Umatilla National Forest
North Fork John Day Ranger District
South Tower Fire Recovery Assessment

COMPETING VEGETATION ANALYSIS

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Introduction

Fire is a native ecological process affecting forests of the Interior Columbia Basin (Quigley and Arbelbide 1997). For at least the last several thousand years, it has been the principal initiator of plant succession in the Inland West (Stickney 1990). The severity of burning in these forests varies from light ground fires to severe, stand-replacing crown fires (TFEA 1997). Holocaustic fire (stand-replacing crown fire) represents one of the most severe disturbance events that a forest ecosystem ever experiences (Stickney 1990, TFEA 1997).

A holocaustic fire is one that: 1) kills the coniferous tree overstory, 2) reduces the tree-shrub understory and herb layers to ground level, and 3) consumes all of the dead organic material on the forest floor clear down to the mineral soil surface. Although holocaustic fire incinerates the above-ground portion of the forest community, the below-ground portion can remain intact and essentially undisturbed. Plants that compose the initial community following a holocaustic wildfire have been classified as survivors, residual colonizers, and offsite colonizers (Stickney 1990).

Survivor plants recover rapidly because they can sprout from underground organs such as rhizomes, root crowns or caudexes. Residual colonizers arise from seed stored in the lower duff, upper soil, and other onsite sources in the burned areas. Offsite colonizers also originate from seed, but from sources located outside the burned area. Survivors and residual colonizers are often best equipped to capitalize on the environmental conditions created by a holocaustic wildfire. Offsite colonizers may also be successful, but only if their seed is small, light weight, and capable of being carried on the wind for great distances.

In the Tower wildfire, many of the conifers found in the pre-burn forests were offsite colonizers. Since most of them were killed in the moderate and high intensity burns, and since the seeds of surviving trees are generally not small or dispersed by the wind for great distances, many decades will pass before conifers recover unless we decide to intervene by planting them (TFEA 1997). If tree planting is not implemented promptly, certain shrub and herb species may respond so aggressively that they interfere with the purpose and need to reforest the fire area with an ecologically appropriate mix of tree species.

Objectives of a Competing Vegetation Analysis

The objective of a competing vegetation analysis is to identify those reforestation units where survival of tree seedlings might be compromised by the presence of highly competitive shrubs and herbs, and then to propose control strategies that would minimize treatment costs and mitigate potential impacts on the environment and human safety. For the South Tower area, competing vegetation was analyzed using a 9-step process (Figure 1).

A vegetation management plan (VMP), which discloses the results of the competing vegetation analysis, was prepared in accordance with the Final Environmental Impact Statement for Managing Competing and Unwanted Vegetation (USDA Forest Service 1988) and its associated Mediated Agreement (US District Court 1989). The vegetation management plan is a site-specific analysis of the competing vegetation treatments that may occur in the project area – it is included at the end of this report as Table 9.

Table 9, the vegetation management plan, shows the most efficacious treatment method for control of competing vegetation in 151 reforestation units totaling 6,120 acres (uplands only). For the 57 reforestation units where application of an herbicide is the preferred treatment (a total of 2,530 upland acres), a second treatment option is also provided in the VMP – it would be implemented if the decision-maker selects a South Tower environmental assessment alternative that precludes use of herbicides (such as alternatives 3 or 4). Other factors could influence a decision about whether or not to treat competing vegetation, even in situations where an established threshold would be exceeded.

The Analysis Context for Reforestation. The National Forest Management Act of 1976 (NFMA), as implemented by the Code of Federal Regulations, states that “when trees are cut to achieve timber production objectives, the cuttings shall be made in such a way as to assure that the technology and knowledge exists to adequately restock the lands within 5 years after final harvest” (36 CFR 219.27(c)(3)).

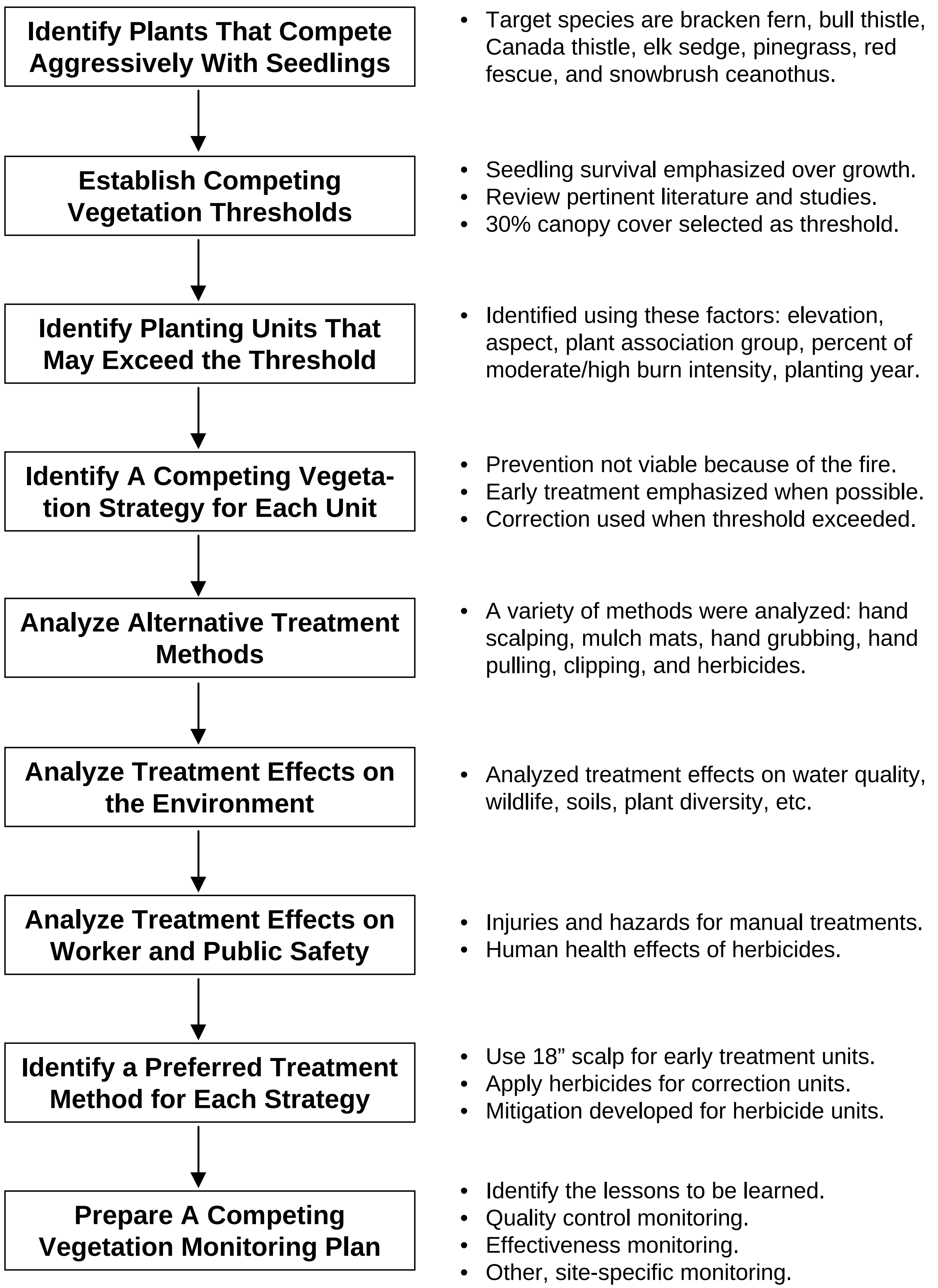

Figure 1 – Process used to analyze competing vegetation for the South Tower project area.

In the South Tower area, a reforestation need was created by wildfire rather than timber harvest because all of the trees being removed in salvage units were killed by fire, or by insects that attack and kill fire-damaged trees. Even though fire killed the trees, the Forest Service is still required to reforest salvage units within 5 years. The only exception is salvage on unsuitable lands, since those areas do not have a 'timber production objective' as established by the Umatilla National Forest's Land and Resource Management Plan (USDA Forest Service 1990).

For burned areas where the fire-killed trees are not salvaged, NFMA does not require that reforestation occur, whether within a 5-year timeframe or at all. Even so, the Forest Service is still interested in reforesting many of those areas promptly, particularly when tree planting could attain a desired future condition more quickly than waiting for natural plant succession to restore a forested condition. The objective of tree planting, competing vegetation treatments, animal damage control, and other connected activities is to successfully reforest the moderate- and high-intensity burns located within the South Tower area.

The Analysis Context for Control of Competing Vegetation. The Big Tower project made a decision to plant "native trees, shrubs and other vegetation within 8,700 acres of the Tower fire area" (USDA Forest Service 1997b). Those acres are also included in the South Tower area. However, the Big Tower environmental assessment did not include a competing vegetation analysis, primarily because reforestation (and connected actions) was considered to be a restoration activity and it was assumed that restoration projects would be analyzed in the South Tower Fire Recovery Projects Environmental Assessment.

It is important to emphasize that control of competing vegetation is not a separate management objective. There is no desire to eradicate vegetation in the South Tower project area, particularly since vegetation stabilizes soil and impedes erosion, provides ungulate forage and wildlife habitat, and contributes to a pleasant environment in which to recreate. If certain shrubs and herbs occur near conifer seedlings, the result is problematic only if they interfere with meeting goals and objectives, the purpose and need of this project, or a desired future condition established by the Forest's Land and Resource Management Plan (USDA Forest Service 1990).

Hundreds of studies have shown that competition between plants for sunlight, nutrients, and soil moisture can result in reduced survival of tree seedlings (Stewart and others 1984). Early-seral plants have the capability to rapidly colonize the open sites created by wildfire or another disturbance. They seed in or sprout from existing roots to completely occupy the site, and their rapid growth produces crown and root volumes that greatly exceed that of young conifers. Competition is particularly intense when the seedlings are small because at that stage, the shrubs, herbs, and trees share the same soil layers and compete for the same soil moisture.

Plants With High Risk of Competing Aggressively With Planted Seedlings

Table 1 provides information about the fire response mode and seedling competition risk associated with 27 shrubs and herbs commonly found in the moderate- or high-intensity burns of the South Tower project area. Seven of those plants pose a high risk of competing aggressively with planted conifer seedlings and are collectively referred to as 'competing vegetation.' Additional information about each of those species is provided below.

Bracken fern *(Pteridium aquilinum)* is considered to be the most widely distributed vascular plant species in the world. It is a large, stout fern with triangular-shaped fronds up to four feet tall. Although commonly found on toe slopes and other moist topography, bracken quickly expands onto dryer upland sites following disturbance by fire, timber harvesting, or livestock grazing. In fact, Native Americans used fire as a tool to maintain bracken glades on Puget Sound's Whidbey Island (Robbins and Wolf 1994).

Although windborne spores can spread bracken over long distances, the most common reproductive method involves expansion of its underground rhizomes. Spore-based regeneration is rare because the spores require nearly sterile soil conditions in which to germinate (Ferguson and Boyd 1988, Haeussler and Coates 1986). However, an intense wildfire that consumes the litter and duff layers and sterilizes the upper mineral soil would readily provide those conditions (Haeussler and Coates 1986).

Table 1: Fire response mode and seedling competition risk ratings for post-fire shrubs and herbs found abundantly in the moderate or high intensity forest burns, South Tower area

PLANT SPECIES	FIRE RESPONSE MODE	SEEDLING COMPETITION RISK
Bracken Fern *(Pteridium aquilinum)*	Survivor	High
Bull Thistle *(Cirsium vulgare)*	Offsite Colonizer	High
Canada Thistle *(Cirsium arvense)*	Survivor	High
Chokecherry *(Prunus virginiana)*	Survivor	Low
Common Snowberry *(Symphoricarpos albus)*	Survivor	Moderate
Dandelion *(Taraxacum officinale)*	Offsite Colonizer	Low
Dogbane *(Apocynum androsaemifolium)*	Survivor	Low
Dwarf Rose *(Rosa gymnocarpa)*	Survivor	Low
Elk Sedge *(Carex geyeri)*	Survivor	High
Fireweed *(Epilobium angustifolium)*	Offsite Colonizer	Moderate
Heartleaf Arnica *(Arnica cordifolia)*	Survivor	Low
Kinnikinnick *(Arctostaphylos uva-ursi)*	Survivor	Moderate
Low Oregongrape *(Mahonia repens)*	Survivor	Moderate
Miners Lettuce *(Claytonia perfoliata)*	Residual Colonizer	Low
Northwestern Sedge *(Carex concinnoides)*	Survivor	Moderate
Oregon Boxwood *(Paxistima myrsinites)*	Survivor	Low
Pearly Everlasting *(Anaphalis margaritacea)*	Offsite Colonizer	Low
Pinegrass *(Calamagrostis rubescens)*	Survivor	High
Red Fescue *(Festuca rubra)*	Survivor	High
Scouler Willow *(Salix scouleriana)*	Residual Colonizer	Moderate
Showy Aster *(Aster conspicuus)*	Survivor	Low
Snowbrush Ceanothus *(Ceanothus velutinus)*	Residual Colonizer	High
Tailcup Lupine *(Lupinus caudatus)*	Residual Colonizer	Low
Western Hawkweed *(Hieracium albertinum)*	Offsite Colonizer	Low
Western Yarrow *(Achillea millefolium)*	Offsite Colonizer	Low
White Spirea *(Spiraea betulifolia)*	Survivor	Low
Woods Strawberry *(Fragaria vesca)*	Survivor	Low

Sources/Notes: 'plant species' were those observed to be the most abundant in moderate- and high-intensity burn areas; 'fire response mode' assignments were based on Stickney 1990, TFEA 1997, and other sources; 'seedling competition risk' ratings were based on local experience. Some species have several fire response modes, in which case the predominant one is shown above. Species with a high competition risk are capable of killing conifer seedlings; species with a moderate risk may cause limited seedling mortality, but more commonly cause substantial growth losses; plants with a low risk cause limited growth losses and no seedling mortality. Note that other highly-competitive plants exist in the Tower fire area, such as smooth brome, red top, and Kentucky bluegrass (TFEA 1997), but were not observed to be abundant at this time.

In situations where bracken fern dominates the post-fire herbaceous community, it has been able to retard or exclude all forest regeneration (McMinn 1951). Once established, bracken remains dominant because it is unpalatable to livestock, it has chemical defenses against insects, it possesses a tremendous capacity to sprout following disturbance, and it produces phytotoxins that suppress competitors. Bracken kills conifers just after they germinate; as the germinant's radicle penetrates the upper soil surface, it quickly encounters phytotoxins that have accumulated there over time (Ferguson and Boyd 1988).

There is a high risk that bracken will compete aggressively with conifer seedlings for moisture, nutrients, and sunlight (see Table 1). Studies in British Columbia showed that bracken 'consumes' an average of 80% of the site resources that are needed for survival and growth of conifer seedlings (Burton 1996). It can also influence seedlings and other plants by smothering them with senescing fronds, and by producing phytotoxins that chemically inhibit their germination, survival, or growth (allelopathy). Bracken has a cumulative toxic effect on livestock and has also been linked to cancer in humans (Ferguson and Boyd 1988, Haeussler and Coates 1986).

Grasses and Sedges. Pinegrass (*Calamagrostis rubescens*) and elk sedge *(Carex geyeri)* are common on dryer sites where the potential natural vegetation will be dominated by subalpine fir (ABLA2/CAGE and ABLA2/CARU plant associations), lodgepole pine (PICO/CARU plant association), grand fir (ABGR/CAGE and ABGR/CARU plant associations), Douglas-fir (PSME/CAGE and PSME/CARU plant associations) or ponderosa pine (PIPO/CAGE and PIPO/CARU plant associations)(Johnson and Clausnitzer 1992). They are quite shade tolerant, persisting throughout all successional stages (Clausnitzer 1993).

In the undergrowth of forest stands, pinegrass and elk sedge tend to form a loose, open turf connected by a system of creeping rootstocks or rhizomes. The root system quickly develops into a continuous grass sod after logging, wildfire, or another disturbance that opens the canopy substantially (Coates and others 1990, Hermann 1970). Pinegrass competes effectively with conifers because of its rapid growth in early spring when soil moisture is abundant. It can also tolerate low plant water potentials while maintaining a high transpiration rate – pinegrass loses at least twice as much water per unit of foliage as Douglas-fir. This suggests that pinegrass handles drought better than conifers (Nicholson 1989).

When a forest canopy is opened by wildfire or another disturbance, elk sedge, pinegrass, and red fescue *(Festuca rubra)* respond to the increased sunlight by flowering profusely. They spread quickly when abundant seed production coincides with sprouting from roots and rhizomes that survived the fire. In particular, elk sedge is a fibrous-rooted species with a huge root mass that penetrates the soil to a greater depth than its graminoid and forb associates (Figure 2).

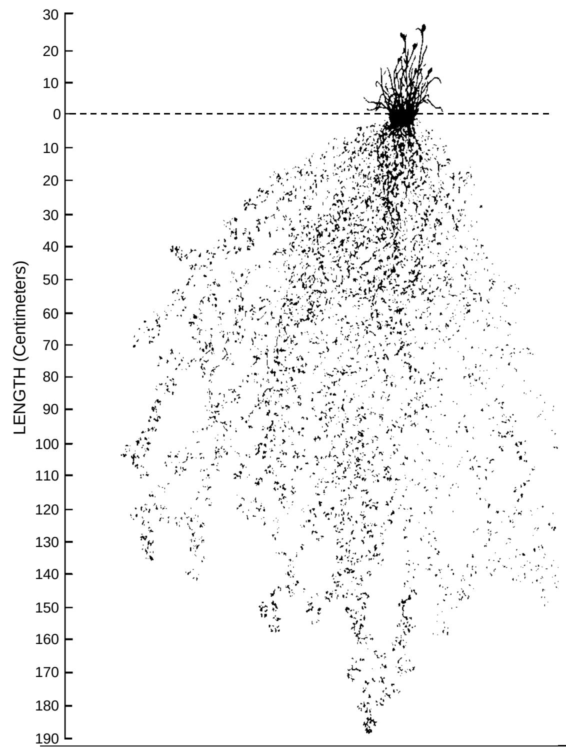

Figure 2 – Elk sedge has a fibrous root system that occupies an enormous volume of soil. This plant is 12” tall and 10” wide, but its roots spread 56” wide and 75” deep (reproduced from Sloan and Ryker 1986).

Sites dominated by pinegrass are frequently low in nitrogen, a not uncommon situation for intensely burned areas where much of the nitrogen, potassium, and sulfur was volatized by the fire (TFEA 1997). Therefore, any fertilization treatments designed to supply forest stands with nitrogen, sulfur, and phosphorus could have the unintended result of stimulating pinegrass growth and reproduction (Haeussler and Coates 1986).

In northeastern Oregon and other areas with a hot dry summer, soil moisture is usually the factor that most limits survival and growth of young conifers. During the first few growing seasons, grasses and other herbaceous plants compete aggressively with conifers because their surficial root systems completely occupy the upper soil profile, absorbing moisture before it can percolate to the deeper roots of woody species (Oliver and Larson 1996). In subsequent years, shrubs may be more competitive than herbs as a result of their deeper root systems (Lotan 1986). One study, however, found that pinegrass reduced mid-summer soil water content at depths of 12 and 24 inches to lower levels than did snowbrush ceanothus, but the difference was small (Lopushinsky and Klock 1990).

There is a high risk that elk sedge, pinegrass, and red fescue will compete aggressively with conifer seedlings for moisture, nutrients, and sunlight (Table 1). To give tree seedlings a chance against them, it is important to maintain some overstory tree cover – both to protect the seedlings, and to inhibit the heavy graminoid seed production associated with an open tree canopy (Lotan 1986). Since very few trees survived in the moderate and high intensity burns, it will not be possible to maintain sufficient overstory cover to inhibit rhizomatous grasses and sedges – it is likely that they will have a detrimental impact on reforestation success (Dimock and Collard 1981, Lotan 1986, Sloan and Ryker 1986, Stewart 1977).

Snowbrush ceanothus *(Ceanothus velutinus)* commonly grows in clumps or patches that are 2 to 6 feet tall. Its seeds are long lived, remaining viable on forest sites for 200 to 300 years. High temperatures (80 to 95° C) are necessary to break the seed coat and allow germination, which explains why this shrub may suddenly proliferate after severe fires (Lotan 1986). Snowbrush sprouts vigorously from the large burls that form its root crown, so it can also increase in abundance following moderate- or low-intensity fire.

Following a wildfire, ceanothus may form a dense stand that persists for 10 to 75 years. Since it is very intolerant of shade, ceanothus declines rapidly after being overtopped by conifers. On dry or open sites where conifer regeneration has been delayed or is sparse, snowbrush is frequently a long-term component of the shrub layer (Conard and others 1985).

Ceanothus can be valuable browse for deer and elk, especially in the winter (Noste and Bushey 1987). Although snowbrush foliage is high in protein, deer and elk do not browse it as much as deerbrush *(Ceanothus integerrimus)* or redstem ceanothus *(Ceanothus sanguineus)*, two other *Ceanothus* species that occur on the Forest (Botanical Resources Group 1996). Snowbrush seeds provide food for small mammals, birds, and insects. Dense stands provide cover for small mammals and birds. Ceanothus can fix atmospheric nitrogen, eventually making it available for plant use (Conard and others 1985).

In the Trail, Cable, Long Meadows, Crane, Jumpoff and other fires of 1986 on the North Fork John Day Ranger District, ceanothus germinated from stored seed and covered many acres where no plants had been observed before the fires. Surveys completed in the summer of 1997 show extensive ceanothus germination on many sites in the Tower Fire. Once it becomes established, there is a high risk that ceanothus will compete aggressively with conifer seedlings for moisture, nutrients, and sunlight (Table 1).

Thistles. Canada thistle *(Cirsium arvense)* is a perennial forb that reproduces from seed and widely-spreading, horizontal rootstocks. This noxious weed was introduced from Eurasia and is now naturalized throughout most of northern North America. It is a tall plant found in crop lands, pastures, meadows, and on disturbed sites in forested environments. Unlike many thistles that are most competitive on dry, poor sites, Canada thistle can persist quite well in rich, heavy soils (Reed and Hughes 1970).

Bull thistle *(Cirsium vulgare)* is a biennial forb that reproduces primarily from seed, and occasionally from sprouts. An individual plant typically produces a rosette of spiny leaves in its first year, over-winters in that form, and then bolts to produce a flowering stalk 2-5 feet high in its second year. Some individuals, however, flower in their first year, whereas others require 3 years or more to mature. The plants die after producing seed (Randall and Rejmanek 1993).

Bull thistle is an aggressive weed found in fields, pastures, disturbed meadows, wastelands, and on forested sites that have been harvested, burned, or otherwise disturbed. Like Canada thistle, it was introduced from Eurasia and is now naturalized throughout the conterminous United States and most of Canada (Reed and Hughes 1970). It was probably introduced to eastern North America during colonial times but was unknown in California and the far West until circa 1900 (Randall and Rejmanek 1993).

Bull thistle is similar to snowbrush ceanothus and pinegrass in that its seeds are stored in the duff and upper soil (Neuenschwander and others 1986). Following wildfire, even one of high intensity, the stored seeds germinate promptly and allow this plant to dominate an area for 3 or 4 years. After 4 or 5 years, bull thistle declines rapidly because it cannot compete effectively with more persistent species. During the seedling establishment period, however, there is a high risk that Canada thistle and bull thistle will compete aggressively with conifers for moisture, nutrients, and sunlight (Table 1).

Thresholds for Competing Vegetation

The mere presence of competing vegetation does not necessarily affect seedling survival – when occurring at low levels, it may have little or no impact on seedlings. As it increases in both abundance and stature, however, competing vegetation gradually exerts an influence on trees, eventually reaching the point where it captures enough of a site's resources to seriously compromise seedling performance (survival or growth). The point where competing vegetation causes an unacceptable reduction in conifer performance is referred to as a threshold.

Threshold values could vary depending on the target species (rhizomatous grasses versus sprouting shrubs), which aspect of seedling performance is of most concern (survival or growth), or which site resource is most limiting (light, water, nutrients). For example, high levels of vegetative competition on dry sites are likely to reduce seedling survival before reducing growth, so a threshold for survival would probably be different than one for growth (Wagner and others 1989). On moist sites, competition for light may be much more important than competition for moisture or nutrients (Comeau and others 1993). For this analysis, the objective was to identify a threshold that would enable 70% or more of the planted seedlings to survive for at least three growing seasons.

Results from two long-term studies suggest that any amount of shrub cover will restrict diameter growth of conifers, and that shrubs become the dominant vegetation of a site once they attain a crown closure of 30% or more. Those studies found that shrubs compete aggressively with conifer seedlings when their canopy coverage (crown closure) exceeds 10-20% on poor sites, or 20-30% on good sites (McDonald and Fiddler 1989, Miller 1986a). Oliver (1984) found that ponderosa pine growth increased dramatically after controlling shrubs whose canopy coverage exceeded 30%. Shrub-free trees grew 140-170% faster than those established in dense brush.

Once snowbrush ceanothus becomes established, it can rapidly overtop seedlings, growing five feet or more within five years of a disturbance (Conard and others 1985, Lotan 1986). One study found that ponderosa pine survival was reduced by 60%, and growth by 50%, when the trees were growing under a ceanothus canopy (Zavitkowski and others 1969). In another study, a treatment that reduced ceanothus cover by 44-79% resulted in a two- to three-fold increase in ponderosa pine survival, and a two-fold increase in growth (Ross and others 1986).

Herbaceous vegetation can also affect the survival of tree seedlings. Studies found that grass cover had to be reduced to 40% or less to assure that 60% or more of the conifer seedlings survived. Sites with low summer rainfall or soils with a low water-holding capacity required even less graminoid cover to ensure adequate seedling survival (Miller 1986a). Another study in northwestern Montana found that the biomass of ponderosa pine seedlings, when measured four years after planting, was five times greater in areas where pinegrass had been controlled as compared to the untreated plots (Petersen 1988).

A study conducted in the Blue Mountains of northeastern Oregon found that the survival of ponderosa pine seedlings was two to three times higher for spot applications of an herbicide (hexazinone) than for the untreated control. Broadcast (whole-site) herbicide applications resulted in seedling survival rates that were approximately 20% higher than for spot applications. Seedling vigor and growth were also improved for either herbicide application method when compared with the untreated control. The study sites were dominated by pinegrass, elk sedge, and Kentucky bluegrass (Oester and others 1995).

In a study conducted on the east slopes of the Cascades in Washington, grass competition caused substantial growth and survival impacts in a ponderosa pine plantation. As a result of their research, the investigators recommended a competition threshold of 30% for ponderosa pine sites where the predominant competing vegetation consists of grasses (Blake and Crooker 1986). Other studies found that seedling survival rates dropped to between 35 and 60 percent when grasses were not controlled, as compared to survival rates of 60-80% when 50-70% of the grass was controlled (Petersen 1982).

Several thistle species have been found to compete with conifer seedlings. In a study conducted at Blodgett Forest Research Station in the Sierra Nevada mountains of north-central California, bull thistle was found to suppress growth and survival of ponderosa pine seedlings to nearly the same extent as greenleaf manzanita *(Arctostaphylos patula)*, an aggressive shrub somewhat similar to snowbrush ceanothus in terms of its competitiveness. The growth rates of pines exposed to high thistle densities were reduced by 25 to 33% (Randall and Rejmanek 1993).

Reforestation Units That Are Predicted to Exceed the Competing Vegetation Threshold

All reforestation units in the project area were analyzed to predict levels of competing vegetation. *Based on the studies described above, a competing vegetation threshold of 30% canopy cover was used for the analysis*. This means that control treatments would be considered for any reforestation unit in which highly-competitive shrubs and herbs – bracken fern, bull thistle, Canada thistle, elk sedge, pinegrass, red fescue, and snowbrush ceanothus – occur individually, or in combination, at a density high enough that their foliage covers 30% or more of the ground surface in the vicinity of planted seedlings.

Canopy (foliar) cover was selected as the measure of plant competition because it is easily estimated and interpreted in the field (Wagner and others 1989). But it is not necessarily the most effective measure for all seven species of competing vegetation. Plant density, rather than canopy cover, would have been a better choice for grasses and sedges because most of their total biomass exists below ground (see Figure 2). For newly-planted conifer seedlings, just one grass or sedge plant within a 3-foot radius of the tree is considered too much competition (McDonald 1986).

Units that are predicted to exceed the competing-vegetation threshold were identified using a variety of biophysical factors, including elevation, aspect, plant association group (PAG – the potential natural vegetation of a site; see TFEA (1997) for more information), the proportion of a unit that sustained moderate- or high-intensity burning, and the estimated year of planting (Table 9). The estimated planting year reflects the length of time that competing vegetation has had to grow and develop since the wildfire.

Predicted levels of bracken fern. Bracken fern is typically found on mid-slope benches, moist toeslopes, ravines, and similar topographic situations. Following wildfire, it often expands outward from those environments and colonizes drier sites. Reforestation units that are expected to exceed the threshold for bracken fern occur on moist ecological environments (the Cool Moist PAG; see Table 9) and on cool slope exposures (particularly northwest aspects) at moderate to high elevations.

Predicted levels of grasses and sedges. On severely burned sites, the fire killed plant roots to the extent that grasses and sedges have reestablished more slowly, and cover less of the ground surface, than in the moderate- or low-intensity burns. Reforestation units that are expected to exceed the competing vegetation threshold for grasses and sedges occur primarily in the moderate-intensity burn and at lower elevations.

Predicted levels of snowbrush ceanothus. The greatest potential for ceanothus establishment is on south- and west-facing slopes in the moderate-intensity burn, and on slopes with any aspect that burned at a high intensity (Noste 1985). Reforestation units that occur in the high-intensity burn are expected to have the greatest ceanothus coverage; units on south- or west-facing slopes in the moderate-intensity burn may have slightly lower canopy coverage, but are still expected to exceed the threshold.

Competing Vegetation Strategies

The vegetation management plan (Table 9) emphasizes early treatment as the preferred strategy for managing competing and unwanted vegetation in the South Tower project area. The Final Environmental Impact Statement for Managing Competing and Unwanted Vegetation (USDA Forest Service 1988) analyzed four strategies for managing competing vegetation on National Forest lands of Pacific Northwest, as described below.

Prevention. The FEIS selected prevention as the preferred strategy for dealing with competing and unwanted vegetation. It refers to detection or amelioration of site conditions that stimulate or favor competing vegetation. Prevention does not involve direct treatment of competing vegetation, but anticipates potential vegetation problems and takes steps to avoid reaching a damage threshold. Use of natural controls is the key concept behind this approach (USDA Forest Service 1988).

Unfortunately, prevention is not a viable strategy for the South Tower area because an unanticipated, uncontrollable wildfire created the conditions that are conducive to competing vegetation. This differs from timber harvest in green (live) stands where silvicultural systems could be modified in anticipation of competing vegetation problems, such as retaining shade trees to inhibit rhizomatous grasses and sedges.

Early Treatment. Early treatment involves initiating action to control competing vegetation before a damage threshold is reached. Control during the early development stages is usually easier, less costly, and can require fewer treatments. For some areas that cannot be planted until the 1999 growing season or later, early treatment is not a viable strategy because competing vegetation would have exceeded the threshold by then.

Maintenance. This strategy emphasizes maintenance of vegetative conditions that are currently below a damage threshold, but can be expected to periodically exceed it. Maintenance focuses on stable conditions that are desirable to sustain over time. Vegetative conditions following the Tower wildfire, however, are anything but stable – nor are they desirable to sustain through time.

Correction. This strategy includes actions that are taken after a competing vegetation threshold has been exceeded.

The longer the period between a wildfire and tree seedling establishment, the more likely that competing vegetation will become a reforestation problem. Prompt planting of physiologically and genetically suitable seedlings would minimize the need to use a correction treatment (Lotan 1986), although it is logistically and financially impossible to reforest the entire South Tower burn in the first two growing seasons. Due to unavoidable delays in producing sufficient seedlings and getting them planted promptly, it is almost certain that competing vegetation will gain an advantage over planted trees in some portions of the project area.

The portion of the South Tower project area that cannot be planted during the first two growing seasons will need a higher proportion of correction treatments such as herbicides. If planting is delayed or if competing vegetation establishes more rapidly than anticipated, correction treatments may be needed to a greater extent than predicted.

Competing Vegetation Treatment Methods

The proposed competing vegetation treatments support the purpose and need to reforest the South Tower area. They also meet the Code of Federal Regulations (36 CFR 219.27(c)(3)), which requires adequate restocking of harvested forest land. Experience has shown that prompt site preparation is necessary to meet reforestation objectives and to minimize the need for costly replanting. Desired stocking levels are 151-222 trees per acre, depending on the site (TFEA 1997). The minimum stocking level is 150 trees per acre (USDA Forest Service 1990); a stocking rate below that level usually triggers a decision to replant.

Final determination of treatment methods will occur when each reforestation unit becomes available for planting. Availability depends on when salvage has been completed (for salvage units), appropriation of reforestation funding by Congress, and logistical considerations. Planting cannot commence until funding and seedlings are available, and site preparation has been ensured. Beginning with the 1999 growing season, competing vegetation would be taller than planted seedlings – its root system could be deep enough that control treatments would be ineffective or inordinately expensive.

In its proposed action, the Big Tower project considered 8,700 acres for revegetation with tree seedlings and other plants (USDA Forest Service 1997b). The proposed action for this project includes 422 acres of conifer planting (Table 2). By the third growing season after the Tower wildfire (1999), about 41% of the estimated area to be planted with conifers is expected to exceed the 30% canopy coverage threshold for bracken fern, ceanothus, grasses and sedges, and thistles. Control of competing vegetation using any of the following methods would be considered for reforestation units that exceed the threshold.

Hand scalping. Scalping involves using a hand tool to clear competing vegetation and woody debris from a small area in which a tree seedling is to be planted. It provides fair control of competing vegetation during the first growing season, particularly for grasses and sedges that are not yet well established. When used on sites without competing vegetation problems, this treatment method is typically implemented as 18-inch square scalps.

Table 2: On-going and proposed reforestation activities for the South Tower project area.

REFORESTATION ACTIVITY	ACRES	COMMENTS
Planting in Junewood sale area	734	Reforestation of burned plantations
Planting in Placer sale area	752	Reforestation of burned plantations
Planting of Big Tower salvage sales	3,377	Reforestation of Dragon, Lone Salvage, Overlook
Reforestation of non-salvaged area	835	Planting in upland areas other than salvage units
Planting of South Tower salvage units	422	Located mostly in Big Creek/Winom Creek area
Total	6,120	41% could need competing vegetation treatments

Sources/Notes: Summarized from the reforestation and competing-vegetation analysis (Table 9). Acres include uplands only; riparian habitat conservation areas were excluded from the totals.

Hand scalping would be done once as an early treatment and possibly several times when used as a maintenance or correction treatment. When used as a correction measure, four-foot scalps may be necessary – a difficult, expensive practice and one whose advantage can be short lived due to relatively rapid recovery by the competing vegetation (Sloan and Ryker 1986).

Once competing vegetation is well established, scalping may not be effective depending on the target species. For example, bracken fern has a dense system of creeping underground rhizomes that occur in two widely-separated levels. The upper level, located just beneath the soil surface, is responsible for producing the vegetative shoots (fern fronds). Scalping could remove the fronds and most of the upper rhizomes. The lower rhizome level is extremely deep (20 inches beneath the soil surface) and is responsible for storing food reserves and for lateral expansion of the colony (Haeussler and Coates 1986). Scalping would not affect the lower rhizome level. Grubbing might be able to disrupt the deep rhizomes, but at a high cost in terms of soil displacement and potential sedimentation.

Research found that scalps would need to be very large to assure conifer survival on sites with a shrub-dominated plant community. For example, an 8' by 8' scalp resulted in statistically-significant increases in seedling survival on dry or mesic sites in central Idaho (Kittams and Ryker 1975). Another study in central Idaho compared 2-, 4-, and 8-foot scalps, and found much higher seedling survival and growth on the 4-foot scalps and 8-foot dozer strips when compared with the 2-foot scalps. The study found that "the 2-foot hand-made scalp is too small on sites with a high coverage of elk sedge" (Sloan and Ryker 1986). Although effective, large scalps can be a costly treatment method (Table 3).

Mulch mats. Mulch mats are made of woven plastic, Kraft paper, wood excelsior, synthetic fibers, newspaper, and a variety of other materials. They are placed around seedlings in an effort to mitigate high surface temperatures or soil moisture losses, and to control competing vegetation. Popular mats consist of a thin paper or synthetic material sheet, three feet or more square, with a hole in the center for the planted seedling. The mat is staked to the ground with metal pins to keep it close to the soil (McDonald and Helgerson 1990, Windell and Haywood 1996).

Mulch mats can alter a seedling's environment in several important ways. Certain sheet mulches such as VisPore allow moisture to pass through the upper surface, while restricting evaporative losses from below. Consequently, they tend to maintain higher soil temperatures and moisture. Since the soil temperature does not fluctuate as much as it would if evaporation was occurring, mulches have been observed to reduce frost damage and frost heaving of newly planted seedlings (Windell and Haywood 1996).

As an early treatment strategy, mulch mats can be applied over young grass and shrub germinants without thick root masses. Mats suppress competing vegetation by blocking sunlight required for photo-synthesis and, to a lesser extent, by mechanically impeding growth. The area covered by a mat is usually scalped or grubbed first to reduce the amount and height of any competing vegetation that was already established. If mats are installed without pre-treatment, it may be necessary to use heavy materials such as woven polypropylene or thick cardboard to obtain acceptable results. Control is provided for a period of 1 to 3 years, depending on the mat material being used, site conditions, and other factors.

Mulch mats can be dislodged by cattle, big game, or gravity on steep slopes, and may require periodic maintenance to ensure that they do not come loose and smother the seedling. Mats have been observed to reduce erosion by water and wind, thereby decreasing sedimentation (Windell and Haywood 1996).

Table 3: Estimated costs for reforestation and competing vegetation treatments.

TREATMENT COMBINATION	PROJECT COST	SOURCE
Planting and an 18" Square Scalp	$407/acre	From Kohrman (1998)
Planting and an 48" Square Scalp	$1045/acre*	From Kohrman (1998)
Planting and Clipping of Shrubs	$633/acre	Estimated from McDonald and Fiddler (1989)
Planting and Grubbing	$757/acre	From USDA Forest Service (1996b)
Planting and Herbicides	$542/acre	From Kohrman (1998)
Planting and Mulch Mats	$802/acre	From Kohrman (1998)
Planting and Pulling of Shrubs	$607/acre	From USDA Forest Service (1996b)

* Includes cost of an increased planting density to compensate for lower-than-normal survival.
Note: Project costs do not include Forest Service overhead or other indirect costs.

Hand grubbing, hand pulling, and clipping. These methods are short-term maintenance or correction treatments to reduce competition within a three-foot radius around each tree seedling. Grubbing is the manual digging and uprooting of shrub plants below ground level. Pulling consists of removing the entire plant, generally in its smallest stages of growth. Clipping consists of manually cutting the above-ground shrub stems, typically by using sharp-edged hand tools or hand-held power equipment.

Grubbing is not feasible for plant species that regenerate from sprouts or rhizomes. For example, grass communities cannot be grubbed in the fall because the risk of 'planting' thousands of grass seeds is too great. Grubbing can be effective if implemented within a 5-foot radius of conifer seedlings and shortly after the competing vegetation has gotten established. Costs for grubbing can be reasonable if it is completed when the target plants are young and small. However, a second grubbing treatment is often needed to ensure plantation success (McDonald and Fiddler 1993).

Snowbrush recovers quickly after a clipping treatment because the roots are still alive and they resprout immediately. On the Willamette National Forest, the annual height growth of snowbrush sprouts averaged 16 inches after a clipping treatment; each cut stem produced an average of 4.3 sprouts. This study demonstrates that clipping provides shrub control for a short period at best – perhaps a year or two – and that repeated treatments would be necessary to ensure conifer establishment. Clipping is not efficacious except when used with shrubs that are not overly dense and do not resprout (Miller 1986b).

Hand pulling was also used for snowbrush control on the Willamette National Forest. It worked for shrubs that were 2 to 5 years old; younger plants were too hard to grasp and older plants were well established and had a deep root system. Although effective when implemented at the right time and on sites with loose, light-textured soils, hand pulling was costly since each worker could only treat one acre per day (on average, a worker pulled 2,300 plants per acre) (Miller 1986b).

Mulch mats, grubbing, pulling, clipping, and other manual methods can be effective as early treatments when the competing vegetation is small. They can also be used as maintenance treatments, but are seldom successful as correction measures. Areas treated with early treatment or maintenance methods have a moderate likelihood of achieving the purpose and need to reforest the project area; areas in which a correction strategy are used have a lower likelihood of success. Even though manual methods can control competing vegetation for only a short period, they may still be successful if implemented at a critical point in the seedling establishment period.

Herbicides. Herbicides would be used as a correction treatment when other methods are ineffective or would increase project costs unreasonably. Application would be by hand within a three-foot radius of each planted seedling; however, the seedling would be planted in the center of an 18" square scalp and the scalped area would not receive any herbicide (Figure 3). With an average of 222 planted seedlings per acre, this means that herbicides would be applied to only 13% of a reforestation unit – 87% of the ground surface in treated units would not receive any herbicide (Figure 4).

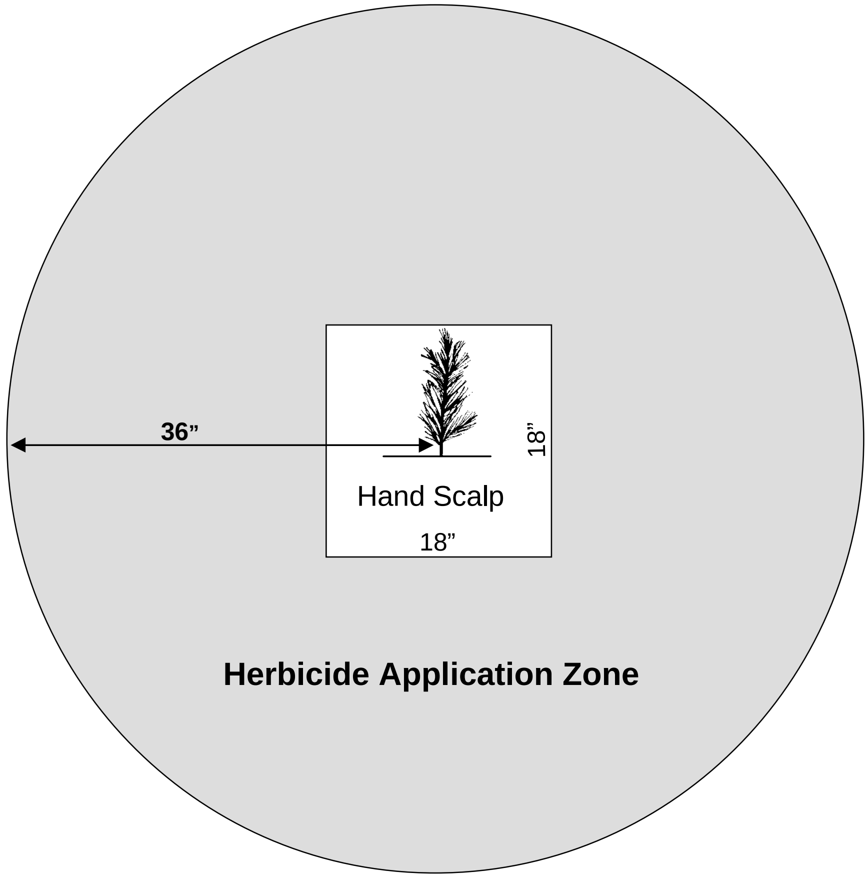

Figure 3 – Seedlings will be planted in the center of an 18″ scalp; herbicides will be applied in a 3-foot radius around the seedling, but excluding the scalp area.

Herbicides would be applied once during the five-year tree establishment period. They would not be used within the PACFISH buffers established along all water courses, which are referred to as riparian habitat conservation areas (300 feet on each side of class 1 and 2 streams; 150 feet on each side of class 3 streams; 100 feet on each side of class 4 streams).

Areas treated with herbicides have a high likelihood of achieving the purpose and need to reforest the project area. Target vegetation would not be eradicated because no more than 13% of a reforestation unit would be treated; competing vegetation species would continue to survive and prosper on 87% of the treatment area (see Figure 4). Restricting application to hand applied spots would reduce the risk of wind drift affecting non-target vegetation.

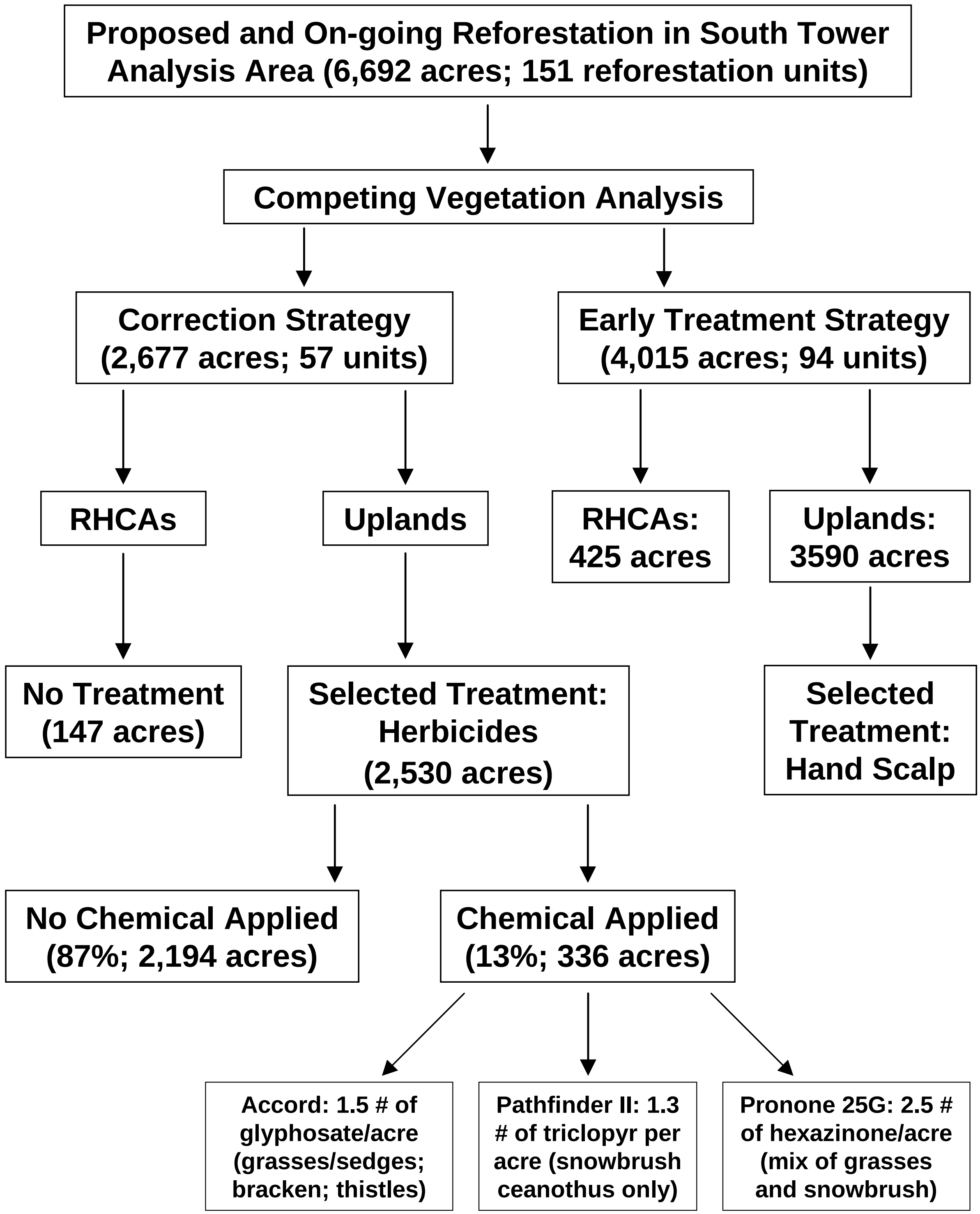

Figure 4 – Summary of results from a competing vegetation analysis for the South Tower area.

One of three regionally approved herbicides would be used, based on the expected type of competing vegetation. Glyphosate would be used if grasses and sedges, bracken fern, or thistles exceed the 30% canopy coverage threshold. Hexazinone would be used if both grasses and sedges, and snowbrush ceanothus, were over threshold. Triclopyr would be used if ceanothus alone exceeded the threshold (see Figure 4). Hexazinone is soil active and applied in either spring or fall; the other two chemicals are primarily foliage or bark active and typically applied in summer or fall (McDonald and Fiddler 1993).

Glyphosate (Accord formulation) would be used to control sod-forming grasses and sedges, bracken fern, or thistles. It is a broad-spectrum, relatively non-selective herbicide – it kills or damages nearly all vegetation except broadleaf woody shrubs. It was found to be particularly effective on sedges (Dimock 1981), and can also provide good control of bracken fern (Coates and others 1990). Glyphosate is applied to foliage and is absorbed by the leaves. It prevents the plant from producing amino acids essential for growth (USDA Forest Service 1997a).

Accord is applied by spraying a 1-2 percent liquid solution (by volume) on competing vegetation located within a 3-foot radius of the planted seedling; plants would be thoroughly wetted, but not to the point where solution would be running off. To be fully effective, glyphosate requires a rain-free period of at least 6 hours, but preferably 24 hours, after application (Willoughby 1997).

Based on similar projects elsewhere in the Blue Mountains, it is expected that the 'spray-to-wet' technique will result in an application rate of approximately 1½ pounds of glyphosate per treated acre (personal communication, Rosemary Guttridge, La Grande Ranger District). If Accord was applied around 222 seedlings per acre, excluding the 18" square scalp in which the tree is planted, then each acre would receive approximately 0.2 pound of the active ingredient (glyphosate).

Hexazinone (Pronone 25G formulation) would be used where control of both grasses/sedges, and shrubs, is needed. It is selective, killing only certain plant types. It is readily absorbed by plant roots and leaves and moves up through the plant, killing it by inhibiting photosynthesis. It remains in the soil and controls vegetation for up to three years (USDA Forest Service 1992). Hexazinone was more effective on Intermountain sites with relatively low amounts of organic matter than on coastal areas with abundant organic material (Balfour 1989).

Pronone is applied in granular form (hexazinone coated clay particles, 25% by weight) within a 3-foot radius of planted seedlings and at a rate of approximately 10 pounds (2½ pounds of active ingredient) per acre. Rainfall dissolves the herbicide from the granules and moves it into the rooting zone, where susceptible plants can absorb it during periods of active growth. Fall applications may be better than spring if rainfall is more dependable then. If Pronone 25G was applied around 222 seedlings per acre, excluding the 18" square scalp in which the tree is planted, then each acre would receive approximately 0.33 pound of the active ingredient (hexazinone).

Hexazinone was particularly effective at controlling competing vegetation on warm dry sites where ponderosa pine and Douglas-fir are planted. It not only provided consistently good to excellent control of herbaceous vegetation, but control persisted for 2 to 3 growing seasons so that multiple treatments were unnecessary. It produced substantial increases in ponderosa pine survival, and impressive gains in both height and diameter growth when compared with untreated areas (Dimock and others 1983).

Hexazinone would not be appropriate on all sites because it can injure or kill certain conifer species (Table 4) – western larch and western white pine are particularly susceptible (Boyd and others 1985). It has also been noted that hexazinone-treated areas may be attractive to cattle as places to bed down or rest, which could then result in seedling damage or death from trampling and other cattle-related impacts (Dimock and others 1983).

Triclopyr (Pathfinder II formulation) would be used for control of snowbrush ceanothus. It is selective, not injuring grasses. It is absorbed by roots, leaves, and green bark, and then moves throughout the plant, eventually accumulating in the meristem (growth region). It acts like a growth hormone, interfering with normal growth processes. Since the solution is applied only to ceanothus plants, there is low risk of harming other (non-target) species within the application zone. Because it is a pre-mixed formulation that eliminates the need for mixing, Pathfinder greatly reduces the risk of operator exposure during handling.

Pathfinder is used for low-volume, basal-bark treatments – it is applied by spraying the basal parts of ceanothus stems located within a 3-foot radius of the planted seedling. The lower 12 inches or less of each stem would be thoroughly wetted, including the root collar area, but not to the point where solution would be running off. Based on similar projects elsewhere in the Blue Mountains, it is expected that this 'spray-to-wet' technique will result in an application rate of about 1.3 pounds of triclopyr per treated acre (personal communication, Elaine Waterbury, Prairie City Ranger District). If Pathfinder II was applied around 222 seedlings per acre, excluding the 18" square scalp in which the tree is planted, then each acre would receive approximately 0.17 pound of the active ingredient (triclopyr).

Inert Ingredients. An herbicide is nothing but a growth regulator designed to affect a specific plant process, such as photosynthesis, amino acid production, or meristem function. In addition to an active ingredient, commercial herbicide products often contain one or more inert ingredients. An inert ingredient is anything added to the product other than the active, plant-regulating ingredient. The names of inert ingredients are generally not listed on the product label. Some product labels require that another substance, called a surfactant, be added to the herbicide for certain application situations (USDA Forest Service 1997a). Surfactants and other herbicide additives can also contain inert ingredients.

Accord consists of glyphosate (41.5%) and water (58.5%). For forestry site preparation and certain other application situations, the manufacturer of Accord requires that it be used in combination with a nonionic surfactant. Although several surfactant alternatives are available, the only one proposed for use in this project is Agri-Dex due to its low toxicity to fish and aquatic invertebrates (USDA Forest Service 1997a).

Pronone 25G includes several inert ingredients, including montmorillonite clay that serves as the core of the granule. No inert ingredient in any hexazinone formulation was categorized by the Environmental Protection Agency (EPA) to have evidence or suggestion of toxic effects (USDA Forest Service 1992).

Pathfinder II contains an inert ingredient that is described by the manufacturer as a naturally-derived, non-petroleum oil. This oil-based solvent is classified by EPA on Inert List #4, which includes substances that are characterized as slightly toxic or non-toxic (USDA Forest Service 1996a).

Table 4: Tolerance of conifer seedlings to the herbicide hexazinone.

TREE SPECIES	TOLERANCE TO HEXAZINONE
Douglas-fir	High
Engelmann Spruce	Moderate
Grand Fir	High
Lodgepole Pine	High
Ponderosa Pine	High
Subalpine Fir	High
Western Larch	Low
Western White Pine	Low

Sources: Tolerance ratings were taken from a fact sheet entitled "Hexazinone recommendations for Intermountain forestry sites" and published by the DuPont Company, and from Boyd and others (1985).

Additional information about these herbicides is available in the Pacific Northwest Region Final Environmental Impact Statement for Managing Competing and Unwanted Vegetation, Appendix C, Herbicide Use and Efficacy (USDA Forest Service 1988).

Effects of Competing Vegetation Treatments on the Environment

The environmental effects of controlling competing vegetation are generally short-term. They would occur during the five-year seedling-establishment period, and possibly persist for a few years past that. The primary long-term effect could involve changes in vegetation patterns resulting from modification of early plant succession. Successful control of competing vegetation, if necessary, could result in reforestation of the Tower wildfire much sooner than would otherwise occur (TFEA 1997).

Clipping (cutting above-ground shrub stems) produces woody material that would remain on site, possibly increasing the seedling's risk of future (near-term) fire mortality. Cut material could provide shade and otherwise benefit the seedling microclimate, while not competing for soil moisture. Cut material would be in contact with the ground and would decay somewhat sooner than standing dead shrubs, thereby contributing to nutrient replenishment. Clipping and other hand treatment methods can be costly, especially if the vegetation is well established (see Table 3).

Herbicide Effects on Water Quality. Since herbicides do not disturb the forest floor, they serve to protect water quality and maintain site productivity by retaining nutrient-rich organic matter and soil surface horizons on-site. This differs from mechanical control methods, which can increase sediment losses by 1 to 2 orders of magnitude as compared to natural losses from undisturbed watersheds (Neary and Michael 1996). Herbicides kill vegetation in place – several investigators found that the mat of dead grass present after an application may have acted like a mulch, improving seedling survival by conserving soil moisture and by moderating temperatures at the soil surface (Miller 1986b, Stewart and Beebe 1974).

In the soil, herbicides tend to be immobile or move only short distances as long as there is negligible surface runoff. Several studies involving triclopyr found that the herbicide was adsorbed so strongly by the soil's organic matter that leaching or downward movement through the profile was minimal or non-existent (Newton and others 1990; Lee and others 1986). In one study, minor triclopyr residues were produced after passing an herbicide solution through a control medium of pure quartz sand (not a soil), although the resulting concentrations were still one to three orders of magnitude below the acute-dose (LC_{50}) values for trout, bluegill, daphnia, and other aquatic organisms (Lee and others 1986).

Concerns about soil mobility are particularly germane to hexazinone, a soil-active, soil-mobile herbicide used frequently in forestry. The chemistry of hexazinone is such that it is weakly adsorbed to soil particles, it is highly soluble in water, and it is mobile within or over the soil matrix. The mobility and weak adsorption are important characteristics affecting the efficacy of hexazinone – those traits facilitate access and uptake of the herbicide by plants. Hexazinone is transported predominantly in an aqueous state, moving in the soil both as overland flow and interflow or subsurface flow (Beaudry 1990).

The issues involving hexazinone are mostly concerned with how uncontrolled movement of the herbicide could damage streamside vegetation in untreated buffer zones, or affect wildlife browse or cattle forage in intervening areas between the treated spots. Contamination of fish-bearing streams is of little concern because hexazinone is virtually non-toxic to fish (USDA Forest Service 1992). Due to its high mobility, hexazinone is susceptible to off-site movement in storm runoff, snowmelt, and leaching (Beaudry 1990).

A recent study in British Columbia examined the soil mobility and movement of liquid hexazinone (Velpar L). Since application periods vary, the study included both spring and fall treatments. Fall applications caused the most concern, primarily because of higher precipitation in the fall (more opportunity for movement), a lack of uptake by plants during the fall and winter dormant periods, low levels of biological activity in the soils during winter (little or no microbial degradation occurs then), and the herbicide's high relative concentration in the soil profile during the spring snowmelt runoff period (Beaudry 1990).

Some of the findings from Beaudry's (1990) water-quality study were: in general, there was a reduction in hexazinone concentrations as the downslope distance from the point of application increased; downslope movement was predominately sub-surface rather than over the soil surface; a fall application appeared to produce more downslope movement than a spring application; most downslope movement occurred in the first fall or spring after application; presence of hexazinone in soil water was almost undetectable by 12 months after application; although detectable in only minute amounts, movement as far as 25 meters (82 feet) was observed in a few instances; and the amount of organic matter and the micro-topography at the point of application seemed to have the greatest impact on downslope movement (Beaudry 1990).

It is important to note that Beaudry's (1990) study was conducted on a subalpine spruce site with cold, wet soils. Those characteristics differ substantially from forests in the South Tower project area, where soils are warm and dry in comparison to Beaudry's study sites. In north-central California, hexazinone has not been observed to leave the application zone when used on warm, dry soils (personal communication, Philip McDonald, Pacific Southwest Forest and Range Experiment Station, Silviculture Laboratory, Redding, California).

Herbicide Effects on Wildlife. Silvicultural herbicides are non-toxic to wildlife and do not bioaccumulate if ingested. Laboratory studies showed that 95% of ingested glyphosate is eliminated within 5 days, and that

93% of hexazinone is eliminated in 24 hours. This differs from older phenoxy pesticides such as DDT that tended to accumulate in fatty tissues. To have an acute effect, an animal would have to consume a large amount of treated foliage. For example, a 150-pound deer would have to ingest all of the chemical sprayed on an area of 54 feet by 54 feet to consume enough hexazinone to reach the LD_{50} level (at an application rate of 2 gallons active ingredient per acre). Even assuming that the deer would find treated foliage palatable, consumption must occur rapidly since hexazinone is degraded quickly (McNabb 1991).

Some studies found wildlife impacts following herbicide treatments, but they were always associated with changes in the vegetation, not with the herbicides themselves (Lautenschlager 1993, Sullivan and others 1997). Since wildlife impacts are typically indirect and most often result from changes in vegetation density or species composition, they tend to persist for no longer than it takes the vegetation to recover (Norris 1981). In situations where herbicides are applied as 'spots' around seedlings, rather than broadcast across an entire site, the impact on small mammals and other wildlife species is negligible.

Dense herbaceous vegetation is prime habitat for pocket gophers (*Thomomys* spp.) and voles (*Microtus* spp.) that feed on the stems, roots and, to a lesser extent, the foliage of seedlings and saplings of most conifer species. Their feeding activities often result in seedling mortality. In southern Oregon, dramatic improvements in seedling survival were observed following an herbicide application. Further investigation found that much of the improvement was related to a post-treatment decline in gopher populations, which occurred after the herbicide reduced their herbaceous food supply (Crouch 1979, McDonald 1986).

Research found that the acute-dose (LD_{50}) values for glyphosate were greater than 1,000 mg/kg for five species of amphibians. A study in western Oregon examined the effects of an operational glyphosate application on amphibians. The study predicted that oral and dermal absorption of glyphosate after field application likely would not exceed 1.2 mg/kg for amphibians in the treated area. The investigators concluded that the effects of a glyphosate application on amphibians, if any, would therefore be attributable to indirect impacts such as habitat modification (Cole and others 1997).

Treatment Effects on Soils. Soil can be churned, displaced, or exposed during implementation of competing vegetation treatments. Two to four inches of soil can be affected in scalped areas. With grubbing, four to six inches can be disturbed because to be effective, this treatment must be deep enough to sever the root collars of sprouting plants. Hand pulling would expose small amounts of soil in the immediate vicinity of plants being removed. Small amounts of soil would be disturbed when using herbicides or mulch mats because both would occur in conjunction with an 18" scalp. Table 5 summarizes the soil disturbance implications of the competing vegetation treatments.

Mycorrhizae are structures formed when young seedling roots are invaded by fungi. The fungi form a symbiotic association with the living cells of plant roots and play an important role in tree physiology. The fungal structures extend outward from the seedling, greatly increasing the absorptive surface area of its root system. Mycorrhizae benefit the trees by increasing uptake of nutrients and water, particularly in cold soils. Seedlings with mycorrhizal associations have consistently done better, in terms of survival and growth, than those without them. Since mycorrhizae are incapable of rapidly re-colonizing a site using spores, it is important to select competing vegetation treatments that retain as much of the on-site mycorrhizal diversity as possible (Coates and others 1994, Jones and others 1996).

The use of herbicides or other pesticides could temporarily damage mycorrhizal fungi in the soil. In a greenhouse study, application of granular hexazinone (Pronone 5G) caused a reduction in mycorrhizal development on lodgepole pine and white spruce seedlings. At low application rates, recovery to untreated (control) conditions occurred within 4 months. At higher application rates, mycorrhizal colonization had improved after 6 months, but was still significantly lower than untreated controls or the low-application-rate seedlings. It was observed that the fine roots of seedlings were more sensitive to hexazinone than the mycorrhizae were, which suggests that mycorrhizal suppression was caused by a lack of colonization sites (seedling roots) rather than the herbicide itself (Chakravarty and Sidhu 1987).

Table 5: Soil disturbance associated with competing vegetation treatment methods.

	PLANTED	AFFECTED	POTENTIAL	SOIL

TREATMENT METHOD	TREES PER ACRE	ACRES PER TREATED ACRE	TREATMENT ACRES	DISTURBED (ACRES)	COMMENTS
18" scalp	222	.011	3,590	39.5	2-4" deep
48" scalp/IPD*	436	.160	2,530	404.8	2-4" deep/10' tree spacing
Clipping	222	0	2,530	0.0	Aboveground stems only
Grubbing	222	.144	2,530	364.3	4-6" deep; 3' radius
Herbicides	222	.011	2,530	27.8	18" scalp around seedling
Mulch Mats	222	.011	2,530	27.8	18" scalp around seedling
Pulling	222	.072	2,530	182.2	50% of 3' radius disturbed

Treatment Method The potential treatment method, as described in the "Competing Vegetation Treatment Methods" section. *IPD is Increased Planting Density which, when combined with a larger-than-normal scalp (48"), would be used to compensate for lower-than-expected survival.

Planted Trees Per Acre The number of planted seedlings per acre.

Affected Acres Per Treated Acre Calculated by computing the square feet of treated area (2.25 for 18" scalp), dividing by the square feet in an acre (43,560), and then multiplying by the trees per acre (222).

Potential Treatment Acres The 3,590 acres include reforestation units for which the early treatment competing vegetation strategy was selected; the 2,530 acres includes units for which the correction strategy is predicted to be necessary. Acres include uplands only; RHCAs were excluded.

Soil Disturbed (Acres) Calculated by multiplying column 3 (affected acres) by column 4 (potential treatment acres).

Comments Comments about treatment specifications.

In another study on a forest site dominated by pinegrass, spot application of herbicides resulted in greater diversity of mycorrhizae than did mechanical scarification. Mycorrhizal diversity was equivalent for the herbicide-treated and untreated (control) seedlings, but the long-term survival and growth of untreated seedlings was poor as a result of competition from pinegrass. Consequently, herbicides were considered to be the superior competing-vegetation treatment with respect to maintenance of mycorrhizal diversity on planted sites (Jones and others 1996).

Soil microbial activity may be temporarily reduced after application of herbicides, but the effect is short-lived because microbes serve as the primary mechanism for degradation of herbicides over time (Newton and others 1990). Relatively rapid degradation is expected in the Tower fire area due to warm conditions caused by a lack of shade and the absence of an insulating duff layer. No sustained adverse effect on soil productivity is anticipated as a result of the proposed use of herbicides (Neary and Michael 1996).

Herbicide Effects on Plant Diversity. Although herbicides may cause an initial reduction in plant diversity and species richness, the effect is short lived. In a wildfire study in northern California, plant diversity in herbicide-treated areas was not statistically different from that of the unburned areas when measured 8 years after treatment. In contrast, unsprayed burned areas showed a long-term reduction in plant diversity and species richness when compared to unburned forest. Even though the unsprayed areas had similar levels of vegetative cover as the unburned or herbicide-treated sites, it was dominated by just a few shrubby species (mostly ceanothus and manzanita) (DiTomaso and others 1997).

Summary of Herbicide Effects. Glyphosate does not have herbicidal properties once it contacts soil, and is not absorbed by plant roots. It has been frequently used in forest ecosystems because of its low mobility, and because it is readily immobilized by organic matter in the forest floor (Neary and Michael 1996). It has a very low potential for leaching into groundwater because it is strongly adsorbed by soil particles (USDA Forest Service 1997a). Long-term water quality monitoring in northern California showed that 98% of the samples had no detectable glyphosate residues; when detected, residues were so low that they presented a safety margin of three orders of magnitude when using the water quality standards for rainbow trout (Trumbo 1996).

Glyphosate is degraded by soil microorganisms and remains in the soil for 3 to 249 days (Table 6). It does not easily evaporate. It is practically non-toxic to fish (LC_{50} is 1,000 ppm) and is essentially non-toxic to aquatic invertebrates, birds, mammals, and bees (USDA Forest Service 1997a). Wildlife and fish studies have shown that glyphosate has an extremely low bioaccumulation factor (Newton and others 1984, Norris 1981, USDA Forest Service 1997a).

Hexazinone is moderately persistent in the soil, remaining in low concentrations for up to three years until it is degraded by soil microorganisms. It has a higher leaching potential than glyphosate or triclopyr because it is not adsorbed well by the soil, particularly sandy soils that are low in organic matter (Norris 1981). It does not easily evaporate. It is slightly toxic to mammals, and practically non-toxic to fish (LC_{50} is 274-505 ppm), aquatic invertebrates, and birds. Hexazinone does not accumulate in animal tissues (USDA Forest Service 1992). Long-term water quality monitoring in northern California found that 99% of the samples had very low hexazinone residues; samples with higher residues presented a 10-fold margin of safety for aquatic organisms (Trumbo 1996).

Triclopyr is readily degraded by soil microorganisms, especially under warm, moist conditions. Soil half-life has been measured in western Oregon at about 80 days but detectable residues may remain up to 477 days. It can be leached away from the soil, particularly if soil organic matter is low and the climate is cold and dry. It is slightly toxic to fish (LC_{50} for trout is 117 ppm, LC_{50} for salmon is 7.8 ppm), but has low toxicity for mammals and birds and has a low tendency to bioaccumulate (USDA Forest Service 1996a). Long-term water quality monitoring showed that 99% of the samples had very low triclopyr residues – those with higher residues presented a 3-fold margin of safety for aquatic organisms (Trumbo 1996).

The herbicides are not expected to accumulate in the soil due to relatively short half-lives and/or generally low adsorption rates (Table 6).

Table 6: Selected properties of herbicides being proposed for use in 57 reforestation units in the South Tower project area

TRADE NAME	ACTIVE INGREDIENT	HALF-LIFE	SOIL ADSORPTION
Accord	Glyphosate	3-249 days	High
Pathfinder II	Triclopyr	75-81 days	Low
Pronone 25G	Hexazinone	30-180 days	Low

Sources/Notes: From USDA Forest Service 1992, 1996, 1997a. Half-life is the time required for a chemical to be reduced by natural processes to one half its original amount. Adsorption is the process of a substance attaching to a surface, such as a chemical being adsorbed to organic matter or another soil constituent.

Effects of Competing Vegetation Treatments on Worker and Public Safety

Manual Treatment Methods. Manual methods can pose hazards because workers use sharp-edged hand tools while performing hard labor in a forest environment. Cuts, bruises, muscle strains, hypothermia, poisonous plants, ticks, poisonous snakes, and insect stings are just a few of the injuries or hazards that workers are exposed to when using manual methods. Moreover, there is a substantial risk of long-term injuries to backs and knees associated with these methods (Newton 1997). There are no known hazards to the public associated with the use of manual control methods.

Forestry differs from many other enterprises in that decisions are often influenced by public perceptions, particularly with regard to safety and risk. The typical belief outside forestry is that herbicides present a high human health risk, and that control of brush species by hand and power tools is ‘safe.’ Decisions based on such beliefs may compromise worker safety by substituting an alternative that is perceived as low risk (manual methods) for one believed to be high risk (herbicides), when in fact the opposite may be true. Whereas many studies have found the human health risk of herbicides to be low, comparable safety information is scarce for non-chemical treatment methods (Dost and others 1996).

Recent Canadian research found that injury frequency and lost time can be surprisingly high for manual methods. Their data indicates that a worker who stays in a manual 'brushing' program for a full six months had an 80% chance of requiring emergency attention. About 44% of the injuries resulted from falls and sprains; chainsaw wounds accounted for 15% of the cases. In fact, work in progress indicates a very high risk associated with exposure to chainsaw exhaust, which contains several carcinogens, neurotoxic hydrocarbons, carbon monoxide, and various respiratory irritants (Dost and others 1996).

Herbicides. Many people are concerned about herbicides and have been for a decade or more. Some view any compound that ends in 'cide' (fungicide, herbicide, insecticide, rodenticide, etc.) as a dangerous, highly toxic chemical that is unsafe at any application level. Others see herbicides as indestructible compounds that inevitably find their way into a food chain or water supplies to pose a threat to public safety (McNabb 1991).

Some of those perceptions may relate to an agricultural or household situation, where chemical fertilizers, herbicides, or pesticides could be applied up to six times within a single growing season (McMahon and others 1994). According to Pimentel and Levitan (1986), 75% of household lands and 58% of agricultural (crop) lands were treated with herbicides each year. Those percentages contrast sharply with forest use; only 0.7% of forest lands were treated with herbicides in a typical year (0.1% for National Forest lands).

There are few similarities between herbicide use in forestry and agriculture. Not only are forestry herbicides used infrequently (perhaps once during the 100 to 150 year lifespan of a tree stand), but they are also applied in low amounts. Research and development over the last decade have produced highly selective formulations and improved application techniques. Moreover, a recent emphasis on applicator training by state regulators and professional organizations has helped to ensure that forestry herbicides are applied in a safe and effective manner (McNabb 1991).

Table 7 compares the toxicity of three herbicides with table salt, baking soda, aspirin, gasoline, and other commonly-used substances. It shows that the active ingredients in forestry herbicides have lower toxicity than all of those substances. Although that may seem like a contradiction, it really isn't because herbicides are designed to interact with the metabolism of plants only, and not humans or animals. Since plants photosynthesize and many herbicides operate by interrupting that process, it is not surprising that they have little or no impact on humans and other organisms that do not photosynthesize (McNabb 1991).

Human health risks to workers are associated with exposure to chemicals, and to hazards encountered during the application process. Hand application of herbicides poses some of the same injury and hazard risks described for the manual treatment methods, primarily as related to working in steep, rugged terrain. Herbicide application, by law, must be under the direct supervision of a trained and licensed applicator who follows the label directions. Label directions prescribe proper application rates and conditions, personal protective equipment for workers, spill protection and response measures, and disposal procedures. When followed, the label directions minimize risk to humans and the environment.

Studies are available that measure actual worker doses of herbicide for some typical forestry operations. Applicators using a backpack apparatus to apply Roundup in forest plantations have been monitored for the doses they experienced in actual spray operations. [Roundup is a formulation of glyphosate that is similar to a mix of Accord and Entry II, a surfactant.] The measured doses for workers averaged 1/1000 of the amount that was predicted in the FEIS (USDA Forest Service 1988) for routine applications, and 1/67 the amount predicted for a worst-case application scenario (USDA Forest Service 1997a).

The public could be exposed to herbicides through spray drift, an accident in transit, or dermal contact with treated plants. They could also eat food or drink water containing herbicide residues. Spray drift would be extremely limited or nonexistent with the use of backpack sprayers, which is the only application alternative being considered for this project. To help protect the public from inadvertent exposure, herbicide treatment areas would be signed (see the Mitigation Measures section below).

Table 7: Relative toxicity of proposed herbicides, and other common substances (included for comparison purposes).

TRADE NAME	ACTIVE INGREDIENT	ORAL LD_{50} VALUES (MG/KG)
Accord	Glyphosate	> 5,000
Pathfinder II	Triclopyr	4,200–4,500
Pronone 25G	Hexazinone	> 5,000
For Comparison:	Baking Soda	3,500
	Table Salt	3,000
	Vitamin A	2,000
	Aspirin	1,240
	Malathion (an insecticide)	370
	Caffeine	200
	Gasoline	150
	Nicotine	53

Sources/Notes: LD50 values for comparison substances were taken from McNabb (1991), and McMahon and others (1994). LD50 values for the herbicide formulations were taken from their respective Material Safety Data Sheets. LD50 is the dose that is lethal to 50 percent of a test animal population (usually rats), expressed as milligrams of active ingredient per kilogram of body weight. High LD50 numbers indicate low toxicity; low LD50 numbers indicate high toxicity.

The effects of herbicides on humans is addressed in detail in the Pacific Northwest Region Final Environmental Impact Statement for Managing Competing and Unwanted Vegetation, pages IV-123 to IV-160, and in Appendices D and H, which are incorporated into this document by reference (USDA Forest Service 1988). The Record of Decision found that 13 herbicides, including triclopyr, glyphosate, and hexazinone, could be used with acceptable risk if reasonable precautions were followed.

The FEIS analysis examined the extent of exposure and resultant doses to workers and the public from routine herbicide operations and accidents. Estimates were made for backpack operations for both routine-realistic and routine-worst case scenarios. Risks to humans were quantified by comparing the scenario dose estimates, for both direct and indirect exposures, with doses from toxicity tests conducted on laboratory animals. Refer to the quantitative and qualitative human health risk assessments (Appendices D and H of the FEIS) for detailed information about results from the herbicide exposure assessments. *The projected site-specific exposures for the South Tower herbicide applications would not exceed the conditions modeled in the FEIS risk assessment scenarios*.

In summary, there are sound reasons for using herbicides in the South Tower project area and solid evidence (research results and an FEIS) to address environmental and public concerns. Any individual site would be treated only once or twice in the 100-150 year lifespan of a tree stand, which is a much lower intensity than herbicide usage in agricultural and residential environments. In treated units, only 13% of the ground surface would actually receive any herbicide because it would be applied as small spots around planted seedlings. The direct, indirect, and cumulative risks from herbicides are low due to the nature of the project and its associated mitigation measures (see page 40).

More information about the herbicides is available in the analysis file, including the USDA Herbicide Information Profiles for glyphosate, hexazinone, and triclopyr (USDA Forest Service 1997a, 1992, 1996), the Accord, Pathfinder II, and Pronone 25G product labels, and their respective Material Safety Data Sheets.

Competing Vegetation Treatment Alternatives That Were Considered, But Eliminated From Detailed Study

Competing vegetation alternatives that did not address the project's purpose and need or its key issues are described below, along with the rationale for their elimination from detailed study.

1. A no action alternative was considered but dropped from detailed analysis. A no action strategy is not viable because wildfire initiated or stimulated the germination and growth of competing vegetation, which

means it is already present on the reforestation sites. If not controlled, competing vegetation will interfere with achieving the purpose and need to reforest the project area with an ecologically appropriate mix of tree species. The objective of 70% or more of the planted seedlings being alive after 3 growing seasons would not be met without controlling competing vegetation.

2. An alternative that considered mechanical site preparation was dropped from detailed analysis because mechanical methods can cause adverse impacts on soils and site productivity. Machine scarification has the potential to cause severe soil damage by mixing and displacing organic matter and the upper soil horizons, and by compacting the upper soil layers (Neary and Michael 1996). Even if those impacts could be mitigated, mechanical scarification is not appropriate on steep slopes (those over 30%), shallow soils (depth of 20" or less), or soils with a high rock content (greater than 35%).
3. An alternative that considered biological control methods was dropped from detailed analysis. There are no known biological methods that are effective at controlling the competing vegetation in the South Tower project area. Although research found livestock grazing to be efficacious in some situations (Edgerton 1971, Newsome 1996, Ratliff and Denton 1995, Sharrow 1993), long-term studies generally concluded that grazing was ineffective or questionable as a site preparation or release treatment (McDonald and others 1996). Grazing by cattle and sheep did not prove to be biologically effective in northern California, probably because below-ground competition is not appreciably affected by above-ground browsing (McDonald and Fiddler 1993). Although native pathogenic fungi were tested as mycoherbicides in British Columbia (Wall and Shamoun 1990), no biological agents are currently known to be efficacious for control of competing vegetation in the South Tower project area.
4. An alternative that considered the use of prescribed fire was dropped from detailed analysis. The Tower wildfire consumed much of the woody fuel present in the moderate and high intensity burn areas (the areas being considered for tree planting), which means there is insufficient fuel remaining to carry a fire at the intensity needed to control competing vegetation. Low-intensity (cool) burns are not effective at controlling the competing vegetation present in the South Tower project area (Lotan 1986). In fact, many of the rhizomatous species such as elk sedge, pinegrass, and bracken fern are stimulated by cool burns (TFEA 1997).
5. An alternative that considered aerial application of herbicides was dropped from detailed analysis. Spot herbicide applications with a backpack pump or spreader would be most effective at treating the competing vegetation in an area immediately adjacent to planted seedlings. Although aerial applications can result in higher seedling survival (Oester and others 1995), present lower health risks to workers, and are more economical, they present higher risk of environmental impacts to water quality and fisheries, and are more likely to injure the conifer seedlings (Neary and Michael 1996).
6. An alternative that considered an increased planting density to compensate for expected losses was dropped from detailed analysis. Research found that planting on sites where competing vegetation was not controlled could require 3 to 4 times as many seedlings, along with a corresponding cost increase, to meet a 3-year stocking objective (Hall 1971). Tree planting is costly under normal circumstances (see Table 3); it would be prohibitively expensive if seedlings were planted at triple or quadruple their normal density. Planting at high densities would also result in accelerated use of scarce seed and seedling supplies, which means that fewer acres could be planted in any given year and that some sites would be planted later than they otherwise would have been, thereby exacerbating their competing vegetation problems.

Preferred Treatments for Control of Competing Vegetation

The preferred treatment for control of competing vegetation varies by treatment strategy. For the 94 reforestation units that are not expected to exceed the threshold, the early treatment strategy is appropriate and competing vegetation will be treated with an 18" square scalp. For the 57 reforestation units that are predicted to exceed the threshold, the correction strategy will be implemented by applying herbicides (see Table 9).

Application of non-phenoxy herbicides such as Accord, Pathfinder, and Pronone was the most efficacious treatment alternative for correction sites (Table 8). Herbicides are biologically effective on all seven species of competing vegetation, they are the most cost effective of the six treatment options that were evaluated in detail (see Table 3), they provide the quickest results in terms of seedling survival, and they have the longest lasting effect on competing vegetation when considering just a single treatment (Ross and others 1986).

Table 8: Efficacy summary for treatment methods for control of competing vegetation.

TREATMENT METHOD	NUMBER OF TREATMENTS	LIKELIHOOD OF SUCCESS	COMMENTS
18” Square Scalp	1	Low	Only effective as an early treatment
48” Square Scalp	2	Medium	Provides short-term control of grasses and sedges
Clipping/Cutting	2	Low	Effective for non-sprouting shrubs only
Grubbing	2	Medium	Not effective for rhizomatous or sprouting plants
Herbicides	1	High	For rhizomatous, sprouting, or non-sprouting plants
Mulch Mats	1	Medium/High	Effective when used early; otherwise, generally not
Pulling	1–2	Low	Only effective for small shrubs of seedling origin

Sources/Notes: ‘number of treatments’ refers to the number of times that a method would have to be used to meet the seedling survival and stocking objectives. ‘Likelihood of success’ ratings are: High = greater than a 75% chance that 70% or more of the planted seedlings will survive at least 3 growing seasons, and that plantations will have at least 150 trees/acre at the time of certification; Medium = 50-75% chance; Low = less than a 50% chance.

Manual treatment methods, particularly grubbing and scalping, can be effective in certain situations. Grubbing or hand pulling are effective in shrub communities that originated from seed rather than sprouts, although either one must be completed when the plants are small. Scalping or grubbing are not recommended for control of grasses and sedges because either of those treatments could promote germination of stored (on-site) seed and thereby increase grass abundance. Neither grubbing nor scalping are effective at treating bracken fern, which has deep rhizomes situated up to 20 inches below the soil surface.

Mulch mats may also be highly effective, especially as an early treatment before competing vegetation has had a chance to fully develop. Mats are not suitable for shrubs beyond the seedling stage because the mat must be in contact with the ground to be effective, and that is seldom possible with taller shrubs. Mulch mats can be expensive (see Table 3) and require periodic maintenance to ensure that they do not come loose and smother the seedling. Recreationists and other visitors to the Forest could find mats to be aesthetically objectionable due to their dark color and regular geometric (unnatural) shape.

Smaller mats (such as 3’ x 3’ VisPore) have been found to be ineffective, so current practice involves larger mats (5’ x 5’ or 6’ x 6’) made of woven plastic (personal communication, Tim Grace, Bend/Fort Rock Ranger District). Preliminary results from a study in the Blue Mountains found mulch mats to be as effective, if not more effective, than herbicides (personal communication, Paul Oester, Oregon State University Extension Service). As a result of those findings, the Umatilla National Forest is considering the use of mulch mats on selected reforestation units in the Tower fire to evaluate their effectiveness and to gain first-hand experience in their installation and maintenance.

The analysis file contains three maps that display the reforestation and competing vegetation treatments associated with this analysis. Map 1A shows the reforestation units that would be managed using the correction strategy for competing vegetation (application of herbicides); map 1B shows South Tower/Big Tower reforestation units that would be managed using the early treatment competing vegetation strategy (18” scalps); and map 1C shows replanting of previously-established plantations that were burned in the Tower fire – they will also receive an early treatment (18” scalps).

Mitigation Measures for the Competing Vegetation Correction Strategy

The FEIS quantitative risk assessment (see appendix D in USDA Forest Service 1988) predicted the amount of human exposure – both to project workers and the public – from typical forestry herbicide operations, and also from a large accidental spill. The risk assessment compared predicted health risks to established EPA standards of acceptable risk for human health effects. Any herbicide operations that exceeded the EPA standards were identified as a ‘moderate’ or ‘high’ risk. Specific mitigation measures were then designed to reduce human exposure from such operations; they are mandatory for every applicable project on National Forest System lands.

The following 34 mitigation measures pertain to application of herbicides within South Tower/Big Tower reforestation units that are predicted to exceed the 30% canopy coverage threshold.

1. Seedlings will be protected from direct spray during herbicide application.
2. A Human Health Risk Management Plan will be developed, including: A Project Risk Plan, An Environmental Monitoring Plan, A Spill Incident Response Plan, and an Herbicide Application Plan.
3. Adjacent water users and landowners who could be directly affected by stream transport of herbicides, or an accidental spill, will be notified prior to any chemical application (normally 15 days prior).
4. Permittees grazing cattle in or near the proposed herbicide areas will be provided with advance notification of the treatment schedule. They will be given a two-week warning before any herbicide applications occur.
5. All applicable state and federal laws, including the labeling requirements of the Environmental Protection Agency (EPA), will be strictly followed.
6. Herbicides will be applied within the prescribed environmental conditions stated on the label and in permits issued to licensed applicators.
7. Herbicides will not be applied when wind speeds are such that the material leaves the application zone (a 3-foot radius around each seedling).
8. Herbicide applications will be conducted in accordance with direction in the Forest Service's Environmental Management Manual, chapter 2150 (Pesticide-Use Management and Coordination).
9. Forest Service Handbook 2109.14 (Pesticide-Use Management and Coordination) will be used to direct project planning. This handbook establishes procedures to guide managers in planning, organizing, conducting, and reporting pesticide use projects. It also provides direction for herbicide storage facilities, posting, handling, accountability, and transportation, as well as spill prevention, planning, cleanup, and container disposal requirements.
10. All contractors will be required to be licensed pesticide applicators or commercial operators. The Pesticide Applicator Licensing and Training program administered by the Oregon Department of Agriculture will be used to evaluate this requirement. Training and testing of applicators includes information about laws and safety, protection of the environment, handling and disposal, pesticide formulations and application methods, calibration of application devices, use of labels and material safety data sheets, first aid, and recognition of pesticide exposure symptoms.
11. Protective clothing will be worn by all workers (both Forest Service employees and contract workers) involved in herbicide mixing, loading, and backpack applications.
12. A Forest Service representative will be on site whenever herbicide mixing or application occurs.
13. Public notification will be used for all applications, requesting that people who know or suspect that they are hypersensitive to herbicides contact the local Forest Service office to determine appropriate risk management measures.
14. Workers (both Forest Service and contract) who know that they are hypersensitive to herbicides will not be used for application projects. Workers who display symptoms of hypersensitivity to herbicides during application will be removed from the project.
15. Material Safety Data Sheets will be posted at chemical storage facilities, in vehicles, and made available to workers. The sheets provide physical and chemical data, fire and reactivity information, specific health hazard warnings, spill or leak procedures, instructions for worker hygiene, and any special precautions.
16. The Material Safety Data Sheets, Herbicide Specimen Labels, and R6 Herbicide Information Profiles will be used to ensure that all employees and workers are fully informed about the potential effects and correct mitigation measures for the herbicides being used.
17. Project safety will be guided by Forest Service Handbook 6709.11 (Health and Safety Code, Chapter 9). This handbook establishes basic safety procedures, and discusses safety aspects of the storage, transportation, and disposal of the herbicides.
18. Both worker and public exposure monitoring is required for all herbicide application projects. Pertinent details will be documented, including the herbicides used, land areas treated, dates and times of application, people involved, and mitigation measures that were followed.
19. Any employee not wanting exposure to the herbicides glyphosate, hexazinone, or triclopyr will be given alternate work assignments that do not involve direct contact with the herbicides. There are many assignments, even in an herbicide project, that do not involve direct contact with herbicides.

20. Each worker (Forest Service or contract employee) shall be informed of any known potential human health effect associated with the herbicides being used. Notification shall occur prior to initiation of the project. Each worker will be provided with a copy of the relevant Herbicide Information Profiles produced by the Pacific Northwest Region. Prior to project initiation, each worker shall sign a statement indicating that he or she has reviewed the materials, and either agrees to work on the project as assigned, or requests a reassignment to other duties.
21. All herbicide application projects shall have available at the work site a permanent or portable eyewash unit and other washing facilities, including a supply of uncontaminated water and soap that is sufficient to wash hands as required, and to wash the entire body in the event of accidental contact with herbicides.
22. All workers shall have a complete change of clothes available at the work site in case of accidental exposure to herbicides. A complete set of clean clothes shall be worn daily.
23. Where premixed packages exist in operationally efficient quantities for the herbicide formulations selected for use, they shall be used. When effective, exposure-reducing equipment such as drip-free couplings and nozzle shields for hand-held spray wands shall be used in both Forest Service and contract operations.
24. For all backpack applications of herbicide, the following personal protective equipment made from materials impervious to the herbicide shall be available at the job site for each worker: overpants and jacket or coveralls, hood, unlined gloves, face shields, and goggles. These items may be either disposable or reusable; in either case, they must be used in accordance with the manufacturer's requirements and may not be used beyond the manufacturer's recommended wear-times. Workers may elect to use all or any of these items. However, impervious gloves and rubber boots (which may be the responsibility of the worker to provide) as well as any other items required by the herbicide labels or material safety data sheets must always be worn. Contracts for herbicide application shall include a provision that specifies the personal protective equipment described here.
25. Precautions will be taken to ensure that equipment used for storage, transport, mixing, or application will not leak herbicides into surface water or the soil. Areas used for mixing herbicides and cleaning equipment shall be located where spillage will not run into surface waters or result in ground water contamination.
26. Designated locations for mixing herbicides must be at least 300 feet away from streams and stream channels. The Forest Service will designate all water drafting and mixing locations prior to project initiation.
27. Applications must not take place within 6 hours of predicted rainfall. Spot weather forecasts will be made available to the applicator.
28. Streams or other surface waters must not be used for washing equipment or personnel.
29. To minimize the risk of contamination, a separate water truck will be required for drafting water for mixing. The chemical mix truck will not be used for drafting water from approved sources.
30. No herbicide applications will occur within designated Riparian Habitat Conservation Areas (300 feet on each side of class 1 and 2 streams; 150 feet on each side of class 3 streams; 100 feet on each side of class 4 streams). In order to minimize the potential for a spill into surface waters, applicators will not travel through RHCAs (except by road) when transporting herbicide application equipment (backpack sprayers) and herbicides from one treatment area to another.
31. When transporting more than 120 gallons of herbicide concentrate or 2,000 gallons of mix or ready-to-use formulation on forest roads, a pilot vehicle will be used. Truck drivers shall be briefed on all haul route hazards, defensive driving, the project safety plan, and the Spill Incident Response Plan.
32. Full and empty herbicide containers must remain in locked storage. Containers will be checked frequently for leaks, tears, or loose lids. If containers are in poor condition, contents will be transferred to a suitable container and labeled properly. The labels of herbicide containers will be protected to maintain their legibility. Herbicides will be stored away from pesticides or fertilizers.
33. All known occurrences of endangered, threatened, or sensitive plant or animal species in the project area will be protected by means of avoidance, including any occurrences identified during the course of a project.
34. To help protect the public from inadvertent exposure to herbicides, warning signs will be posted in areas where herbicide applications have occurred. The signs will be posted along roads, trails, or other routes where people would be likely to gain access to a treated area. Signing will provide information about the treatment date, name of the herbicide(s) that were applied, and who to contact for further information

about the project. The public and Forest Service employees will be excluded from treated areas during any restricted entry intervals (REI) required by the herbicide label.

Monitoring Associated With the Competing Vegetation Correction Strategy

Monitoring is essential for implementation of the preferred alternative for control of competing vegetation. This section describes monitoring objectives and methods as related to application of herbicides within 57 reforestation units (see Table 9).

Monitoring Objectives:

- To assess effectiveness of the project in terms of achieving satisfactory control of competing vegetation, and acceptable survival of planted seedlings.
- To provide information and empirical experience that could improve future project planning.
- To ensure that appropriate application and safety procedures are followed during project implementation.
- To ensure that project implementation does not result in adverse impacts on non-target components of the forest environment.

Monitoring Methods:

Quality Control Monitoring. The project coordinator will ensure that the project is implemented according to the project plans, application procedures, and safety measures specified in the "Mitigation Measures for the Competing Vegetation Correction Strategy" section of this report. Monitoring the human health effects of this project will be accomplished by recording the following information:

- Description of the treatment method, herbicide identity, formulation, manufacturer, mixture, and application method.
- The name of each person who worked on the project, their assignment, training received, dates of actual work, and personal protective equipment used.
- Specific details about exposure incidents, accidents, and worker health complaints.

Effectiveness Monitoring. The North Fork John Day Ranger District will establish evaluation plots within selected reforestation units where herbicides are to be applied. A representative plot of one-half acre or more in size will be designated as a no-treatment area in each sample unit. Site-specific, post-treatment information will be gathered from both herbicide-treated and untreated portions of the sample units during the 1st, 3rd, and 5th year survival and stocking surveys, as follows:

- Efficacy of the herbicide treatment as related to seedling survival and growth.
- Efficacy of the herbicide treatment as related to vegetative response, such as changes in species composition and canopy coverage.
- Recovery rates of the competing vegetation plant species.
- Discernable effects on non-target vegetation species.
- Indications that herbicides are moving out of the application zone, such as the death of susceptible plant species beyond a 3-foot radius around treated seedlings.
- Effectiveness of mitigation measures used on the unit.
- Other information that would improve any future projects of the same nature.

Other, Site-Specific Monitoring. It is anticipated that herbicides would be applied by a contractor. To ensure contract compliance, a variety of items would be monitored by the Contracting Officer's Representative and by designated inspectors on each treated site, for every day of operation. The methods of contract monitoring would include visual inspections, sample plot measurements, and communications with contractors and their representatives. Some monitoring items would include:

- Assurance that application procedures and safety measures are followed, as specified in the "Mitigation Measures for the Competing Vegetation Correction Strategy" section of this report.
- Assurance that all mitigation measures are discussed and understood by contractor and their representatives at the pre-work meeting.

- Assurance that sufficient equipment, personnel, and material are always available to implement the spill management plan.
- A colorant or dye will be added to liquid herbicide mixtures in order to monitor the effectiveness of spot applications in terms of their size, configuration, and distance from designated no-spray zones.
- Water quality and soils monitoring may occur in a sample of treated units, or in flowing or standing waters located adjacent to treated areas.

Table 9: Vegetation Management Plan for the South Tower Project Area (planting units only).

	NFS Acreage:				Slp		Fire Inten			Plant	Competing Vegetation Results:			
Unit	**Tot**	**Rip**	**Up**	**Elev**	**Pct**	**Asp**	**Mod**	**High**	**PAG**	**Year**	**Thresh**	**Strategy**	**Treat1**	**Treat2**
BT01	11	2	9	3972	7	SO	0	0	PP	1998	<30%	Early Treat	18scalp	
BT02	96	5	91	4277	26	SW	40	0	WD	1998	<30%	Early Treat	18scalp	
BT03	27	16	11	4425	13	SW	27	0	WD	1998	<30%	Early Treat	18scalp	
BT04	36	9	27	4618	23	SW	36	0	WD	1998	<30%	Early Treat	18scalp	
BT05	56	3	53	4730	28	SO	39	0	WD	1998	<30%	Early Treat	18scalp	
BT06	137	1	136	5181	11	NW	112	25	WD	1998	<30%	Early Treat	18scalp	
BT08	344	66	278	4379	16	SO	209	70	WD	1998	<30%	Early Treat	18scalp	
BT10	61	3	58	5002	16	SO	61	0	WD	1998	<30%	Early Treat	18scalp	
BT11	33	0	33	5015	14	WE	33	0	WD	1998	<30%	Early Treat	18scalp	
BT13	14	1	13	4890	17	SW	14	0	PP	1998	<30%	Early Treat	18scalp	
BT14	54	2	52	4851	24	NE	52	2	WD	1998	<30%	Early Treat	18scalp	
BT15	16	0	16	4733	24	SW	15	1	PP	1998	<30%	Early Treat	18scalp	
BT16	14	1	13	5455	5	SO	7	7	WD	1998	<30%	Early Treat	18scalp	
BT17	28	0	28	4742	29	SO	25	0	PP	1999+	>30%	Correction	Herb	48s/IPD
BT18	5	2	3	4064	2	LE	5	0	PP	1999+	>30%	Correction	Herb	48s/IPD
BT19	5	0	5	4205	6	WE	5	0	CM	1999+	>30%	Correction	Herb	48s/IPD
BT20	8	0	8	4205	1	LE	8	0	CM	1999+	>30%	Correction	Herb	48s/IPD
DG01	102	15	87	5407	34	SO	79	0	PP	1999+	>30%	Correction	Herb	48s/IPD
DG02	15	1	14	5252	30	SW	15	0	WD	1999+	>30%	Correction	Herb	48s/IPD
DG03	6	1	5	5051	23	SW	6	0	WD	1999+	>30%	Correction	Herb	48s/IPD
DG05	43	2	41	5135	30	SW	43	0	WD	1999+	>30%	Correction	Herb	48s/IPD
DG06	105	9	96	5033	6	WE	105	0	CM	1999+	>30%	Correction	Herb	48s/IPD
DG08	86	2	84	4990	14	SW	86	0	WD	1999+	>30%	Correction	Herb	48s/IPD
DG09	53	4	49	4724	16	SO	51	2	PP	1999+	>30%	Correction	Herb	48s/IPD
DG10	118	4	114	4827	12	SO	112	0	PP	1999+	>30%	Correction	Herb	48s/IPD
DG13	45	1	44	4216	36	EA	13	11	WD	1999+	>30%	Correction	Herb	48s/IPD
DG14	31	4	27	4339	27	EA	21	10	WD	1999+	>30%	Correction	Herb	48s/IPD
DG15	83	0	83	5292	42	SW	83	0	WD	1999+	>30%	Correction	Herb	48s/IPD
DG16	40	0	40	5514	37	SW	40	0	PP	1999+	>30%	Correction	Herb	48s/IPD
DG18	26	0	26	4683	28	SW	14	0	WD	1999+	>30%	Correction	Herb	48s/IPD
DG19	100	3	97	4648	33	SW	79	11	PP	1999+	>30%	Correction	Herb	48s/IPD
DG20	30	2	28	5112	14	WE	26	4	WD	1999+	>30%	Correction	Herb	48s/IPD
DG21	53	1	52	5028	38	WE	35	5	WD	1999+	>30%	Correction	Herb	48s/IPD
DG22	36	5	31	5438	26	NW	13	23	WD	1999+	>30%	Correction	Herb	48s/IPD
DG23	41	0	41	5371	24	WE	2	38	WD	1999+	>30%	Correction	Herb	48s/IPD
DG24	24	1	23	5109	47	SE	23	1	WD	1999+	>30%	Correction	Herb	48s/IPD
DG25	29	0	29	5096	32	SW	26	0	WD	1999+	>30%	Correction	Herb	48s/IPD
DG26	16	0	16	5551	12	NO	15	1	CM	1999+	<30%	Early Treat	18scalp	
DG27	84	4	80	5482	22	SO	27	52	WD	1999+	>30%	Correction	Herb	48s/IPD
DG28	42	0	42	5622	5	WE	1	41	WD	1999+	>30%	Correction	Herb	48s/IPD
DG29	19	0	19	4577	48	EA	19	0	WD	1999+	<30%	Early Treat	18scalp	
DG30	18	2	16	5203	30	SE	18	0	WD	1999+	>30%	Correction	Herb	48s/IPD
DG34	78	3	75	5351	19	WE	29	49	WD	1999+	>30%	Correction	Herb	48s/IPD
DG35	56	6	50	5029	47	SE	38	0	WD	1999+	>30%	Correction	Herb	48s/IPD
DG37	94	0	94	4909	37	WE	86	3	WD	1999+	>30%	Correction	Herb	48s/IPD
DG38	34	2	32	4069	29	WE	23	11	WD	1999+	>30%	Correction	Herb	48s/IPD
DG39	7	0	7	4244	41	NW	6	1	WD	1999+	>30%	Correction	Herb	48s/IPD
DG40	21	0	21	5191	10	SW	21	0	PP	1999+	>30%	Correction	Herb	48s/IPD
JW01	39	7	32	4751	19	SO	38	0	PP	1998	<30%	Early Treat	18scalp	
JW02	33	5	28	4902	24	SE	33	0	WD	1998	<30%	Early Treat	18scalp	
JW04	43	13	30	4934	11	WE	43	0	WD	1998	<30%	Early Treat	18scalp	
JW05	38	0	38	5181	14	SE	38	0	WD	1998	<30%	Early Treat	18scalp	
JW06	24	0	24	5264	44	EA	24	0	WD	1997	<30%	Early Treat	18scalp	
JW07	26	4	22	5216	32	SW	26	0	WD	1998	<30%	Early Treat	18scalp	
JW08	33	10	23	5423	27	SW	24	0	WD	1998	<30%	Early Treat	18scalp	
JW09	23	0	23	5090	39	NE	0	23	WD	1997	<30%	Early Treat	18scalp	
JW10	29	15	14	5021	35	SW	26	3	WD	1997	<30%	Early Treat	18scalp	
JW11	38	13	25	5201	19	WE	20	18	WD	1997	<30%	Early Treat	18scalp	
JW12	29	3	26	4827	31	NO	0	29	WD	1997	<30%	Early Treat	18scalp	

Unit	NFS Acreage: Tot	Rip	Up	Elev	Slp Pct	Asp	Fire Inten Mod	High	PAG	Plant Year	Competing Vegetation Results: Thresh	Strategy	Treat1	Treat2
JW13	21	6	15	5297	14	SO	21	0	PP	1997	<30%	Early Treat	18scalp	
JW15	36	8	28	4561	19	WE	36	0	WD	1997	<30%	Early Treat	18scalp	
JW16	39	3	36	4187	9	SW	39	0	PP	1997	<30%	Early Treat	18scalp	
JW17	44	6	38	4290	9	WE	16	27	WD	1997	<30%	Early Treat	18scalp	
JW18	24	3	21	3705	31	NE	8	0	WD	1998	<30%	Early Treat	18scalp	
JW21	39	5	34	4093	8	NW	39	0	WD	1997	<30%	Early Treat	18scalp	
JW23	27	4	23	3983	2	LE	0	0	PP	1997	<30%	Early Treat	18scalp	
JW27	39	3	36	4043	13	SE	0	0	WD	1997	<30%	Early Treat	18scalp	
JW28	26	5	21	3820	10	SW	0	0	WD	1997	<30%	Early Treat	18scalp	
JW29	23	3	20	4777	11	SW	0	0	WD	1998	<30%	Early Treat	18scalp	
JW31	29	3	26	4869	34	NW	3	26	WD	1997	<30%	Early Treat	18scalp	
JW32	37	2	35	4741	34	WE	0	0	WD	1997	<30%	Early Treat	18scalp	
JW33	34	3	31	4839	28	SW	34	0	WD	1997	<30%	Early Treat	18scalp	
JW34	36	13	23	4205	23	SW	35	1	WD	1997	<30%	Early Treat	18scalp	
JW36	40	5	35	4721	38	NO	0	40	WD	1997	<30%	Early Treat	18scalp	
JW37	35	8	27	4963	16	SW	35	0	WD	1998	<30%	Early Treat	18scalp	
LS01	30	1	29	5503	18	NE	3	27	CM	1999+	<30%	Early Treat	18scalp	
LS02	150	14	136	5446	6	NE	116	33	CD	1999+	<30%	Early Treat	18scalp	
LS03	125	7	118	5530	7	SE	125	0	CD	1999+	<30%	Early Treat	18scalp	
LS04	199	10	189	5510	9	NO	199	0	WD	1999+	<30%	Early Treat	18scalp	
LS05	17	0	17	5283	19	NO	15	0	PP	1999+	<30%	Early Treat	18scalp	
LS06	184	3	181	5586	10	NO	52	0	PP	1999+	<30%	Early Treat	18scalp	
LS08	48	1	47	5401	11	NE	48	0	WD	1999+	<30%	Early Treat	18scalp	
OL02	34	1	33	4200	8	NO	34	0	CM	1999+	>30%	Correction	Herb	48s/IPD
OL03	115	12	103	4240	10	WE	115	0	WD	1999+	>30%	Correction	Herb	48s/IPD
OL04	65	4	61	4584	17	WE	65	0	WD	1999+	>30%	Correction	Herb	48s/IPD
OL05	47	7	40	4857	25	SW	47	0	WD	1999+	>30%	Correction	Herb	48s/IPD
OL06	74	0	74	5261	21	SW	74	0	PP	1999+	>30%	Correction	Herb	48s/IPD
OL07	19	3	16	5044	31	SW	14	5	PP	1999+	>30%	Correction	Herb	48s/IPD
OL08	40	2	38	4657	31	SO	21	19	PP	1999+	>30%	Correction	Herb	48s/IPD
OL09	51	4	47	4595	31	NW	6	45	WD	1999+	>30%	Correction	Herb	48s/IPD
OL10	43	3	40	4845	29	WE	43	0	WD	1999+	>30%	Correction	Herb	48s/IPD
OL11	85	3	82	5020	27	SW	74	11	PP	1999+	>30%	Correction	Herb	48s/IPD
OL12	49	2	47	4028	13	SW	5	0	PP	1999+	>30%	Correction	Herb	48s/IPD
OL13	87	2	85	5303	16	SW	87	0	PP	1999+	>30%	Correction	Herb	48s/IPD
OL14	46	5	41	4477	38	NW	46	0	WD	1999+	>30%	Correction	Herb	48s/IPD
OL15	8	1	7	4924	20	WE	5	3	WD	1999+	>30%	Correction	Herb	48s/IPD
OL16	63	1	62	5102	18	SO	59	4	PP	1999+	>30%	Correction	Herb	48s/IPD
OL17	58	9	49	4807	36	SO	0	58	PP	1999+	>30%	Correction	Herb	48s/IPD
OL18	31	3	28	5462	12	NW	12	0	WD	1999+	>30%	Correction	Herb	48s/IPD
OL19	83	5	78	5198	28	WE	32	44	WD	1999+	>30%	Correction	Herb	48s/IPD
OL20	39	2	37	4869	27	NO	0	39	WD	1999+	>30%	Correction	Herb	48s/IPD
OL21	16	0	16	5142	31	NO	0	16	WD	1999+	>30%	Correction	Herb	48s/IPD
OL22	28	0	28	5229	31	NE	1	27	WD	1999+	>30%	Correction	Herb	48s/IPD
OL23	23	1	22	5050	31	NE	0	23	WD	1999+	>30%	Correction	Herb	48s/IPD
OL24	26	10	16	4929	23	WE	25	1	WD	1999+	<30%	Early Treat	18scalp	
OL25	63	8	55	5186	25	WE	59	3	WD	1999+	<30%	Early Treat	18scalp	
OL26	19	3	16	5363	33	SW	12	0	WD	1999+	>30%	Correction	Herb	48s/IPD
OL27	18	12	6	5434	19	NW	12	0	CM	1999+	<30%	Early Treat	18scalp	
OL28	46	3	43	5600	16	WE	1	0	WD	1999+	<30%	Early Treat	18scalp	
OL30	30	3	27	5181	14	NW	28	2	WD	1999+	<30%	Early Treat	18scalp	
PC01	1	0	1	5410	1	LE	1	0	CM	1997	<30%	Early Treat	18scalp	
PL04	13	2	11	4446	51	SE	0	0	WD	1998	<30%	Early Treat	18scalp	
PL05	21	7	14	5534	32	EA	3	0	WD	1997	<30%	Early Treat	18scalp	
PL06	21	4	17	5216	29	SW	21	0	WD	1998	<30%	Early Treat	18scalp	
PL07	31	0	31	5045	20	SW	31	0	PP	1998	<30%	Early Treat	18scalp	
PL08	23	0	23	5576	11	WE	2	20	CD	1997	<30%	Early Treat	18scalp	
PL09	70	3	67	5585	15	NE	66	4	CD	1998	<30%	Early Treat	18scalp	
PL11	14	0	14	5462	13	SE	14	0	CD	1998	<30%	Early Treat	18scalp	
PL12	36	4	32	4577	22	EA	36	0	WD	1997	<30%	Early Treat	18scalp	
PL13	24	0	24	4270	47	EA	24	0	WD	1997	<30%	Early Treat	18scalp	
PL15	29	0	29	5282	30	SO	29	0	WD	1998	<30%	Early Treat	18scalp	

	NFS Acreage:				Slp		Fire Inten			Plant	Competing Vegetation Results:			
Unit	**Tot**	**Rip**	**Up**	**Elev**	**Pct**	**Asp**	**Mod**	**High**	**PAG**	**Year**	**Thresh**	**Strategy**	**Treat1**	**Treat2**
PL16	32	0	32	5036	11	SE	32	0	PP	1998	<30%	Early Treat	18scalp	
PL18	5	0	5	4839	17	WE	5	0	WD	1998	<30%	Early Treat	18scalp	
PL19	39	3	36	4945	31	SO	35	2	PP	1997	<30%	Early Treat	18scalp	
PL20	45	5	40	4391	26	SW	39	3	PP	1998	<30%	Early Treat	18scalp	
PL21	69	1	68	5514	8	SW	59	10	WD	1998	<30%	Early Treat	18scalp	
PL23	16	2	14	4740	44	NW	14	0	CM	1998	<30%	Early Treat	18scalp	
PL24	14	0	14	4499	35	NW	14	0	WD	1998	<30%	Early Treat	18scalp	
PL25	32	0	32	4222	35	WE	26	6	WD	1998	<30%	Early Treat	18scalp	
PL26	6	0	6	3856	45	SE	0	5	PP	1997	<30%	Early Treat	18scalp	
PL29	21	13	8	3655	41	WE	0	0	PP	1998	<30%	Early Treat	18scalp	
PL30	20	1	19	4827	8	SW	20	0		1998	<30%	Early Treat	18scalp	
PL31	42	5	37	4513	33	SO	18	22	WD	1997	<30%	Early Treat	18scalp	
PL32	25	0	25	4340	31	WE	25	0	WD	1998	<30%	Early Treat	18scalp	
PL34	72	2	70	4352	28	SE	0	0	PP	1998	<30%	Early Treat	18scalp	
PL36	25	3	22	5117	33	WE	24	0	WD	1998	<30%	Early Treat	18scalp	
PL39	34	0	34	4976	10	WE	34	0	WD	1998	<30%	Early Treat	18scalp	
PL40	29	1	28	5155	16	WE	20	9	WD	1998	<30%	Early Treat	18scalp	
ST01	84	12	72	5087	16	SO	0	25	WD	1999+	<30%	Early Treat	18scalp	
ST02	56	6	50	5156	16	SE	0	38	WD	1999+	<30%	Early Treat	18scalp	
ST03	46	2	44	5059	6	SO	1	0	LP	1999+	<30%	Early Treat	18scalp	
ST04	176	12	164	5061	7	SO	1	28	LP	1999+	<30%	Early Treat	18scalp	
ST06	12	0	12	5074	12	SE	0	0	LP	1999+	<30%	Early Treat	18scalp	
ST07	18	1	17	5111	23	WE	0	0	LP	1999+	<30%	Early Treat	18scalp	
ST08	22	2	20	5016	11	NW	0	0	LP	1999+	<30%	Early Treat	18scalp	
ST09	6	0	6	4996	10	NO	0	0	LP	1999+	<30%	Early Treat	18scalp	
ST10	19	0	19			SE	19	0	WD	1999+	<30%	Early Treat	18scalp	
ST12	7	0	7	5206	25	NW	0	0	LP	1999+	<30%	Early Treat	18scalp	
ST13	3	0	3	5155	20	NW	0	0	LP	1999+	<30%	Early Treat	18scalp	
ST14	3	3	0			SE	3	0	LP	1999+	<30%	Early Treat	18scalp	
ST15	8	0	8	3961	32	WE	0	0	WD	1999+	>30%	Correction	Herb	48s/IPD
Total	4015	425	3590	(A total of 94 reforestation units)							<30%	Early Treat	18scalp	
Total	2677	147	2530	(A total of 57 reforestation units)							>30%	Correction	Herb	48s/IPD

Sources/Notes: **Unit** is the reforestation unit identifier as shown on the maps; **NFS** (National Forest System) **Acreage** shows the total (**Tot**), riparian (**Rip**), and upland (**Up**) acres in each unit; elevation (**Elev**), slope percent (**Slp Pct**), and aspect (**Asp**) were derived using the Arc GIS software and a digital elevation model; the fire intensity (**Fire Inten**) fields show the moderate (**Mod**)- and **High**-intensity burn acreages for each unit; **PAG** is plant association group (see TFEA (1997) for more information); **Plant Year** shows the predicted year in which planting would occur; **Thresh** shows whether the unit is predicted to exceed the 30% canopy cover threshold at the time of planting; **Strategy** shows the competing vegetation strategy predicted for the unit; **Treat1** is the preferred competing vegetation treatment selected for the unit; **Treat2** is the treatment that would be implemented for Correction units if herbicides cannot be used. Early Treat = Early Treatment; 18scalp = 18" square hand scalp; Herb = Application of herbicides; 48s/IPD = 48" square scalp in conjunction with an Increased Planting Density (436 trees per acre) to compensate for lower-than-normal survival. Note: the first two letters of the Unit identifier refer to the project name, as follows: BT – units located in the Big Tower project area, but outside of proposed salvage areas; DG – units located in the proposed Dragon salvage sale; JW – units located in the old Junewood sale area (these were established plantations destoyed by the Tower fire; they are now being replanted); LS – units located in the proposed Lone Salvage sale; OL – units located in the proposed Overlook salvage sale; PC – one small unit located near the Pearson Cabin summer home site; PL – units located in the old Placer sale area (these were established plantations destroyed by the Tower fire; they are now being replanted); ST – units located in the proposed South Tower salvage areas (this project).

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