands which are not accessible to the general public.

For these reasons the public is not expected be exposed to glyphosate through drinking or recreating in contaminated water, consuming contaminated fish, or direct spray.

As such, the primary pathways in which the general public could be exposed to herbicides include; 1) dermal contact with recently sprayed vegetation and 2) eating recently sprayed vegetation or its fruit. As part of a series of Human Health and Ecological Risk Assessments prepared for the USDA Forest Service, Syracuse Environmental Research Associates, Inc. (SERA) developed models in Excel workbooks to detail calculations relating to exposure scenarios and risk characterization (SERA 2011b). These calculations incorporate non-site specific parameters (i.e., body weight and surface area of exposed individual) and site specific parameters (i.e., application rate, herbicide and vegetation properties, dermal absorption rates). The same models and calculations were used for this project to evaluate the two exposure pathways described above.

Contact with recently sprayed vegetation was modeled using a 120 pound woman wearing shorts and a short-sleeved shirt exposed to recently sprayed vegetation for one hour, with effective washoff in 24 hours. This exposure scenario assumes the woman's arms, hands, lower legs, and feet are exposed and depends on estimates of dislodgeable residue (a measure of the amount of the chemical that could be released from the vegetation) and dermal transfer rates (i.e., the rate at which the chemical is transferred from the contaminated vegetation to the surface of the skin) (SERA 2011b). The SERA model assumes 10 percent of the deposited herbicide is dislodgeable and uses transfer rates derived in Durkin et al. (1995). Based on the SERA model the absorbed dose in this scenario would range from approximately 0.0010 to 0.0073 mg/kg-bw. See Appendix F, Figure 1 for model parameters and calculations.

Exposure to sprayed vegetation was modeled using a 120 pound woman who consumes 0.5 pounds of fruit shortly after application. Modeled herbicide residue rates on fruit are based on values reported in Fletcher et al. (1994) and are a function of application rate and the physical characteristics of the vegetation. Based on the SERA model the estimated dose in this scenario would range from approximately 0.0287 to 0.1345 mg/kg-bw. See Appendix F, Figure 2 for model parameters and calculations.

Risk Analysis: For the risk analysis dose levels estimated in the exposure analysis were compared to the toxic levels described in the hazard analysis. For acute health effects a hazard quotient is used to quantify the potential risk to the general public. This is accomplished by comparing the expected doses calculated in the exposure analysis to the reference dose (RfD) of glyphosate. A RfD represents an estimate of daily exposure that would not likely result in deleterious health effects over a lifetime. For glyphosate EPA has proposed a RfD of 2 mg/kg/day (EPA 1993). This value was derived by applying an uncertainty factor of 100 to definitive studies defining a NOAEL and then rounding to the nearest whole number (175 mg/kg/day/100 and rounded to nearest whole number = 2 mg/kg/day) (SERA 2011a).

A HQ was calculated for the two dose estimates by dividing the expected dose to the RfD (Table 1). Hazard Quotients that exceed one represent a potential risk of health effects (EPA 2011). Based on the HQ's reported in Table 1, the modeled scenarios pose little risk of acute or chronic effects to the general public. Additionally, the implicit assumptions in this assessment likely resulted in an overestimate of risk. For example, the risk assessment assumed the public would not avoid recently sprayed areas and that public has unrestricted access to these sites. Because

all sites occur on private or tribal lands where access is restricted these assumptions likely lead to an overestimate of risk. Also, under hot and arid conditions, such as those found along the Klamath and Scott rivers during summer months, plants sprayed with glyphosate would succumb quickly, often wilting within two or three days. Therefore, these plants would likely be avoided by fruit gatherers. Finally, comparing short-term duration exposures, such as those likely to be experienced by the public, to NOAELs derived from studies with longer exposures, tends to overestimate potential risk (Bakke 2000).

Table 1. Hazard quotients for two modeled glyphosate exposure scenarios using project specific parameters.

Exposure Scenario	**Upper Dose Estimate (mg/kg-bw)**	**RfD (mg/kg-bw)**	**HQ**
Contact with recently sprayed vegetation	0.0073	2	.0036
Eating 0.5 pounds of recently sprayed fruit	0.1345	2	0.0672

R-11

The primary active ingredient in R-11, nonylphenol polyethoxylate, readily degrades into NP which has been shown to affect liver, kidneys, growth rates in different mammal species, reproductive function in male rats, and weak estrogenic effects in female rats (de Jager et al. 1999; Laws et al. 2000; Environment Canada 2001; Nagao et al. 2000; EPA 2009). Based on liver and kidney affects and growth rates reported in these and other studies a NOAEL for chronic effects is assumed to be 10mg/kg-bw/day (Bakke 2003; EPA 2009). Two multigeneration studies of rats exposed to different levels of NPE found no indication of carcinogenesis (Chapin et al 1999; Nagao et al. 2000).

The NOAEL for R-11 from studies reported in this assessment are several times less than those reported for glyphosate and therefore, pose a more significant risk to human health. However, R-11 constitutes only 0.25 percent of the herbicide formulation to be used in this project. Using a similar scenario as for glyphosate, a 120 pound (54.43 kg) woman would have to consume 544 mg of NP/day to reach the NOAEL level. Given that R-11 constitutes only 0.25 percent of the herbicide formulation and assuming 20 percent of the herbicide formulation contacts edible non-target plants or fruits and there is no dissipation or degradation of the applied formulation, a 120 pound woman would have to consume all of the non-target vegetation and fruit on a 522ft^2 treatment area (See Appendix F Figure 3 for scenario calculations). Because treated areas would be small ranging from one to two plants up to 0.16 acres and are spread out over 60 river miles, some level of degradation would occur prior to the consumption of contaminated vegetation, and treated areas would occur on private lands that are not accessible to the general public, it is unlikely the general public would be exposed to amounts of R-11 that would represent a risk to health effects.

Cumulative Impacts

The majority of public lands along the Klamath and Scott rivers and in Quartz Valley are managed by the Klamath National Forest. The Klamath National Forest does not currently use herbicides to treat weeds on their property. Outside of the Quartz Valley herbicides are not used on tribal lands. Private landowners may use over-the-counter weed control that contains glyphosate to control weeds on their property. However, private lands within the Klamath and Scott river basins and Quartz Valley areas are rural and not densely populated, thus glyphosate use by private landowners is expected to be minimal. The SCDA has used glyphosate in the past to treat Leafy spurge. However, because glyphosate readily degrades in soil, has a short foliar half-life, and dissipates rapidly from natural water bodies, it does not readily accumulate in the environment. Therefore, the cumulative impacts of this project when added to other past, present, or reasonably foreseeable future actions are expected to be negligible.

Mixtures or combinations of herbicides and other chemicals can also have a joint action. Organophosphate herbicides such as glyphosate have been shown to express a synergistic effect, increasing the cumulative toxicologic impacts of the mixture (Laetz et al. 2009). Research also suggests that glyphosate and aquatic parasites may synergistically affect the development and survival of some freshwater fishes (Kelly et al. 2010). Due to the adsorptive characteristics of glyphosate, the topography and geology of the landscape where it is to be applied, and project best management practices that minimize drift, detectable levels of glyphosate and R-11 are not expected to be introduced into a fish bearing stream. Thus, no synergistic effects resulting from herbicide application in this project are expected to occur.

Environmental Justice

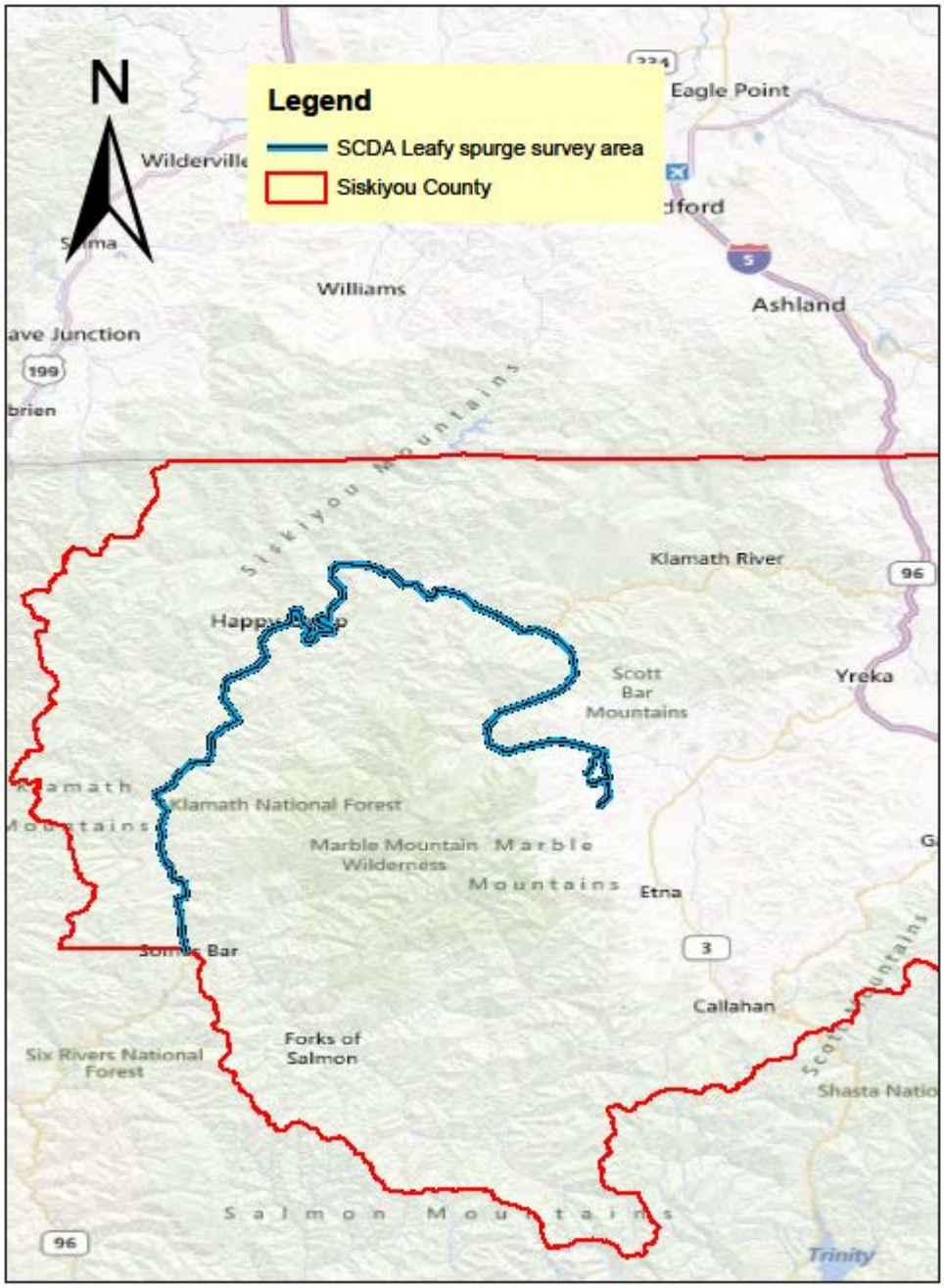
Executive Order 12898, relating to Environmental Justice, requires federal agencies to consider disproportionately high and adverse environmental effects on minority and low-income populations. Based on the analysis of environmental effects, the proposed alternatives are not expected to result in significant effects on human health or the environment. For these reasons the project does not appear to have a disproportionately high or adverse effect on minority or low-income populations. Therefore, no mitigation measures to ameliorate or offset adverse effects to these populations have been identified.

Summary Table of Alternatives

General	**Alternative 1**: No Action	**Alternative 2**: Manual Control	**Alternative 3**: Manual and Herbicide Control
Overall potential to meet purpose and need	Low	Low to Moderate	Moderate to High
Environmental consequences			
Impacts to soil quality	No direct impacts. Likely indirect	Likely but limited or short-term direct	Likely but limited or short-term direct

	impacts at sites where Leafy spurge is not treated.	impacts. No indirect impacts.	impacts from manual treatments. Likely but short-term or insignificant impacts from herbicide treatment
Impacts to botanical species	No direct impacts. Likely indirect impacts at sites where Leafy spurge is not treated.	Localized but no direct impacts to rare or endangered species from tarping. No indirect impacts.	Localized but no direct impacts to rare or endangered species from tarping. Unlikely or negligible direct impacts from herbicides.
Impacts to water quality	No direct impacts. Potential indirect impacts at sites where Leafy spurge is not treated.	No direct impacts. Potential short-term indirect impacts from hand pulling and digging.	Potential short-term indirect impacts from hand pulling and digging. Unlikely direct or indirect impacts from herbicides.
Fish and wildlife	No direct impacts. Likely indirect impacts at sites where Leafy spurge is not treated.	No direct impacts. Likely but limited or short-term indirect impacts from hand pulling and digging. .	No direct impacts to fish or other aquatic species. Likely but limited or short-term indirect impacts from manual treatments. Unlikely indirect impacts to fish or other aquatic species from herbicides. Unlikely or negligible direct or indirect impacts to terrestrial wildlife from herbicides.
Human health and safety	No impact.	Low potential for worker injury.	Low potential for worker injury. Very low potential for public exposure.

Map 1. General area surveyed by the Siskiyou County Department of Agriculture for Leafy spurge in 2010 and 2011. Proposed treatment areas within the surveyed area include only private lands and tribal lands within the Quartz Valley.



Appendices

Appendix A. Results and assumptions for the DRIFTSIM modeling exercise simulating potential herbicide drift using project best management practices.

Herbicide drift is the movement of a spray solution from the intended target to a place where it is not wanted. Although complete elimination of spray drift is impossible, drift can be minimized if herbicides are applied with the proper equipment and methods under favorable weather conditions. Factors that significantly influence off-target movement of droplets are wind velocity, turbulence, and direction; droplet size, density and velocity; distance from the spray nozzle to the target plant; relative humidity; and ambient temperature (Dexter 1993; Zhu et al. 1995a). To minimize drift in this project herbicide application would occur only at low nozzle pressure ($\leq$ 20 PSI) and within 2.5 feet of the ground and application would be halted when wind speeds exceed five miles per hour (mph).

For this project, DRIFTSIM, a computer model developed by agricultural engineers from Ohio State University and the U. S. Department of Agriculture, was used to estimate the amount of herbicide that potentially could drift from the intended target plant to water. DRIFTSIM was developed from a large data base of empirical drift distances and uses six major drift-causing factors to estimate mean drift distances (Zhu et al. 1995b). The factors used in DRIFTSIM and the project specific units of measure are listed in Table 1. Air turbulence can vary considerably in field conditions. Based on the frequency of turbulence intensity observed in many of field measurements, a constant value of 20 percent turbulence intensity is used in DRIFTSIM for all calculations (Zhu et al. 1995b).

Table 1. Factors and their units of measure used in DRIFTSIM. Wind velocity is set at 5 mph as specified in project best management practices. Weather data is set to conservatively estimate drift and herbicide application data is from the SCDA. Droplet velocity is generated within the model and is a function of droplet size and discharge height.

Factor	Unit Measure
Wind Velocity	5 mph
Droplet Size	294 Microns (µm)
Droplet Velocity	44.7 mph
Discharge Height	2.5 ft
Temperature	85 F^o
Relative Humidity	10 %

Results of the DRIFTSIM model using the units of measure displayed in Table 1 indicate that herbicides applied with a backback sprayer would drift less than one foot (DRIFTSIM result = 0.52 feet) during application with 5 mph winds.

Appendix B. Siskiyou County Department of Agriculture Noxious Weed Consent Agreement.

SISKIYOU COUNTY DEPARTMENT OF AGRICULTURE
Noxious Weed Consent Agreement

This Consent/Agreement is made and entered into between the Siskiyou County Agricultural Commissioner (hereinafter designated collectively as "Commissioner") and _____,
(please check one) ☐ Owner/Operator or ☐ Lease/Renter (hereinafter designated as "Cooperator").

Consent is hereby given by the Cooperator to the Commissioner, agents, employees and contract crew to enter upon the following described premises owned or controlled by the Cooperator for the purpose of surveying and treating described lands for the control of targeted noxious weeds. Such premises being more particularly described as follows (please print all information except signature):

Property Name _____ Property Address _____ City _____

Property Description (if property address does not give adequate property location or property does not have an address) _____

Name: ☐ Owner/Operator or ☐ Lease/Renter _____ Address (if different than property address) _____ City _____

Phone # (Daytime) _____ Is the property access locked? ☐ Yes, ☐ No. _____
(if yes, please provide a key or appropriate property access information)

Request contact prior to entering property: ☐ Yes, ☐ No. _____
(if yes, please provide name and daytime phone number of person to contact, if other than above name and phone number)

In accordance with the provisions of Chapter 6 of Division 4, commencing with Section 5401, of the Food and Agricultural Code of the State of California, it remains the landowner's responsibility to eradicate the noxious weeds on said property. This agreement shall in no way affect or eliminate cooperator's obligations pursuant to law including, but not limited to, the obligation to maintain and to remove such weeds. All noxious weed pest control operations conducted by the Commissioner pursuant to this agreement shall be under the sole direction of Commissioner. Commissioner will furnish the necessary materials and/or control methods and provide supervision for said operations at no cost to the undersigned Cooperator.

In consideration whereof Cooperator agrees:
1. That the Siskiyou County Agricultural Commissioner shall be allowed at all reasonable times to carry out all necessary and reasonable measures for the purpose of eradication of noxious weeds and to perform such acts as may seem necessary and proper to assist in this effort.
2. To release, indemnify, defend and save harmless the county of Siskiyou, its officers, agents and employees from any and all claims, expenses, causes of relating to or arising out of the activities performed pursuant to this agreement.
3. To notify all other parties on said property that the Commissioner will be entering said property for the purpose of weed survey and eradication and that future property entrance shall continue in effect for as long as targeted noxious weeds are on or are potentially on said premises.

This request and consent may be canceled by the undersigned property owner at any time hereafter upon giving two (2) days notice in writing, delivered to the Siskiyou County Agricultural Commissioner, 525 South Foothill Drive, Yreka, California 96097. Furthermore, Commissioner may terminate this agreement immediately upon oral notice should funding cease or be materially decreased.

_____ _____
Cooperator Signature (if different from above printed names, please add printed name to signature, plus phone number) Date
☐ Verbal consent of cooperator (check this box if received verbal consent in lue of a signature, date above is date consent was given).

By: _____ _____ _____
Agricultural Commissioner or agent signature Print Name Date

Target species: _____ Area: _____

Information supplied to Cooperator (check all that apply): ☐ Flyer (species information), ☐ Herbicide product label(s),
☐ Species and product information verbally discussed with Cooperator. Additional comments: _____

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Appendix C. Results and assumptions for the GLEAMS modeling exercise simulating a worst case scenario following an herbicide treatment.

Table 1. Result of GLEAMS model for herbicide losses due to runoff, sediment, and percolation following a three inch rainfall occurring on the same day two acres of Leafy spurge were treated with the herbicide glyphosate.

Pesticide Losses						
Herbicide	Runoff		Sediment		Percolation	
Glyphosate	G/HA	% App.	G/HA	% App	G/HA	%App
	0.0000	0.00	0.0000	0.00	0.0000	0.00

Model assumptions

This modeling exercise simulated a summer thunderstorm that deposited three inches of rain on the same day two acres of Leafy spurge we treated with an herbicide containing glyphosate. The GLEAMS model requires the input of four categories of parameters; climate, pesticide, hydrology, and erosion, to estimate the amount of herbicide lost from runoff and sediment following a rainfall event. Listed below are the key assumptions made for each of these categories.

Climate Parameters: The precipitation data file consisted of a single, three inch rainfall occurring on 8/1/2011.

Pesticide (Glyphosate) Parameters:

Water solubility: 500,000 mg/L (based on Messersmith 2007).

Foliar half-life: 10 days (median values from Mortensen et al. 2008 and Newton et al. 1984).

Herbicide residue: 0 (Due to short foliar and soil half-lives it was assumed that there was no herbicide residue present from any previous applications when simulation begins).

Fraction of pesticide applied to foliage: 0.8 (fraction of herbicide estimated to come in contact with Leafy spurge during application; from J. Aceves pers.comm).

Fraction of pesticide applied to soil: 0.2 (fraction of herbicide that does not come in contact with Leafy spurge during application).

Application rate: 4lbs active ingredient per acre (maximum application rate under EPA approved label).

Hydrology Parameters:

Drainage area: 2 acres (For this simulation the area treated with herbicides consisted of a 25 foot wide strip totaling 2 acres and represents the maximum number of acres that could be treated in a day. The drainage area for this simulation was synonymous with and included only the two acres treated with herbicides).

Fraction of plant available water when simulation begins: .5 (model range 0 = dry wilting point and 1 = wet to field capacity; assumed that riparian areas in mid-summer would have median value between fully wetted and wilting point).

Slope of drainage area: 20 percent

Longest flow path in drainage area: 25 feet

Organic matter content of soil: 2 percent of soil mass

Soil porosity (ratio of pore space per unit volume of soil): .4 in^3/in^3 (model range for hydrologic soil group A = 0.30 to 0.50).

Field capacity of soil horizon (water retention value): 0.11 in/in (model range 0.11 for coarse sandy soils to 0.40 for silty clay soils).

<u>Erosion Parameters</u>:

Specific surface area for clay particles: $400m^2g$ (model range 20 to 800).

Soil loss ratio for overland flow profile segment: 0.4 (model range 0.01 for bare soil to 1 for dense vegetation cover; assumed moderate vegetation cover for this simulation).

Hydraulic roughness: 0.05 (model range 0.01 to 0.4; assumed moderate vegetation cover for this simulation).

Appendix D. Assumptions and calculations used to estimate the amount of glyphosate and R-11 transported to the Klamath and Scott rivers in decaying vegetation during high water events.

This scenario assumes two acres of treated vegetation is transported during a high water event and collects in one discrete area in the Klamath and Scott rivers two months (60 days) after a treatment and that all glyphosate residues were extracted and they diluted uniformly over the first two hours after they entered the rivers. High water events were modeled at 1,000 ft^3/sec discharge for the Scott River and 3,000ft^3/sec discharge for the Klamath River which corresponds to the average early to mid-December flows for these rivers.

Assumptions and calculations

Glyphosate

4.30 lbs of glyphosate (2.15 lbs/acre) is applied to two acres of vegetation.

50 percent of the applied glyphosate is translocated to the roots of the vegetation (based on Lym 2000) where it is not susceptible to high water events, leaving 2.15 lbs in above ground vegetation.

Assuming a 10 day half-life (median values from Mortensen et al. 2008; Newton et al. 1984; Feng and Thompson 1990), there would be 0.0336 lbs (15,240 mg) in above ground vegetation at the time of the high water event.

High water flows for the Scott River = 1,000 ft^3/sec x 60 = 6,000 ft^3/min x 60 = 3,600,000 ft^3/hour x 2 = 7,200,000ft^3/2 hours = 203,881,320 liters15,240 mg/203,881,320 liters = 0.00007mg/L of glyphosate

High water flows for the Klamath River = 3,000 ft^3/sec x 60 = 1,080,000 ft^3/min x 60 = 64,800,000 ft^3/hour x 2 = 129,600,000ft^3/2 hours = 3,669,863,760 liters

15,240 mg/3,669,863,760 liters = 0.000004 mg/L of glyphosate

EPA's minimum detection limit for glyphosate = 0.006 mg/L

These estimates are likely an overestimate of the amount of glyphosate potentially transported to the Scott and Klamath Rivers in decaying vegetation during high flow events because the high water flows used in these calculations approximates the average early winter flows in these systems. Flows necessary to transport decaying vegetation into these rivers would likely occur at significantly greater than average rates. Additionally, based on research by Rampoldi et al. (2011), it is likely that some percentage of the glyphosate residue on decaying vegetation would not be extracted by water.

R-11

1 lbs of R-11 (8oz/acre) is applied to two acres of vegetation.

Assuming a 6 day half-life on foliage (from Sundaram et al. 1980), there would be 0.00098 lbs (444.52 mg) in above ground vegetation at the time of the high water event.

High water flows for the Scott River = 1,000 ft^3/sec x 60 = 6,000 ft^3/min x 60 = 3,600,000 ft^3/hour x 2 = 7,200,000ft^3/2 hours = 203,881,320 liters

444.5 mg/203,881,320 liters = 0.000002mg/L of NP

High water flows for the Klamath River = 3,000 ft^3/sec x 60 = 1,080,000 ft^3/min x 60 = 64,800,000 ft^3/hour x 2 = 129,600,000ft^3/2 hours = 3,669,863,760 liters

444.5 mg/3,669,863,760 liters = 0.0000001 mg/L of NP

Minimum detection limits used by other researchers (Sundaram et al. 1980; Trumbo 2005) = 0.0002 mg/L

Appendix E. Tables depicting the toxicity of glyphosate and R-11 to aquatic and avian species.

Table 1. Observed 96-hour LC_{50} values for glyphosate at different dilutions[1]

Fish species	Water pH 6.3	pH 7.2	pH 8.2
Coho salmon (*Oncorhyncus kisutch*)	27 mg a.e./L[3]	36 mg a.e./L	210 mg a.e./L
Chinook Salmon (*Oncorhyncus tshawytscha)*	19 mg a.e./L	30 mg a.e./L	211 mg a.e./L
Rainbow trout (*Oncorhyncus mykiss*)	10 mg a.e./L	22 mg a.e./L	220 mg a.e./L
Bluegill sunfish (*Lapomis macrochirus*)	Average 99.6; Range 92-107 mg/L (pH unknown)[2]		

[1]Data from Wan et al. 1989.

[2] SERA 2010.

[3] Acid equivalent per liter.

Table 2. EPA glyphosate toxicity classifications for aquatic and avian species (from Giesy et al. 2000).

U.S. EPA toxicity classification	Acute aquatic LC_{50} or EC_{50}[1] (mg/L)	Avian dietary LC_{50} (mg/kg)
Practically nontoxic	>100	>5000
Slightly toxic	>10, ≤ 100	>1000,≤5000
Moderately toxic	>1, ≤10	>500,≤1000
Highly toxic	≥0.1, ≤1	.50,≤500
Very highly toxic	≤0.1	<50

[1]Concentration which induces a response halfway between the baseline and maximum.

Table 3. Observed 48- and 96-hour EC_{50} and LC50 values for other aquatic species exposed to glyphosate.

Species	Exposure	Acid/salt	Response
Mussel (*Lampsilis siliquoidea*)[1]	48 hours 96 hours	Glyphosate salt >95% purity	EC_{50} Larvae 5.0 mg a.e/L Juvenile 7.2 mg a.e/L
Mussel (*Lampsilis siliquoidea*)[1]	48 hours 96 hours	Technical grade glyphosate acid 98% purity	EC_{50} Larvae >200 mg a.e/L Juvenile >200 mg a.e/L
Crustacean (*Daphnia magna*)[2]	48 hours	Glyphosate acid 95.6 %	Average 128; Range 95-172 mg/L
Crustacean (*Daphnia magna*)[2]	48 hours	Glyphosate acid 83 %	Average 647; Range 577-725 mg/L
Midge (*Chironomous plumosus*)[3]	48 hours	Glyphosate acid	EC_{50} Average 55; Range 31-97 mg/L
Tadpoles (*Litoria*	48 hours	Glyphosate acid	LC_{50} Average 81;

moorei)[4]			Range 76-86 ma a.e./L in deionized water Average 121; Range 111-133 mg a.e./L in lake water
Tadpoles (*Litoria moorei* and *Lymnodynastes dorsalis*)[4]	48 hours	Glyphosate salt	LC_{50} >343 mg a.e./L
Sign-bearing froglet (*Crinia insignifera*)[4]	48 hours	Glyphosate acid	LC_{50} Average 83; Range 67-103 mg a.e./L in deionized water
Green frog (*Rana clamitans*)[5]	96 hours	Glyphosate salt	LC_{50} >17.9 mg a.e./L

[1]Data from Bringolf et al. 2007.

[2]Data from SERA 2011a.

[3]Data from Folmar et al. 1979.

[4]Data from Mann and Bidwell 1999.

[5]Data from Howe et al. 2004.

Table 4. Observed 48- and 96-hour LC_{50} values for aquatic species exposed to R-11.

Species	Exposure	Response
Rainbow trout[1] (*Oncorhyncus mykiss*)	96 hours	3.8 mg/L
Juvenile rainbow trout[3] (*Oncorhyncus mykiss*)	96 hours	5.2 to 6.6 mg/L
Bluegill sunfish[1] (*Lapomis macrochirus*)	96 hours	4.2 mg/L
Daphnia magna[1]	48 hours	19 mg/L
Fathead minnow[2] (*Pimephalus promelas*)	96 hours	5.7mg/L
Sacramento splittail[2] (*Pogonichthys macrolepidotus*)	96 hours	3.9 mg/L
Ceriodaphnia dubia[2]	96 hours	5.7 mg/L

[1] Data from Harman 1995, cited in SERA 2010.

[2] Data from Trumbo 2005.

[3]Data from Curran et al. 2004.

Table 5. Avian acute toxicity for glyphosate[1].

Species	% active ingredient	LD_{50}/LC_{50} (mg a.e/kg or ppm a.e.)
Bobwhite quail (*Colinus virginianus*)	83	LD_{50} >3196 mg a.e./kg body weight
Bobwhite quail (*Colinus virginianus*)	98.5	LC_{50} >4570 ppm
Mallard duck (*Anas platyrhychos*)	98.5	LC_{50} >4570 ppm
Mallard duck (*Anas platyrhychos*)	95.6	LC_{50} >4971

[1] Data from EPA 2008.

Appendix F. Human health and safety exposure analysis model calculations.

Figure 1. Parameter assumptions and results from the Syracuse Environmental Research Associates Inc. risk assessment model for contact with recently sprayed vegetation using a 120 pound woman wearing shorts and a short-sleeved shirt exposed to recently sprayed vegetation for one hour, with effective washoff in 24 hours.

Parameter/Assumption	Code / Range	Equation/ Value	Units	Reference/Designation
Application Rate (lbs/acre)	**ApRt**	**2.15**	lb/acre	Set scenario parameter
Conversion Factor	**CnvF**	11.21	ug/cm^2/lb/acre	
Metric Application Rate (ug/cm^2)	**ApR_m**	***ApR × CnvF***		
		24.1015	ug/cm^2	
Surface Area	**SA**	**5761**	cm^2	EPA 1992 table 8-3
Contact Time	**Tc**	1	Hours	Set scenario parameter
Exposure Time	**Te**	24	Hours	Set scenario parameter
Body weight (W)	**BW**	**54.43**	Kg	Set scenario parameter
Proportion Dislodgeable	**PropDr**			
	Central	**0.1**	proportion	Set scenario parameter
	Lower	**0.1**		Set scenario parameter
	Upper	**0.1**		Set scenario parameter
Dislodgeable Residue	**Dr**	***ApR_m × PropDr***		
	Central	*2.41015*	ug/cm^2	
	Lower	*2.41015*		
	Upper	*2.41015*		
Transfer Rate	**Tr**	$10^{(1.09\times Log10(Dr)+0.05)}$ / 1000 µg/mg)		
	Central	*0.002927036*	mg/(cm^2 hr)	Derived from Durkin et al. 1995
	Lower	*0.002927036*		
	Upper	*0.002927036*		
Toxic Equivalency Factor for formulation:	**TEF**			Derived from Risk Assessments completed for the Forest Service by SERA
	Central	**1**	Unitless	
	Lower	**1**		
	Upper	**1**		
Amount Transferred to Skin Surface	**Amnt**	***SA × Tr × Tc x TEF***		
	Central	*16.86265343*	Mg	
	Lower	*16.86265343*		
	Upper	*16.86265343*		
First-order dermal absorption rates	**Ka**			
	Central	**0.00041**	hour-1	Derived from Wester et al. 1991
	Lower	**0.00013**		
	Upper	**0.001**		
Proportion absorbed	**Prop**	**1-exp(-ka Te)**		

over exposure period, Te	Central	*0.009791746*	hour-1
	Lower	*0.003115138*	
	Upper	*0.02371429*	
Absorbed Dose	**Dose**	**Amnt × Prop ÷ BW**	
	Central	*0.003115138*	mg/kg bw
	Lower	*0.000965083*	
	Upper	*0.007346791*	

Figure 2. Parameter assumptions and results from the Syracuse Environmental Research Associates Inc. risk assessment model for exposure to sprayed vegetation using a 120 pound woman who consumes 0.5 pounds of fruit shortly after application.

Parameter/Assumption	Code / Range	Equation/ Value	Units	Reference/Designation
Application Information				
Application Rate (lbs/acre)	**ApRt**	**2.15**	lb/acre	Set scenario parameter
Number of applications	**N**	**1**	unitless	Set scenario parameter
Interval between applications	**intv**	**1**	days	Set scenario parameter
Special Adjustments (See Note 1)				
Metabolite Adjustment Factor :	**MetFact**			
	Central	1	unitless	Default
	Lower	1		Default
	Upper	1		Default
Toxic Equivalency Factor for formulation:	**TEF**			
	Central	**1**	Unitless	Derived from Risk Assessments completed for the Forest Service by SERA
	Lower	**1**		
	Upper	**1**		
Acute Concentrations				
Residue Rates	**Rr**			
	Central	**7**	mg/kg food per lb/acre	Derived from Fletcher et al. 1994.
	Lower	**3.2**		
	Upper	**15**		
Drift	**Drift**			
	Central	**1**	proportion	Derived from Fletcher et al. 1996
	Lower	**1**		
	Upper	**1**		
Concentration on commodity immediately after first application.	C_0	***ApR × rr × Drift × MetFact × TEF***		
	Central	*15.05*		
	Lower	*6.88*		
	Upper	*32.25*		
Half-life on commodity	**Halflife**			
	Central	**10**	Days	Derived from Feng and Thompson 1990; Newton et al. 1984)
	Lower	**10**		
	Upper	**10**		
Decay Coefficient[1]	**K**	***Ln(2)/Halflife***		
	Central	*0.069314718*	$Days^{-1}$	
	Upper	*0.069314718*		
	Lower	*0.069314718*		
Proportion remaining at end of each application interval	**P**	***exp(-k × intv)***		
	Central	*0.933032992*	proportion	
	Lower	*0.933032992*		

	Upper	*0.933032992*	
Concentration on commodity immediately after last application.	**C_n**	***$C_n = C_0 \times (1- p^n) \div (1- p)$***	
	Central	*15.05*	mg/kg food item
	Lower	*6.88*	
	Upper	*32.25*	
Receptor			
Amount consumed per day per unit body weight	**Amnt**		
	Central	**0.00417**	kg food/kg BW per day
	Lower	**0.00417**	
	Upper	**0.00417**	
Estimate			
Dose	**Dose**	***Conc × Amnt***	
	Central	*0.0627585*	mg/kg bw
	Lower	*0.0286896*	
	Upper	*0.1344825*	

[1]The lower bound of the half-life is used to calculate the upper bound of k and the upper bound of the half-life is used to calculate the lower bound of k

Figure 3. Calculations for assessing exposure of R-11 to the general public.

R-11 would be applied at a rate of 8 ounces per acre. This equals 226,796 mg/acre.

Assuming 20 percent of the herbicide formulation contacts non-target vegetation, this equals 45,359 mg/acre of R-11on non-target vegetation.

544 mg (the NOAEL for NP) is 1.2 percent of 45,359 mg.

1.2 percent of an acre = 522 ft^2

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