3.7. Economic Efficiency

3.7.1. Existing Conditions

Economic Impacts of Invasive Plants

Invasive plants (noxious weeds) have an enormous impact on Oregon's economy and natural resources. In 1999, Oregon Department of Agriculture (ODA) partnered with Oregon State University (OSU) to study the economic impacts of 21 of the 99 invasive plants listed in Oregon as noxious (See Appendix I – Oregon State Class A & B Noxious Weeds). Existing populations of these 21 species presently reduce Oregon's total personal income by about 83 million dollar, the equivalent of 3,329 annual jobs lost to Oregon's economy from the production foregone by the presence of these invasive plants. The continued expansion of these species could further reduce Oregon's personal income by another 54 million dollar, the equivalent of another 2,143 jobs lost. The total economic loss is much higher. The study estimated that the existing populations and potential expansion of these 21 species cost 100 million dollar annually in lost economic value. This is equivalent to an asset value of about one billion dollars lost. In other words, the value of Oregon's resources is reduced by approximately one billion dollars because of these weeds (The Research Group, 2000). Of the 21 invasive plants highlighted for economic evaluation by ODA and OSU, seven of the species are present in the Forest and Scenic Area and are targets of this proposal: tansy ragwort, spotted knapweed, diffuse knapweed, yellow starthistle, Scotch broom, rush skeletonweed, and orange hawkweed.

By out-competing and displacing economically valuable native plants, invasive plants deprive the marketplace of an important product and affect employment. The region's non-timber forest product industry was estimated to have a value of more than $190 million in 1992 (Oregon Public Broadcasting, 2005). Schlosser and Blatner (1994) estimated that special forest products contribute $200 million or more annually to the Pacific Northwest (Idaho, Oregon, Washington) economy, much of it from the western parts of Oregon and Washington. The largest component is floral greens and Christmas ornamental products with a wholesale value in 1988 estimated to be $130 million. The portion of this total value attributed to wild edible mushrooms in 1992 was estimated to be $20.3 million (Hansis, 1998). The value of exported wild mushrooms, mostly to Germany and Japan, is estimated to be $6 million annually (Oregon Public Broadcasting, 2005). This economic overview is relevant to the project analysis because non-timber forest products harvested from the Forest are part of a regional economic engine.

Table 3-8 displays the number and cost of special forest product permits sold by the Mt. Hood National Forest for fiscal years 2003, 2004, and 2005 (federal fiscal year = October 1 through September 30). The table does not include free-use permits. Many free, personal-use mushroom permits are issued each year.

Table 3-8: Special Forest Products Summary for the Forest – Fiscal Years 2003, 2004, and 2005.

Product	FY 2003		FY 2004		FY 2005	
	Permits Issued	Cost of Permits	Permits Issued	Cost of Permits	Permits Issued	Cost of Permits
Beargrass	746	$20,970.00	761	$24,006.00	727	$23,575.00
Boughs	35	$56,257.17	25	$76,870.43	21	$42,460.00
Cones	2	$40.00	0	$0.00	2	$40.00
Firewood	2016	$49,110.00	1735	$42,760.00	1342	$30,240.00
Medicinal	3	$95.00	5	$110.00	2	$57.00
Mushrooms	91	$1,884.00	546	$14,150.00	187	$4,111.34
Poles	10	$395.37	14	$613.02	11	$951.18
Posts/Rails	3	$53.05	1	$22.80	0	$0.00
Salal/Forest Greens	36	$956.29	61	$2,705.00	41	$1,210.00
Shakebolts	10	$2,361.21	6	$745.83	6	$1,246.00
Stems	11	$227.23	6	$14,454.00	7	$179.08
Transplants	11	$1,517.90	2	$221.25	5	$480.96
Christmas Trees	5878	$29,747.00	4726	$24,137.00	6064	$28,029.50
Total	**8852**	**$163,614.22**	**7888**	**$200,795.33**	**8415**	**$132,580.06**

Employment

Unemployment rates in the state of Oregon have fluctuated considerably during the past several years. Also, they have been higher than the national average. According to the U.S. Department of Labor Bureau of Labor Statistics (2005), Oregon's seasonally adjusted unemployment rate (preliminary) in August 2005 was 6.7 percent. The preliminary, non-seasonally adjusted rate was 6.3 percent. For the Portland metropolitan area, the preliminary, non-seasonally adjusted rate was 6.2 percent.

In a 2000 report, the Oregon Department of Agriculture estimated that current invasive plant infestations reduce the total personal income of Oregonians by about 83 million dollars (The Research Group, 2000). This is equivalent to 3,329 annual jobs lost to Oregon's economy from foregone production. Furthermore, the continued spread of only six major invasive plant species could potentially reduce Oregon's personal income by another 54 million dollars and reduce annual jobs by another 2,143.

3.7.2. Economic Analysis

Management of invasive plants is costly, and fiscal resources are limited. Users of National Forest System lands would pay some of the cost either directly or indirectly. Also, invasive plant management would compete with other land management needs, resulting in opportunity-cost tradeoffs. Two models were used to compare the alternatives economically. First, the total cost of treating all acres in each of the alternative (including No Action Alternative) was estimated based on the treatment prescriptions described in Appendix S. Second, a menu of costs was developed for the Proposed Action and Reduced Herbicide Use Alternatives which shows how much it would cost and how long it would take to treat all inventoried acres depending on how many acres are treated each year. The number of full-time jobs created is also analyzed.

Total Cost Analysis

The costs of the No Action, Proposed Action and Restricted Herbicide Use Alternatives are first analyzed assuming all proposed treatments begin in year one. The costs for the Proposed Action and Reduced Herbicide Use Alternative are based on an aggressive five-year program to treat 13,000 acres. Appendix S – Economic Assumptions contains the treatment regime prescriptions for all areas, which are the basis for this analysis, and the assumptions used in their development. This calculation does not include an economic estimate of potential benefits from reducing or eliminating invasive plants. Costs for the EDRR of the Proposed Action and the Restricted Herbicide Use Alternative are also not included here. The total costs of the two action alternatives are compared to the cost of the No Action Alternative, which assumes only one year of treatment for every area (See Appendix S). It is important to note that the No Action Alternative would treat fewer acres than either of the two action alternatives.

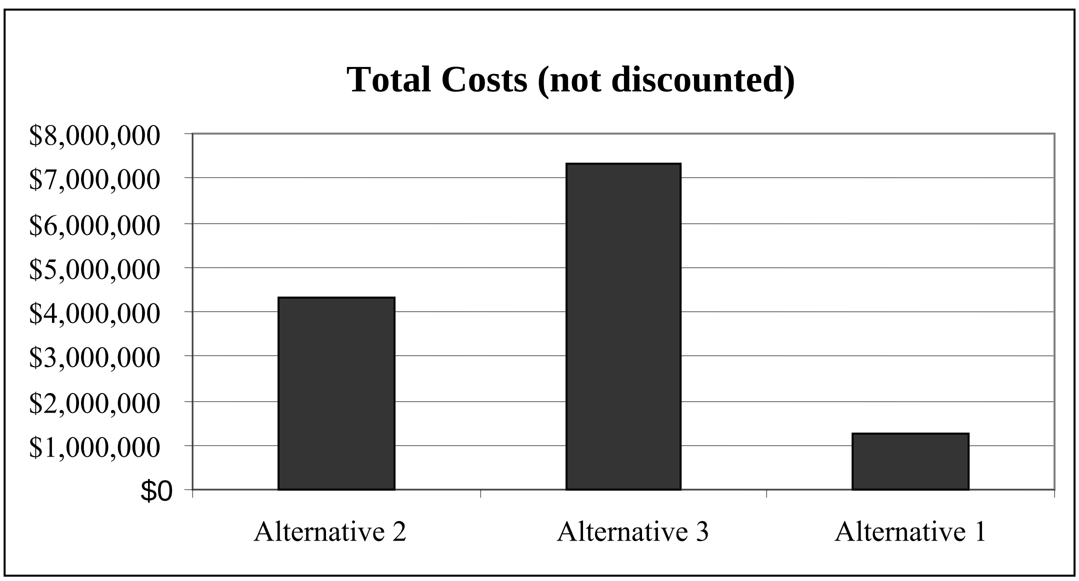
Some treatment costs are based on figures in the Invasive Plant FEIS (2005a) (Pages 4-94 to 4-96). Other treatment costs are empirically derived from recent invasive plant management contracts for the Forest. Herbicide costs not derived from either of these two sources are calculated from data obtained from the 2005 North Dakota Weed Control Guide (Zollinger, 2005). The *Quick-Silver* Program is used to determine the present value of costs. The analysis uses a real discount rate of 4 percent, a rate typically used for ecological investments. The analysis is repeated using a zero percent and a 7 percent real discount rate to test whether the analysis is sensitive to the discount rate. A real discount rate means inflation is not factored into the calculation. The quantitative results of the analysis are shown in Table 3-9 comparing the discounted cash flows (4% and 7% discount rates) to an undiscounted cash flow (0% discount rate). The sensitivity analysis shows that the interest rate used for discounting has no effect on the ranking of alternatives based on cost.

Table 3-9: Total costs for three alternatives to treat inventoried invasive plant populations in the Forest and the Scenic Area calculated using no discount rate, 4% discount rate, and 7% discount rate.

Discount Rate	Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Restricted Herbicide Use
0%	1,271,180	4,329,004	7,317,382
4%	1,214,095	4,241,724	7,174,985
7%	1,175,828	4,180,827	7,076,245

In the total cost analysis, the No Action Alternative would treat 1,235 acres and would cost roughly 1.2 million dollars (4% discount rate). Both action alternatives would treat 13,000 acres. The Restricted Herbicide Use Alternative would be the most expensive, costing nearly 7.2 million dollars (4% discount rate). The Proposed Action would cost about 4.2 million dollars (4% discount rate), which is 60 percent of the cost of the Restricted Herbicide Use Alternative (See Figure 3-3). This difference is attributed to the lower cost of herbicide treatment (compared to manual and mechanical costs) and to the greater assumed effectiveness of herbicide treatments (80 percent for the Proposed Action compared to 60 percent for the Restricted Herbicide Use Alternative).

Figure 3-3: Total costs of Alternatives to treat invasive plants in the Forest and Scenic Area in Oregon without budget constraint.



The average annual treatment cost per acre for each alternative was calculated (See Table 3-10). The No Action Alternative has the lowest per acre cost since it lacks the 5-year integrated treatment strategy of the two action alternatives. All areas included in the No Action Alternative would be treated for only one year; most acres would be treated only once.

Table 3-10: Cost per acre for three alternatives to treat inventoried invasive plant populations in the Forest and Scenic Area.

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Restricted Herbicide Use
$193.48	$324.25	$540.94

Presently, the average annual cost per acre for the No Action Alternative is 193 dollars. The Proposed Action would increase average annual treatment cost per acre to 324 dollars; and the Restricted Herbicide Use Alternative would have an average annual per acre cost of 541 dollars. If the current invasive plant budget for the analysis area were held constant at roughly 200,000 dollars per year, then the number of acres that could be treated annually in the Proposed Action would be reduced by 51 percent. For the Restricted Herbicide Use Alternative, the number of acres treated annually would be reduced by 70 percent. The treatment regimes prescribed in both the Proposed Action and Reduced Herbicide Use Alternative would be expected to more effectively manage invasive plants than No Action, justifying the higher cost per acre. However, without a substantial increase in appropriated funding, the Forest and Scenic Area may be faced with a protracted treatment program regardless of whether the treatment emphasis is herbicides, manual, mechanical or cultural.

Variable Budget Analysis

Since budgets are limited, the data are also analyzed to show the treatment costs for the Proposed Action and Reduced Herbicide Use Alternative for various annual treatment levels and several hypothetical rates of the invasive plant spread. Tables 3-11 and 3-12 display the number of years it would take and the costs to treat the proposed 13,000 acres for various annual treatment regimes (i.e. the number of acres treated each year). The following examples illustrate the use of Table 3-11 for the Proposed Action (Table 3-12 is interpreted similarly for the Restricted Herbicide Use Alternative). These are only examples, not management preferences:

- If 2,000 acres are treated each year, the annual cost would be $648,000. If untreated invasive plants continue spreading at an annual rate of 8 percent per year, then known populations of invasive plants would not be fully controlled for 16 years at a total cost of $7,937,700.

- If annual treatment budgets are $486,000 per year, then only 1,500 acres could be treated annually. If untreated invasive plants continue spreading at an annual rate of 10 percent, then it would take 48 years to control known populations of invasive plants at a total cost of $21,505,310.

- If the current annual treatment budget of approximately $200,000 per year for the analysis area continues unchanged and untreated areas continue spreading at an annual rate of 8 percent, then the current populations of invasive plants would never be fully controlled. Treatments would fall behind the rate of spread.

Some general conclusions that apply to both the Proposed Action and the Restricted Herbicide Use Alternative can be drawn from Tables 3-11 and 3-12. For any given hypothetical invasive plant spread rate, increasing the number of annual treatment acres would decrease the total cost of the project. The deviations from this regression are due to the discrete nature of the "years" factor; that is, calculations used the number of years as whole numbers disregarding fractions of years. Not surprisingly, at higher rates of invasive plant spread, the total cost of the project and the number of years to control inventoried areas would increase for any fixed number of annual treatment acres.

The variable budget analysis shows that the Proposed Action would cost between 6.2 and 21.5 million dollars. The Restricted Herbicide Use Alternative would cost between 14.2 and 47.9 million dollars. The Proposed Action would take from 8 to 48 years to control the known populations of invasive plants; the Restricted Herbicide Use Alternative would take from 9 to 48 years. For any given treatment regime (acres treated per year) and assumed rate of invasive plant spread, the cost of the Restricted Herbicide Use Alternative would cost between 2.1 and 5.2 times more than the Proposed Action. To illustrate, if 5,000 acres were treated each year, and it were assumed that invasive plants spread 10 percent each year, then it would cost 2.1 times more to implement the Reduced Herbicide Use Alternative than the Proposed Action. If 2,000 acres were treated each year, and it were assumed that invasive plants spread 10 percent each year, then it would cost 5.2 times more to implement the Reduced Herbicide Use Alternative than the Proposed Action. All other treatment regimes fall between these two extremes.

Table 3-11: For Alternative 2 (The Proposed Action), number of years and total cost to control 13,000 acres of invasive plants at various annual rates of plant spread and annual treatment regimes for the Forest and Scenic Area. Assumes the average annual treatment cost for the Proposed Action per acre is $324. Years are N+4 (see notes below). Costs are undiscounted cash flows. For more explanation about this table, see Appendix S – Economic Assumptions.

Annual Treatment Acres	Cost (M$) Per Year	No. Years to Control and Total Cost (M$) at Various Annual Rates of Invasive Plant Spread (%)					
		8%		10%		12%	
		Yrs.	Total Cost	Yrs.	Total Cost	Yrs.	Total Cost
500	$162.00	Never	N.A.	Never	N.A.	Never	N.A.
1,000	$324.00	Never	N.A.	Never	N.A.	Never	N.A.
1,500	$486.00	25	$10,327.31	48	$21,505.31	Never	N.A.
2,000	$648.00	16	$7,937.74	18	$9,233.74	22	$11,825.87
2,500	$810.00	13	$7,492.18	13	$7,492.18	15	$9,112.35
3,000	$972.00	11	$7,046.61	11	$7,046.61	12	$8,018.80
3,500	$1,134.00	10	$7,087.05	10	$7,087.05	10	$7,087.05
4,000	$1,296.00	9	$6,803.48	9	$6,803.48	9	$6,803.48
4,500	$1,458.00	8	$6,195.92	8	$6,195.92	8	$6,195.92
5,000	$1,620.00	8	$6,884.35	8	$6,884.35	8	$6,884.35

Table 3-11 Notes:

- *Annual Treatment Acres* – Each treatment regime analyzed (row of data in Table 3-11) assumes five years of integrated treatments for every area of inventoried invasive plants. To simulate the effectiveness of treatment, the acres in each treatment area are reduced by 80 percent per year for years 2 through 5. Treatment is assumed to be accomplished at the end of year 5. Because each area is treated for five years, the numbers of "new" acres treated in years 2 through N are reduced by 20 percent in order to maintain a fixed budget for each treatment regime. For more explanation, see Appendix S – Economic Assumptions.

- *Cost (M$) Per Year* - Values are in thousand dollars. The amount represents the fixed average annual cost (budget) for the treatment regime. It is calculated by multiplying the annual treatment acres by $324 (the average, annual per-acre treatment cost).

- *Years* – The value is determined by performing "annuity due" calculations (advance payment annuity) using the following parameters: i = invasive plant spread rate (%); PMT = "new" acres treated in years 2 through N; present value = 13,000; future value = 0. The annuity calculation solved for N, the number of years during which new areas would receive initial treatments. In the table, N is increased by 4 years to account for the full 5-year treatment regime (N+4).

- *Total Cost* – Values are in thousand dollars. The amount represents the undiscounted sum of treatment costs (cash flow) for N+4 years.

- *Rates of Spread* – For the limited budget analysis, it is assumed that once treatment is begun on any acre of invasive plants, its spread is halted on that acre. However, since not all acres are treated in year 1 (and some acres would not be treated initially until Year N), invasive plants on those acres would continue to spread at some rate. The table displays the number of years it would take to control the current inventoried areas at several hypothetical annual rates of spread (8, 10, and 12 percent).

Table 3-12: For Alternative 3 (Restricted Herbicide Use), number of years and total cost to control 13,000 acres of invasive plants at various annual rates of plant spread and annual treatment regimes for the Forest and Scenic Area. Assumes the average annual treatment cost for the Proposed Action per acre = $541. Years = N+4 (see notes below). Costs are undiscounted cash flows. For more explanation about this table, see Appendix S – Economic Assumptions.

Annual Treatment Acres	Cost (M$) Per Year	No. Years to Control and Total Cost (M$) at Various Annual Rates of Invasive Plant Spread (%)					
		8%		10%		12%	
		Yrs.	Total Cost	Yrs.	Total Cost	Yrs.	Total Cost
500	$270.50	Never	N.A.	Never	N.A.	Never	N.A.
1,000	$541.00	Never	N.A.	Never	N.A.	Never	N.A.
1,500	$811.50	Never	N.A.	Never	N.A.	Never	N.A.
2,000	$1,082.00	25	$22,992.07	48	$47,878.07	Never	N.A.
2,500	$1,352.50	17	$17,920.08	20	$21,977.58	27	$31,986.08
3,000	$1,623.00	14	$16,635.10	15	$18,258.10	17	$22,153.30
3,500	$1,893.50	12	$15,620.62	13	$17,514.12	14	$22,058.51
4,000	$2,164.00	11	$15,688.13	11	$15,688.13	12	$18,717.74
4,500	$2,434.50	10	$15,214.65	10	$15,214.65	10	$15,214.65
5,000	$2,705.00	9	$14,200.17	9	$14,200.17	9	$14,200.17

Table 3-12 Notes:

- *Annual Treatment Acres* – Each treatment regime analyzed (row of data in Table 3-12) assumes five years of integrated treatments for every area of inventoried invasive plants. To simulate the effectiveness of treatment, the acres in each treatment area are reduced by 60 percent per year for years 2 through 5. Treatment is assumed to be accomplished at the end of year 5. Because each area is treated for five years, the numbers of "new" acres treated in years 2 through N are reduced by 40 percent in order to maintain a fixed budget for each treatment regime. For more explanation, see Appendix S – Economic Analysis.

- *Cost (M$) Per Year* - Values are in thousand dollars. The amount represents the fixed average annual cost (budget) for the treatment regime. It is calculated by multiplying the annual treatment acres by $541 (the average, annual per-acre treatment cost).

- *Years* – The value is determined by performing "annuity due" calculations (advance payment annuity) using the following parameters: i = invasive plant spread rate (%); PMT = "new" acres treated in years 2 through N; present value = 13,000; future value = 0. The annuity calculation solved for N, the number of years during which new areas would receive initial treatments. In the table, N is increased by 4 years to account for the full 5-year treatment regime (N+4).

- *Total Cost* – Values are in thousand dollars. The amount represents the undiscounted sum of treatment costs (cash flow) for N+4 years.

- *Rates of Spread* – For the limited budget analysis, it is assumed that once treatment is begun on any acre of invasive plants, its spread is halted on that acre. However, since not all acres are treated in Year 1 (and some acres would not be treated initially until Year N), invasive plants on those acres would continue to spread at some rate. The table displays the number of years it would take to control the current inventoried areas at several hypothetical annual rates of spread (8, 10, and 12 percent).

Comparison of the Total Cost and Variable Budget Analyses

The total cost analysis indicates that the Restricted Herbicide Use Alternative would cost about 1.7 times more than the Proposed Action (see Table 3-9). The variable budget analysis more realistically shows that the Restricted Herbicide Use Alternative would cost between 2.1 and 5.2 times more than the Proposed Action (see Tables 3-11 and 3-12), depending upon the treatment regime (acres treated each year) and rate of spread. In every case, the higher total cost results in the variable budget analysis for both action alternatives are attributed to invasive plant spread. By delaying treatment, there would be more acres to treat. Because undiscounted cash flows were used in the variable budget analysis, the time value of money was not a factor in the increased cost.

To illustrate this point for the Proposed Action, if annual funding for treatment were set at 1.6 million dollars, the variable budget analysis (Table 3-11) shows that it would take eight years to treat all 13,000 acres. If annual funding for treatment were set at 0.5 million dollars, the variable budget analysis (Table 3-11) then shows that it would take between 25 and 48 years to treat all 13,000 acres, depending upon the rate of invasive plant spread. By comparison, the total cost analysis (Table 3-9, undiscounted) shows that it would take about 4.3 million dollars up front to treat all 13,000 acres in five years.

To illustrate the point for the Restricted Herbicide Use Alternative, if annual funding for treatment were set at 1.6 million dollars, the variable budget analysis (Table 3-11) shows that it would take between 14 and 17 years to treat all 13,000 acres, depending upon the rate of invasive plant spread. If annual funding for treatment were set at 0.5 million dollars, the variable budget analysis (Table 3-12) then shows that inventoried invasive plants might never be fully managed. Treatments would fall behind the rate of spread. By comparison, the total cost analysis (Table 3-9, undiscounted) shows that it would take about 7.3 million dollars up front to treat all 13,000 acres in five years.

Early Detection/Rapid Response Strategy

If new invasive plant populations are detected, the cost per acre for treatment would generally be the same as for proposed treatment areas. If new populations or new species are discovered while the infested areas are still small; however, the areas might be controlled with aggressive treatments in one year. In that case, treatment cost would be less because it would not take five years of integrated treatments to fully manage the areas. For small, newly-established populations in the Proposed Action, (using only year one treatment costs and the cost for inventory/monitoring and restoration) the average cost per acre would be $256. This compares to the average annual cost of $324 per acre to treat inventoried areas. For the Restricted Herbicide Use Alternative, the year one treatment regime applied to small, newly-established areas would cost an average of $410 per acre compared to $541 per acre to treat inventoried areas. There is no EDRR in the No Action Alternative.

The cost of treating 30,000 acres of invasive plants was estimated based on these per acre cost assumptions. The 30,000 acre figure includes 17,000 acres of EDRR treatment acres (the most that would be treated in this project) added to the 13,000 proposed treatment acres in both action alternatives. The cost was estimated for both newly-discovered, small populations ($256/acre and $410/acre for the Proposed Action and Reduced Herbicide Use Alternative, respectively). It was also estimated for newly-discovered, large populations ($324/acre and $541/acre for the Proposed Action and Reduced Herbicide Use Alternative, respectively). The results of these calculations, shown in Table 3-13, indicates that rapid response to new invasive plant populations would not change the ranking of the alternatives relative to cost..

Table 3-13: Total costs for action alternatives to treat 13,000 acres of proposed invasive plant populations and 17,000 EDRR acres assuming both large and small newly-discovered invasive plant populations in the Forest and the Scenic Area (assumes 4% discount rate).

EDRR Scenario	Alternative 2 – Proposed Action	Alternative 3 – Restricted Herbicide Use
Small newly-discovered populations.	8,593,724	14,144,985
Large newly-discovered populations.	9,720,000	16,230,000

Cumulative Effects

The Chief of the USDA Forest Service calls invasive plants one of the four chief threats to National Forest System lands. As such, the USDA Forest Service is planning aggressive programs to treat invasive plants nationwide. Many forests, such as those in the Intermountain West, currently have more serious invasive plant problems than the Forest and Scenic Area.

The cumulative economic effect of this widespread and serious problem would be intense competition for limited funds at all governmental levels. The USDA Forest Service currently spends roughly 4.8 million dollars annually treating about 25,000 acres of invasive plants on National Forests in the Pacific Northwest (2005a). The competition among National Forests for limited appropriated federal funds for treatment programs would likely be great. Likewise, potential partner agencies in county and state government may be overwhelmed with requests for funding assistance. The total cost of all such programs has not been quantified since most forests have not yet solidified plans for their newest treatment programs. Nevertheless, funding would likely be a major limiting factor in the effective implementation of aggressive invasive plant treatment decisions throughout the Pacific Northwest.

Oregon Department of Agriculture and Oregon Counties currently spend more than four million dollars annually to manage invasive plants. A January, 2001 report entitled *Oregon Noxious Weed Strategic Plan* recommends that this spending be increased by an additional 5.2 million dollars annually from state and local sources. The same report recommends that spending by all federal agencies in Oregon be increased by 7.2 million dollars per year to adequately implement invasive plant control programs on federal lands in Oregon (ODA, 2001).

Currently, the average, annual cost per acre for treating invasive plants in the Pacific Northwest is $195 (2005a). The average cost per-acre cost to treat invasive plants for both the Proposed Action and the Reduced Herbicide Use Alternative is considerably higher than the current regional average. It is reasonable to assume that when other forests solidify their treatment plans, their average per-acre costs may also exceed the current average.

As the demand for treatment services rapidly increases, and overwhelms the supply of available treatment providers, supply and demand suggests that there would likely be a short-term increase in treatment costs until more providers become available.

3.7.3. Jobs Created Analysis

The Restricted Herbicide Use Alternative would create the equivalent of about 159 jobs. This alternative would create the most jobs because of its greater use of manual and mechanical treatment methods and because of a higher level of site restoration (see Appendix T which displays the job estimate calculation). Also, the Restricted Herbicide Use Alternative minimizes the use of truck mounted application of herbicides relying instead on more labor-intensive hand applications.

The Proposed Action would create the equivalent of about 94 jobs. The predominant herbicide application method in this alternative is broadcast herbicide applications methods (e.g., truck or ATV mounted boom), a less labor-intensive method. Also, there are fewer acres of site restoration.

The No Action Alternative would create the equivalent of about 38 jobs. This smaller number is chiefly due to fewer acres being treated.

Table 3-14 compares the cost of labor, wage income, and number of jobs created by the three alternatives. All job estimates use a ratio of one job equals $20,000 in wage income per year. Although actual annual wage income per job varies, this ratio provides a constant index for the evaluation of alternatives. As described in Section 3.7.1, most of the jobs created are low-wage, physically-demanding work, typical of manual agriculture and forestry jobs. They are seasonal positions with little, if any, job security. Few workers expect to earn $20,000 per year at these jobs, so the actual number of jobs created may be higher.

Table 3-14: Labor Cost, Wage Income, and Potential Job Estimates for Invasive Plant Treatments in the Forest and Scenic Area.

Alternative	Labor Cost	Wage Income	Jobs @$20k/Year
No Action	$960,680	$768,544	38
Proposed Action	$2,352,572	$1,882,058	94
Reduced Herbicide Use	$3,982,469	$3,185,975	159

Early Detection/Rapid Response Strategy

On average, the treatments prescribed in the Proposed Action would create the equivalent of one $20,000/year job for every 138.3 acres treated. For the Restricted Herbicide Use Alternative, the equivalent of one $20,000/year job would be created for every 81.8 acres treated. Table 3-15 shows the number of jobs that might be created by treating 30,000 acres of invasive plants: the 13,000 treatment acres in the Proposed Action and in the Reduced Herbicide Use Alternative plus the maximum EDRR of 17,000 acres. The calculations assume that newly-discovered populations are large and require the same aggressive treatment prescription described in Appendix S. If newly-discovered populations are small, and treatment is less complex, then fewer jobs would be created. There is no EDRR in the No Action Alternative.

Table 3-15: Jobs created (equivalent to $20,000 per year) by the Proposed Action and the Reduced Herbicide Use Alternatives with EDRR for the Forest and Scenic Area. Assumes the maximum EDRR = 17,000 acres and newly-discovered invasive plant populations are large.

Alternative	Jobs/Acres Treated Ratio	Jobs @$20k/Year
Proposed Action	1/138.3	217
Reduced Herbicide Use	1/81.8	367

Cumulative Effects

Government officials estimate that invasive plant control occurs on over 1,250,000 acres in Oregon and Washington, and more than 90 percent of this control is through the use of herbicides (based on informal discussions with state and county agriculture and noxious weed personnel). These data suggests that the broader regional treatment program looks more like the Proposed Action than the Restricted Herbicide Use Alternative. If this is true, then invasive plant control in the region creates roughly 8,038 jobs annually (applying the average of one $20,000 job equivalent for every 138.3 acres treated). If the treatment regimes throughout the region mimic the Restricted Herbicide Use Alternative (average of one $20,000 job equivalent for every 81.8 acres treated), then about 15,281 jobs would be created annually.

3.7.4. Management Standards and Guidelines

Relevant standards and guidelines contained in the Forest Plan and the Northwest Forest Plan are displayed in Appendix B of this document; relevant standards contained in the Scenic Area Management Plan are displayed in Appendix C. This analysis exhibits that the Proposed Action and Restricted Herbicide Use Alternatives are consistent with all relevant standards and guidelines, when the proposed amendments are incorporated. The Forest Plan amendments are discussed in Section 3.16.

3.7.5. Incomplete and Unavailable Information

The magnitude of funding needs for treating invasive plants Region-wide has not been quantified since most National Forests have not yet solidified plans for their newest treatment programs.

No data is available to ascertain the economic value of special forest products harvested from the Forest or Scenic Area.

3.8. Soil Productivity

3.8.1. Existing Conditions

Soils across the analysis area are quite variable, each with numerous management ratings such as erosion risk, compaction hazard, etc. Management ratings logically follow the variability of the soils themselves, with some soils mapped with a high erosion risk, others with low, and many in between. Although ratings are an adequate analysis tool, in actuality almost any soil regardless of rating can become highly erosive under the right (or wrong) circumstances. Low erosion risk soils that are compacted and bare can become highly erosive on even the slightest slope. Conversely, highly erosive soils, such as the volcanic ash derived ones on the Forest, are stable for decades because of sufficient protective groundcover (tree needles, leaves, wood, etc.). Generally, the soils in the proposed treatment areas on the Forest and Scenic Area are of relatively low fertility and once disturbed tend to be invaded by plant species that tolerate low fertility sites, especially the invasive plant species listed in Table 2-3.

The most productive areas of a given ecotype tend to be riparian zones because of water availability and naturally common accumulation of soil organic matter, and this holds true across the Forest and Scenic Area. As illustrated on the proposed treatment areas map (Figure 2-1), there are numerous riparian areas as well as uplands that have been impacted by the invasion of non-native plants. Although they provide some groundcover, many invasive plants generally tend not to have a desirable fibrous root system found in most native grasses and forbs. Fibrous root systems tend to provide more effective erosion control compared to tap-rooted plants, such as knapweed species. The major exception to this is knotweed species, which produces an extremely fibrous, difficult to eradicate root system. For this EIS the main soil resource concerns are effects on erosion, impacts to soil biology, and potential for herbicides to leach through the soil profile and into groundwater.

The productivity and health of the plant community depends on the maintenance of healthy soils. Regional soil productivity protection standards were originally implemented in 1976 and have been revised several times since then (Pacific Northwest Region Monitoring and Evaluation Report, 2001). Areas of reduced soil productivity, which are the result of past land management activities and subsequent invasion of non-native plants have been identified and restoration projects are being proposed and implemented. Restoring ecological function to soil systems affected by invasive plants are high priority. Due to soil restoration activities, the productive potential of soils on the Forest and Scenic Area are improving in small specific locations. However, overall productivity is threatened in increasingly large areas because of the rapid upward trend and potential for increasing spread of invasive plants.

3.8.2. Analysis Area, and Applicable Standards and Guidelines

The analysis area for soils in this EIS is the Forest and Scenic Area boundaries. No soil specific standards are in place for the Scenic Area, so the Forest Plan standards and guidelines will apply for this analysis. A relative comparison of alternatives will be conducted using two Forest Plan standards (Table 3-16) and risk of herbicide leaching as guidance to address specific concerns and as a basis for risk of subsequent impacts such as sedimentation, impacts to aquatic organisms, etc.

- **Erosion Hazard:** Two possible impacts stemming directly from soil erosion are runoff that carries herbicide with it into watercourses, and runoff from bare areas carrying sediment that impact watercourses. This hazard rating is based upon ***bare*** surface soils coupled with a particular soils' texture, slope, etc.

- **Soil Biology:** Poor or non-functioning soil biological systems may lead to difficulties in revegetation efforts, or decline in existing desirable vegetation. In and of itself, soil biology is extremely difficult to evaluate because of infinitely complex interactions occurring between organisms and their physical (soil) environment, including soil physical and chemical characteristics. It is assumed that soil biological systems would properly function given certain habitat components are present, such as non-compacted soils, appropriate levels of organic matter, and types of native vegetation under which the soil developed.

- **Leaching Risk:** No Forest Plan standards directly address this concern. However, using a combination of soil and herbicide characteristics with existing scientific studies there is sufficient information to compare this risk by the type of herbicide proposed. There are two aspects regarding leaching and herbicides – the potential to contaminate groundwater (i.e. wells), and the potential to contaminate surface water through groundwater movement into streams, springs, etc.

Table 3-16: Forest Plan Soil Standards guiding the soils analysis.

<table>
<tr><td>FW – 025
(Page 4-49)</td><td>In the first year following surface disturbing activities, the percent effective groundcover by soil erosion hazard class should achieve at least the following levels:<table><tr><th>Soil Erosion Hazard Class</th><th>Effective Groundcover</th></tr><tr><td>Low to Moderate</td><td>60%</td></tr><tr><td>Severe</td><td>75%</td></tr><tr><td>Very Severe</td><td>85%</td></tr></table></td></tr>
<tr><td>FW – 032
(Page 4-50)</td><td>Favorable habitat conditions for soil organisms should be maintained for short and long-term soil productivity</td></tr>
<tr><td>Leach Risk</td><td>A relative rating is located in the body of this section</td></tr>
</table>

This analysis is *risk-based*. It is not meant to be interpreted that 'more soil erosion would occur' with a particular alternative versus another, but the relative *risk* of erosion occurring may be higher with one alternative versus another.

3.8.3. Direct/Indirect Effects: Alternative 1 – No Action

This section examines the effects that *invasive plants have on soils, not effects from any of the proposed treatments*. The majority of the following information in this section comes from the Invasive Plant FEIS (2005a), and illustrates the risk of negative soil impacts that could be expected from the No Action Alternative.

Invasive plants could have negative effects on soil properties. Invasive plants may increase the proportion of bare ground, increase or decrease the amount of organic matter in the soil, deplete the soil of nutrients or enrich the soil with certain nutrients, change fire frequency, and produce toxic herbicides that affect soil organisms. Some of these changes may be difficult to reverse and could lead to long-term soil degradation and difficulty in re-establishing native vegetation.

- **Soil Moisture:** Knapweed species are widespread on the eastern half of the Forest and Scenic Area in dryer ecotypes. Lacey, Marlow and Lane (1989) found that rangelands infested with spotted knapweed had more bare ground than natural bunchgrass/forb grasslands. In a simulated rainfall test, they found that soil erosion more than doubled in knapweed-dominated areas when compared to uninfested areas. They also found significantly lower infiltration rates in the knapweed sites. Even modest losses of the soil surface could have large impacts on soil functioning, since most of the biologically active organic matter is concentrated in the top 1 to 4 inches of soil. Soil erosion also has negative impacts on water quality in associated aquatic systems and the reduction of infiltration decreases groundwater recharge.

  Tyser (1992) also observed low canopy cover of native forbs and low cryptogam cover in stands invaded by spotted knapweed. Any increase in bare ground caused by invasive plants could have negative effects on soil moisture content. During rainfall events, more rain runs off as surface flow. In dry periods, soil is directly exposed to solar radiation and dries out faster. A dry soil surface hinders seedling establishment and would negatively impact plants with surface root systems, such as many native grasses. Exposure of the soil surface causes soil temperatures to be more extreme, due to solar heating during the day and greater radiative cooling at night. These extreme temperatures make seedling establishment more difficult and may affect soil organisms (Sheley and Petroff, 1999). There are small patches of soil crusts present on the very southeast corner of the Forest in the vicinity of Rock Creek. These very small areas have survived the invasion of invasive plants (knapweed primarily), heavy off-highway vehicle use, and grazing. It is likely these areas were more extensive before these disturbances occurred. Although there is no specific monitoring as to the actual amount and trend of soil crusts, it is a logical assumption that these areas are declining and would continue to do so given the continuous impacts that occur in the area on annual basis.

- **Soil Nutrients and Nutrient Cycling:** One function of soil is the cycling of nutrients from dead organic matter into forms that are available to plants. This nutrient cycling is essential for the health and productivity of the ecosystem. Nutrient cycling is a complex process that depends on a multi-level food web that is specific to the site. Biota involved in nutrient cycling includes bacteria, actinomycetes, fungi (pathogenic, saprobic, and mycorrhizal), amoebas, and a wide range of invertebrates. Since this entire system is powered by root exudates and decomposing vegetation from the plant community, changes in plant communities caused by non-native invasion could have large effects on the soil food web (Hobbie, 1992; Van der Putten, 1997).

  A study that compared soil organisms in native grasslands in a natural state and after invasion by cheat grass (*Bromus tectorum*, also found on the eastern side of the Forest and Scenic Area), found that the cheat grass caused changes in most levels of the soil food web (Belnap and Phillips, 2001). Although it is difficult to predict the specific effects of these changes, it is important to recognize that any change in the soil food web has the potential to interfere with critical nutrient cycling processes and to threaten the long-term integrity of the ecosystem.

A study found pronounced differences in soil properties when soil under exotic understory plants was compared to soil under native shrubs (Ehrenfeld, et al., 2001). Soil pH was significantly higher under the exotic plants, as was extractable nitrate. Net nitrogen mineralization was also higher under the exotic plants, indicating changes in the composition or activity of soil microbes caused by the invasive plants. Over time, these changes may have effects on the ecosystem as a whole. Many invasive plants establish more readily on sites with high nutrient availability. Invasive plants that increase the availability of nitrate in the soil may be promoting conditions that favor their own expansion at the expense of native plants that tolerate low nutrient levels. For example, increases in soil nutrient levels have been shown to favor the invasion and success of non-native species in a serpentine soil ecosystem where resources were limited (Huenneke, et al., 1990).

On the other hand, many non-native species deplete soil nutrients. Spotted knapweed has been implicated in reducing available potassium and nitrogen (Harvey and Nowierski, 1989). A reduction in soil nutrient levels makes it difficult for native plants to compete with the invasive plants, and probably also affects the soil biotic community. The long-term effects of these changes are not known.

- **Soil Organisms:** Some invasive plants are allelopathic to other plants, and may produce secondary compounds that affect soil organisms. If an invasive plant produces a secondary compound, the population of soil microbes that could metabolize this compound would increase, while the populations of other microbes would decrease (Sheley and Petroff, 1999). These changes would affect the soil food web and nutrient cycling, and may have impacts on the native plant community.

  One group of soil organisms that is of particular concern is mycorrhizal fungi. These fungi form a mutualistic relationship with plants in nearly all ecosystems and are critical in supplying water and nutrients to plants, as well as protection from root pathogens. Mycorrhizal fungi also play an important role in creating soil structure, particularly in young or poorly developed soils. Mycorrhizal fungi could produce more than 600 feet of hyphae per gram of forest soil. This mass of hyphae binds soil particles together, stabilizing the soil system. Mycorrhizal fungi also produce polysaccharides that bind soil particles into aggregates. These aggregates increase the water holding capacity of the soil, improve oxygen penetration into the soil, and provide microsites for the normal development of communities of bacteria, actinomycetes, and amoebas. Mycorrhizal fungi appear to mediate the transfer of sugars and nutrients from one plant to another. This function may be important in maintaining diversity in the plant community and in the recovery of the plant community after disturbance. The fruiting bodies produced by some mycorrhizal fungi are an important food source for a variety of animals, from invertebrates to large mammals. More than 70 percent of the diet of some small mammals, including the northern flying squirrel, consists of fruiting bodies of mycorrhizal fungi.

Research on the impact of invasive plants on mycorrhizal fungi is lacking, but since plants and mycorrhizal fungi are strongly dependent on each other, it seems likely that drastic changes in the plant community caused by the invasion of non-natives would be accompanied by changes in the mycorrhizal fungus community. Sylvia and Jarstfer (1997) compared the mycorrhizal status of young slash pines (*Pinus elliottii var. elliottii*) in plots with invasive plants and plots that were kept invasive plant free with herbicide treatment. After 3 years, the number of pine root tips colonized by mycorrhizal fungi was 75 percent lower in the invasive plant plots than the invasive plant free plots. In addition, the species distribution of the mycorrhizal fungi associated with the trees had changed.

In the Sylvia and Jarstfer (1997) study, the invasive plants were associated with different fungi than the trees. It is likely that competition from these introduced fungi caused the decrease in the fungi associated with the trees. If mycorrhizal fungi associated with invasive plants successfully compete with native fungi a redistribution of soil resources in favor of the invasive plant would occur. In addition, species of mycorrhizal fungi associated with native plants may be lost from the area of infestation. It may then be difficult to re-establish native vegetation on the site after the invasive plants are removed.

Researchers have found that specific "helper" bacteria in the soil promote the establishment of mycorrhizae and mycelial growth of mycorrhizal fungi (Garbaye and Bowen, 1989). Although little is known about the ecological requirements of these organisms, invasive plants may not support the helper bacteria employed by native plants and fungi.

Conclusion - Alternative 1

- **Erosion Hazard:** A chronic, slow increase in exposure of bare soil and associated soil erosion risk is expected with this alternative as native vegetative cover is replaced by the poor cover provided by many invasive plants. Although this alternative employs the same types of control measures as the other alternatives, they are inadequate to keep up with the rate and spread of invasive plants.

- **Soil Biology:** Without treatment, invasive plant infestations are likely to cause significant changes to the physical, chemical, and biological properties of soils where the infestation occurs. In some cases, it may be difficult to reverse these changes and restore normal soil functions. This legacy of disrupted soil function may increase the effort required to restore native vegetation long after invasive plants are removed. Therefore, it is a more desirable situation to keep native plants on site so that natural interactions can occur within soil chemical, physical and biological processes.

- **Leaching Risk:** The risk of leaching would remain unchanged, assuming existing environmental documents and identified PDC for current herbicide applications are followed.

In summary, evidence and observation show invasive plants can degrade existing non-disturbed sites; keep disturbed, degraded sites in poor condition; or occupy disturbed sites on a temporary basis and eventually get pushed out by native vegetation. In many cases, the problem is not necessarily the invasive plant itself, but the soil disturbance that allows invasive plants into a site to begin with, which makes EDRR an important tool to treat new sites as they occur.

3.8.4. Direct and Indirect Effects: Alternatives 2 & 3 – Proposed Action and Restricted Herbicide Use Alternatives

Manual Treatment

Removal of plant roots would break mycorrhizal hyphae in the soil and probably cause a transient reduction of mycorrhizal function. Studies on crop plants have shown that leaving an undisturbed mycorrhizal network in the soil after harvest (e.g. zero-till agriculture) significantly increases the nutrient uptake of the subsequent crop (Evans and Miller, 1988 and 1990). Establishment of native plants may be more successful on undisturbed soil.

In lower intensity infestations, non-target vegetation could provide erosion control. Manual treatments, such as lopping or shearing, that remove the aerial parts of invasive plants would cause an input of organic material (dead roots) into the soil. As the roots are broken down in the soil food web, nutrients would be released.

The risk of harm to soils from manual treatment is low.

Mechanical Treatment

Using mowing equipment on existing roads is not expected to impact soils. Mowing equipment used off established roads has the potential to compact soil. Soil compaction eliminates soil pores, and reduces water infiltration, aeration, and the ability of plants to root effectively. Due to the limited amount of mechanical treatment proposed, this is not expected to create significant soil impacts. Other mechanical treatments, such as the use of motorized hand tools, are expected to have effects similar to manual treatments.

Cultural Treatment

In this proposal, goats would be used to control blackberry in the Sandy River Delta. No adverse soil impacts are foreseen due to the highly resilient nature of this area, especially considering the substantial disturbance history.

Herbicide Treatments

The effect of an herbicide treatment on the soil depends on the particular characteristics of the herbicide used, how it is applied, and soil physical, chemical and biological conditions.

- **Erosion Hazard:** Mt. Hood Forest Plan FW-025 – Effective Groundcover: On sites where effective groundcover levels are below the standard, vegetation must be established quickly on sites where invasive plants have been removed to minimize the erosion hazard. In some cases, meeting this Standard is the responsibility of the project that is actually causing the disturbance. All alternatives rely on different combinations of the proposed treatment methods. The Proposed Action and Restricted Herbicide Use Alternatives are beneficial to soils, since these alternatives have flexibility in treatment methods, which allows effective treatments and prevents further spread and subsequent degradation of soils due to the presence of invasive plants. These degraded conditions are described above in the Alternative 1 – No Action Alternative section and include: loss of soil, drying of soil, changes in soil chemistry, changes in soil biota, and changes in nutrient cycling processes. In general, alternatives (No Action and Restricted Herbicide Use Alternatives) that would restrict treatment result in fewer acres of invasive plants being successfully treated. Areas infested with invasive plants would continue to remain in a degraded condition.

  Further, many of the proposed herbicides are identified as a risk for runoff in clay soils. In the analysis area east of the Cascade crest, exposed clay surface soils are uncommon and occur in some roadcuts or wet meadow areas where no application or very restrictive PDC would apply. Therefore, the risk of runoff is very low east of the Cascades. West of the Cascades, clay subsoils are commonly exposed in roadcuts, so the risk of runoff would be higher. However, the overall risk of runoff from a clay surface in either scenario is still quite low given the PDC for weather conditions, time of year sprayed, and other surface covering materials such as rock and organic matter that slow down runoff.

- **Soil Biology:** Mt. Hood Forest Plan FW-032 – Soil Organisms: Soil organisms are important to the human environment because they could affect soil productivity. None of the herbicides under consideration has notable effects to overall long term soil productivity or permanent impairment of soil ecosystems. In addition, the other treatment methods (cultural, manual, and mechanical) are much more *un*likely to incur detrimental soil impacts of any substantial size. Information about specific herbicide effects to each of the myriad of soil organisms is scarce. For example, one study may examine the use and effect of a particular herbicide on soil bacteria, while another study examines the use of different herbicides on the soil invertebrate population. There is no study or set of studies that examines the impacts of different herbicides on each and every aspect of soil biology. Much of the research is based on indirect effects such as changes in persistence or metabolism of nutrients. The observed changes may mean a temporary depression in the activity of existing soil organisms, or could signal a complete change in the organisms present. In addition, while a few of the studies could be applied directly to conditions found locally, the majority of them are not specific to local ecosystem conditions.

Although this information is useful, it would cause uncertainty in the predicted effects (i.e., lower confidence) if the proposed herbicide treatments were in large, continuous, blocky acreages. The areas, however, proposed for herbicide applications are in specific spots or narrow bands, such as along roadsides that result in very localized effects.

All alternatives, including the No Action Alternative, allow the use of herbicides in treatment of invasive plants. Although picloram and sulfometuron methyl are of particular concern due to toxicity to soil microorganisms and persistence (picloram only) in soil, all herbicides have some evidence of temporary effects to soil microorganisms. The known effects on soil organisms from the individual herbicides proposed for use in the Proposed Action and Restricted Herbicide Use Alternatives are presented in Table 3-17. It is likely that all herbicide treatments would have some effect on soil biota, but these effects would be more or less transitory depending on the timing, frequency, and herbicide used. The known effects of herbicide treatments on soil would be weighed against the effects of invasive plants on soil that result from no treatment or less effective treatments. All herbicides could persist under some circumstances related to soil texture, organic matter content, and soil moisture level, among others. All action alternatives include a site by site long-term strategy for restoring infestations of invasive plants (See Section 2.1.3 on site restoration; See Section 3-6 – Botany and Treatment Effectiveness), which necessarily includes protecting or improving soil productivity and conditions for soil microorganisms. Successful restoration of native vegetation to areas infested with invasive plants is dependent, in part, on healthy soil organisms. Negative effects to soil organisms and soil productivity could complicate restoration and could delay restoration of native vegetation for a year or more.

Table 3-17: Effects of Herbicides on Soil Organisms.

Herbicide	Effects
Chlorsulfuron	Growth inhibition for some fungi at >10,000 times the maximum application rate. Effects to soil nitrification (SERA, 2004a)
Clopyralid	No effect on nitrification, nitrogen fixation, or degradation of carbonaceous material at 1-10 ppm (parts per million) in soil (SERA, 2004b)
Glyphosate	Readily metabolized by soil bacteria. Substantial information indicating it is likely to enhance or have no effect on soil microorganisms. One study showed transient decreases in the populations of soil fungi and bacteria (SERA, 2003a)
Imazapic	No information. (SERA, 2004c)
Imazapyr	Toxic to some bacteria at relatively high concentration (SERA, 2004d)
Metsulfuron methyl	At high surface application rates, decreases in soil bacteria were seen for 3 days, but reversed completely after 9 days (SERA, 2004e)
Picloram	Toxic to some soil organisms, even at low levels. Increasing persistence with increasing application rates. Most toxic at low pH levels (SERA, 2003b)
Sethoxydim	No effect on mixed bacterial populations at 50 ppm in soil. At 1000 ppm, substantial but transient increases in actinomycetes and bacteria, and slight decreases in various fungi. *Azobacter* in culture showed no inhibition until 5000 ppm (SERA, 2001b)
Sulfometuron methyl	Toxic to soil microorganisms. Microbial inhibition is likely to occur and could be substantial. Soil residues may alter composition of soil microorganisms (SERA, 2004e)
Triclopyr	One study showed inhibition of mycorrhizal fungi only at high (1000 ppm) levels, another study showed inhibition of one mycorrhizal fungus at 0.1 ppm. Expected levels in soil would be well below effect levels for most mycorrhizal fungi (SERA, 2003c)

- **Leaching Risk:** Factors that determine the fate of herbicides in soil include mobility, degradation, and solubility. Herbicide degradation over time is a result of physical and chemical processes in soil and water. Herbicide fate in soil is determined by herbicide characteristics such as adsorption, solubility, degradation, and volatility. Soil characteristics such as organic matter, pH, temperature, moisture content, clay content, and microbial degradation are important in the fate of herbicides. Degradation rates generally decrease with increasing soil depth and decreasing temperatures. General characteristics for the proposed herbicides are displayed in Table 3-18, with more detailed information by herbicide contained in Appendix U. Herbicides are listed in order of most leach risk to least.

As the table indicates, some of the proposed herbicides are highly soluble in water. Generally this is often taken as an indicator of the mobility of the herbicide in water with few exceptions. Glyphosate, while having a high solubility, also binds tightly with soil particles, because of this it has very low mobility. Herbicides with high mobility potential and long half-lives have a greater potential for leaching into near surface or ground water, if present. All listed herbicides would be expected to have higher adsorption, and lower solubility and half- life than shown in Table 3-18 due to the inherent soil ecological systems found within the Forest and Scenic Area. Therefore, persistence and leaching potentials are some level *lower* than listed in the table, which was constructed by ranking measured levels of adsorption, persistence, and solubility for each herbicide against each other (a relative ranking) in order to display less technical and more understandable results. Examining each of the three ranked criteria together for each herbicide indicates the highest leach risk herbicides are picloram, chlorsulfuron, and imazapyr. Herbicides with the lowest risk for leaching appear to be sethoxydim, triclopyr, and glyphosate.

Table 3-18: Relative Ranking of Herbicide Characteristics and Influencing Factors on Soil Properties. Modified Source: SERA Risk Assessments (2001b, 2003a, 2003b, 2003c, 2004a, 2004b, 2004c, 2004d, 2004e, 2004f).

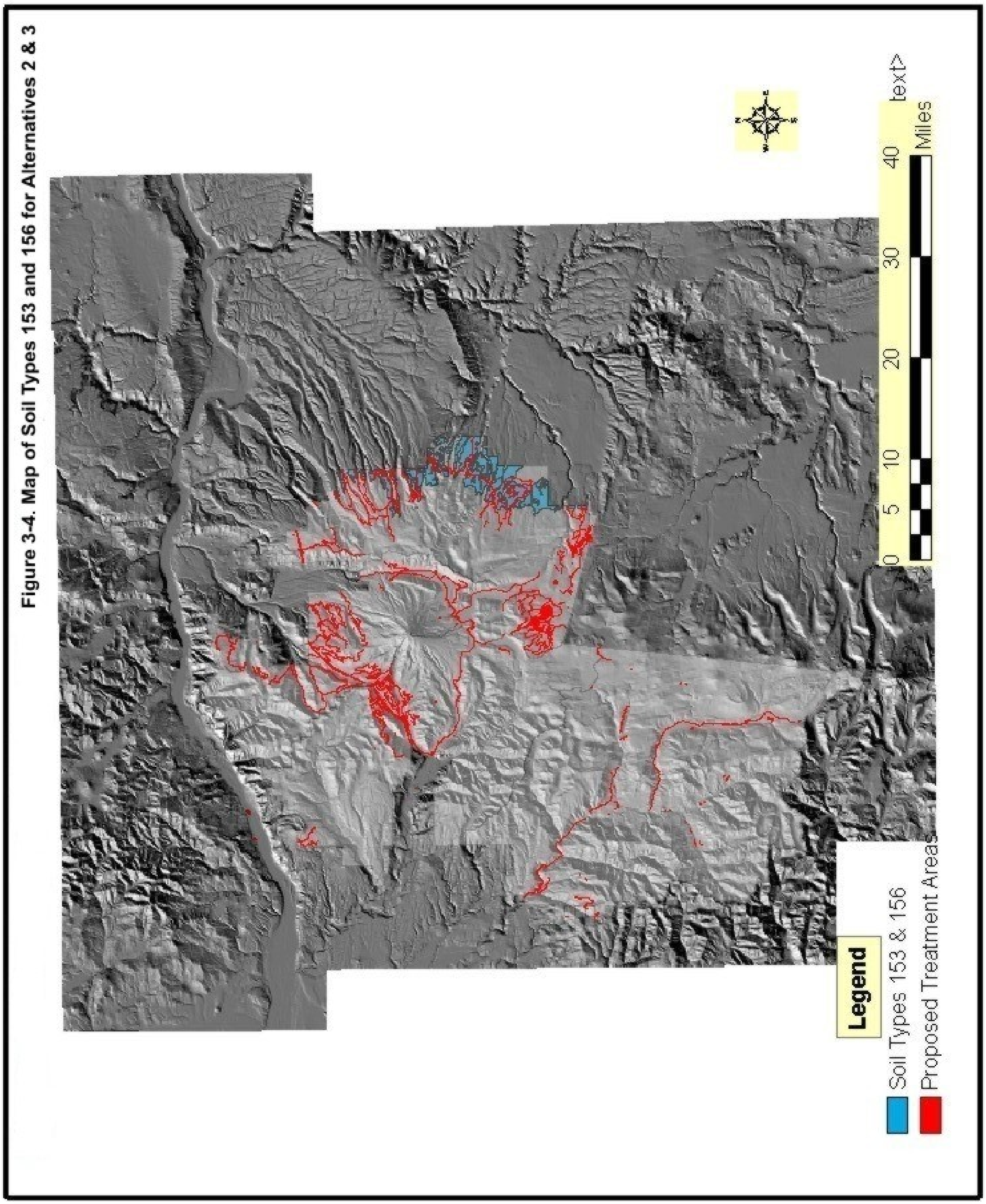
Herbicide	Soil Mobility	Factors Increasing Adsorption	Soil Persistence	Factors Decreasing Half-life	Solubility	Factors Decreasing Solubility
Picloram	High	Increasing organic matter and clay content	Moderate	Decreasing application rate and increasing soil depth	Very High	
Chlorsulfuron	Moderate	Increasing organic matter and low clay content	Moderate	Decreasing pH, increasing organic matter and temperature	High	Decreasing pH
Imazapyr	Low	Increasing organic matter and clay content, decreasing pH (<6.5) and moisture; and time	Moderate	Increasing light, soil microbial activity	Moderate-High	
Clopyralid	High		Low	Increasing moisture	Low	
Imazapic	Low	Increasing organic matter and clay content; and decreasing pH	Moderate	Increasing microflora	High	Decreasing pH
Metsulfuron methyl	Moderate	Increasing organic matter content	Moderate	Increasing microbes	Low-Moderate	Decreasing pH
Sulfometuron methyl	Moderate	Humic acid content	Low-Moderate	Decreasing particle size	Low	Decreasing pH
Sethoxydim	Low	Increasing organic matter	Low		Low-Moderate	Decreasing pH
Triclopyr	Moderate	Increasing organic matter and clay content	Low	Increasing moisture and temperature	Low	
Glyphosate	Very Low	Metallic cations	Low		Moderate-High	Affected by form

An analysis of soil characteristics using the Mt. Hood Soil Resource Inventory (SRI) was conducted to sort which soils would be of lowest risk to soil organism toxicity and leaching when picloram or sulfometuron methyl are applied. It was discovered that there are only two main soil types that do not exhibit the increased risk attributes of soil texture, coarse fragment content, and/or pH. When soils in the SRI are identified as acidic (pH less than 6.9), or have the potential for high percolation rates, then they are recognized as a higher risk for soil organism toxicity or leaching. Potential for high percolation rates occurs with soil textures coarser than loam (i.e., sandy loam and loamy sands), or any texture with greater than 20 percent coarse fragments (i.e., gravel, cobble). The only soil types *not* meeting either of the two criteria are 153 and 156, which are both on the far eastern side of the analysis area, and identified in blue in Figure 3-4. These soils (153 and 156) are wind deposited loamy soils that are located in dryer, more open stands of trees with grass and forbs in the understory, which result in more neutral pH levels. The entire remainder of the analysis areas exhibits acidic pH or relatively high percolation rates. Treatment areas identified as roadside, regardless of soil type, would be of lesser concern for picloram or sulfometuron methyl herbicide applications due to the amount of ground disturbance already present. It is extremely likely that significant soil biological systems have been and continue to be disrupted in these long, linear roadside areas.

Conclusion - Alternatives 2 and 3

- **Erosion Hazard:** There would be a net reduction in soil erosion risk from treated areas in the Proposed Action and Restricted Herbicide Use Alternatives when each site's restoration plan is followed and effective (i.e., restored or temporary effective groundcover). A particular site's effective groundcover level may actually decrease if the amount of vegetation lost from invasive plant eradication exceeds the success of restoration, which is why the implementation of each site's restoration plan is critical. The use of herbicides would accelerate the eradication of invasive plants, allowing desirable native plants to occupy the growing space, which would then provide long-term soil stability and proper function. Based on personal visual observation of previous revegetation efforts (such as riparian and road obliteration projects) on totally denuded sites, few native plants occupied the site in the first year. Effective groundcover for the short-term is achieved with seed, mulch, or combination. By years five to ten, however, sites tended to recover with native plant recolonization, provided the temporary groundcover methods were effective. Some restoration sites on flat terrain actually received no follow-up seeding or mulching and had very good recovery of native plants and thus reduced the erosion hazard.

Figure 3-4. Map of Soil Distribution and Proposed Treatment Areas.



- **Soil Biology:** Alternatives 2 and 3 treat the same amount of acres, but with drastically different strategy. The Proposed Action treats more acres and sites with herbicides, while Restricted Herbicide Use utilizes more non-herbicide treatments. Based on the existing condition and predicted rates of spread, added to the possible restoration, the Proposed Action would result in the most desirable impact on soils. Soil organism communities are likely impacted in some way whether a site is treated or not. Therefore, sites are either considered permanently degraded by invasive plants with no follow-up restoration, or temporarily impacted by herbicides (to some degree depending on which is used), followed by vegetative restoration.

- **Leaching Risk:** Alternative 2 poses the highest leach risk strictly on an acreage treated basis because more acres are treated with herbicides. The risk would be substantially reduced by applicable PDC for application, weather conditions, etc. Table 3-18 above lists herbicides from highest leach risk to lowest, based on numerous factors. The risk of leaching enough herbicide to actually have measurable contamination of a well or surface water body is extremely low, even for the highest leach risk herbicides (picloram, chlorsulfuron, and imazapyr) due to dilution, precautionary PDC, and simply the lack of concentrated multiple applications in a small area that would show up later once sufficient amounts had leached from an application area to a monitoring location.

3.8.5. Alternatives Comparison

The result of this analysis, which examines the impacts on soils from all proposed treatment methods for three alternatives, is summarized in Tables 3-19 and 3-20 below.

Table 3-19: Specific Cause and Effect Concerns as Related to Analysis Standards and Guidelines.

Analysis Element	Cause and Effect	Applicable Forest Service standard or finding	Site-specific Consideration	Process to Address Concern and Tie to PDC Table
Effects of treatments on soil erosion	Treatments have potential to cause soil disturbances that reduce surface cover, thus increasing soil erosion risk	Mt. Hood Forest Plan FW - 025: Effective groundcover	Loss of vegetation that results in elevated surface erosion potential	Annually evaluate proposed treatment sites, review treated sites to determine if groundcover goals have been met, and ensure previous revegetation efforts are not damaged (PDC I.1)
Effects on soil organisms	Picloram and sulfometuron methyl are of concern due to toxicity risks.	Mt. Hood Forest Plan FW – 032: Soil organisms	Soil texture, soil pH	Use other herbicides or treatment methods where soils are acidic (pH > 6.9) due to increased toxicity risk. Where these herbicides are used, no more than one application per year (PDC G.3 and G.4)
Leaching potential	Herbicide treatments may leach through the soil and into groundwater	Concern, no standard or guide	Soil texture, soil pH	Use other herbicides or treatment methods where soils are coarser than loam, or exhibit > 20 percent coarse fragments, or pH is greater than 6.9 (PDC G.3). Identify specific proposed spray areas annually for type of herbicide, soil texture and pH (PDC J.1),

Table 3-20: Summary of Relative Impacts to Soils by Alternative.

Alternative	Acres of Proposed Herbicide Treatment	Acres of Non - Herbicide Treatments	Soil Concerns: Erosion Hazard, Soil Biology, Leach Risk
No Action	600	635	Overall, this alternative addresses soil concerns in *the least* positive way. The current and predicted future negative impacts on soils due to the spread of invasive plants outweigh the small amount of current eradication/control efforts. In addition, without EDRR, future infestations may be difficult to keep in check increasing the risk of future negative soil impacts.
Proposed Action	12,914	50	This alternative addresses soil concerns in *the most* positive way. The current and predicted future negative impacts on soils due to the spread of invasive plants is addressed by aggressively increasing eradication/ control/ containment efforts in a well thought out, sensitive manner. In addition to PDC to substantially reduce the risk of negative effects, the restoration plans for particular sites positively address the effective groundcover standard. With EDRR, future infestations could be addressed while they are small, reducing the risk of negative soil impacts by not treating.
Restricted Use Herbicide	4,047	8,917	This alternative *lies between* the No Action and Proposed Action Alternatives. There may be sufficient positive impacts from treating the priority one sites to 'neutralize' the negative impacts from not treating other areas.

3.8.6. Cumulative Effects

The cumulative effects of an invasive plant infestation could be dramatic and irreversible. Soil lost to erosion may take centuries to replace. The loss of soil biota also could lead to degradation of soil properties that are not easily re-established. Changes in the soil biota could lead to changes in nutrient cycling that lead to a loss of nutrients from the ecosystem. Although very little research has been done on the restoration of soil biological communities, it stands to reason that large persistent invasive plant infestations would detrimentally effect the re-establishment of soil biota and native plant communities. Preventing the spread of invasive plants would have a positive impact on soils.

Cumulative effects of each alternative would be similar to its direct effects. Non-herbicide treatments may result in nutrient decrease, erosion, reduction in mycorrhizal hyphae, increased bare ground, and decreased litter layer, which transient effects are given revegetation with native or non-invasive species. Soil compaction, loss of microbiotic crusts, formation of hydrophobic surface layer on soil, and loss of volatized nitrogen, phosphorus and potassium may have longer term effects and need to be minimized or eliminated through site-specific PDC. Of these three components of this analysis (erosion, leaching risk, and soil organisms), the knowledge of the cumulative effects (defined as multiple applications to one site within a year, which would occur less frequently than single season applications) of herbicide application on soil biota is the most uncertain. Some herbicides are metabolized by soil bacteria, while others are toxic to soil microorganisms or no information about effects to these organisms is available, as described in Table 3-17 above.

Picloram, chlorsulfuron, and imazapic are relatively water soluble and could move off-site in water. These herbicides are moderately adsorbed to soil particles and could be moved off-site with wind or mass soil movement. It is possible, but not likely, that they could be introduced to the Forest and Scenic Area from other sources, such as application(s) on adjacent ownerships. Movement of these herbicides to the Forest and Scenic Area is not expected to affect soil productivity, because most of the Forest and Scenic Area lands are upstream or upwind of other ownerships. It is more likely that these herbicides would move off the Forest and Scenic Area to the other ownerships below. Given the conclusions in the effects analysis, the occurrence of either scenario is very doubtful.

As an example of perspective, the USDA Forest Service use of picloram is less than one percent of agricultural use (SERA, 2003b), while USDA Forest Service use of sulfometuron methyl nationwide is less than one percent of all use in California (SERA, 2004e).

3.8.7. Management Standards and Guidelines

Relevant standards and guidelines contained in the Forest Plan and the Northwest Forest Plan are displayed in Appendix B of this document; relevant standards contained in the Scenic Area Management Plan are displayed in Appendix C. This analysis exhibits that the Proposed Action and Restricted Herbicide Use Alternatives are consistent with all relevant standards and guidelines, when the proposed amendments are incorporated. The Forest Plan amendments are discussed in Section 3.16.

3.8.8. Incomplete and Unavailable Information

Information about specific herbicide effects to each of the myriad of soil organisms is not available. Much of the research is based on indirect effects such as changes in persistence or metabolism of nutrients. The observed changes may mean a temporary depression in the activity of existing soil organisms, or could signal a complete change in the organisms present.

Soil organisms are important to the human environment because they could affect soil productivity, and none of the herbicides under consideration has notable effects to soil productivity. Hence, the unavailable information is insignificant in terms of providing a clear basis for choice between alternatives.

3.9. Water Quality

3.9.1. Existing Conditions

Potential treatment areas are located in nearly every fifth-field watershed on the eastside and westside of the Forest and Scenic Area. The range of elevation, precipitation, and distance from treatment sites to streams is 25 to 5,400 feet, 10 to 120 inches, and zero to more than 2,000 feet, respectively. Site-specific information, including soils, slope, elevation, precipitation, distance to water, and landslide risk, about each potential treatment site is available in Appendix O – Existing Conditions Characteristics.

Water Quality

Surface and groundwater drinking water protection areas were delineated by the Oregon Department of Environmental Quality (DEQ) and Oregon Health Division (OHD) in response to source water assessments required by the 1996 Amendments to the federal Safe Drinking Water Act (SDWA). DEQ and OHD were required to delineate the groundwater and surface water source areas which supply public water systems, inventory each of those areas to determine potential sources of contamination, and determine the most susceptible areas at risk for contamination. Public water systems with greater than three hook-ups or serving more than 10 people year-round are regulated by the requirements in the SDWA.

Watersheds originating on the Forest supply high quality drinking water to approximately one million people in Oregon. There are eight drinking water protection areas including the City of Corbett, Portland, Estacada, The Dalles, various Clackamas River water providers (Oregon City, Lake Oswego), and the Timber Lake Job Corps (Table 3-21) on the Forest that contain proposed invasive plant treatment sites. There are no drinking water protection areas in the Scenic Area. The treatment areas located in each drinking water protection area are shown in Appendix V. Additional information regarding the potential effect of proposed invasive plant treatments on drinking water is located in Section 3-5 – Human Health and Safety.

Table 3-21: Proposed invasive plant treatment acres within drinking water protection areas.

Drinking Water Source	Drinking Water Protection Areas						Grand Total
	Clackamas	Corbett	Estacada	Portland	Timber[1] Lake Job Corp	The Dalles	
Bull Run				1.4			**1.4**
Clackamas River (Estacada)			1,350.0				**1,350.00**
Clackamas River	3.4						**3.4**
Dog River						0.1	**0.1**
Frog Lake					122.3		**122.3**
North Fork Gordon Creek		48.3					**48.3**
South Fork Gordon Creek		12.6					**12.6**
South Fork Mill Creek						24.9	**24.9**
Total	**3.4**	**60.9**	**1,350.0**	**1.4**	**122.3**	**25.0**	**1,562.8**

[1] Frog Lake is a back-up water source for the Timber Lake Job Corp. The primary water source is a well.

Clean Water Act

Rivers, streams, and lakes within and downstream of the treatment areas are used for boating, fishing, swimming, and other water sports. Additionally, the Forest and Scenic Area streams provide habitat and clean water for fish and other aquatic biota, each with specific water quality requirements. The Clean Water Act (CWA) protects water quality for all of these uses.

The CWA requires States to set water quality standards to support the beneficial uses of water. The Act also requires States to identify the status of all waters and prioritize water bodies whose water quality is limited or impaired. For Oregon, the DEQ develops water quality standards and lists water quality limited waters. In addition, Region 6 of the Forest Service has entered into a Memorandum of Agreement (MOA) with the Oregon State DEQ to acknowledge the FS as the Designated Management Agency for implementation of the CWA on National Forest land. In an effort to support the CWA, the Forest and Scenic Area conduct a variety of monitoring and inventory programs to determine status of meeting state water quality standards as well as other regulatory and agency requirements. In an average year, approximately 75 sites are monitored for water temperature throughout the Forest and Scenic Area. In addition, other water quality monitoring occurs at various locations throughout the Forest and Scenic Area depending on the year. This could be turbidity monitoring, instream sediment sampling, water chemical sampling or surveys of physical stream conditions. Currently, approximately 25 miles of physical stream habitat is surveyed every year and to date approximately 1,200 miles of stream have been surveyed. Information collected during these surveys includes the number of pools and riffles, the amount of large wood, riparian area condition and types and numbers of fish and other aquatic organisms to name a few of the parameters.

Various portions of nine streams on the Forest and Scenic Area do not meet Federally-approved state water quality standards (www.deq.state.or.us/wq/standards/wqstdshome.htm), and are now listed as water quality limited under Section 303(d) of the CWA on the DEQ 2002 303(d) list. Streams on the Forest and Scenic Area that are on the 303(d) list are shown in Table 3-22, along with the listed parameter. There is no numeric State water quality standards for any of the potential herbicides or adjuvants that may be used in either of the action alternatives, so none of the streams are categorized as water quality limited based on the use of those chemicals.

Table 3-22: Streams on the Forest and Scenic Area that do not meet Federally-approved state water quality standards. These streams are listed as water quality limited under Section 303(d) of the Clean water Act on the DEQ 2002 list. The parameter for which they are limited is listed below.

Sub-basin	Stream	Listed Parameter(s)
Clackamas	Eagle Creek	Water Temperature
	Fish Creek	Water Temperature
Lower Deschutes	Clear Creek	Water Temperature
	Gate Creek	Water Temperature, Sediment
	Rock Creek	Water Temperature, Sediment
Middle Columbia-Hood	Eightmile Creek	Sediment
	Fifteenmile Creek	Sediment
	Fivemile Creek	Sediment
	Ramsey Creek	Water Temperature, Sediment

Streams listed for temperature do not meet the following current state water quality criteria for salmonids:

- Eagle, Fish, and Ramsey creeks: core, cold water habitat (61 ºF) and salmon and steelhead spawning (55 ºF, spawning periods only)

- Clear, Gate, and Rock creeks: salmon and trout rearing (64 ºF)

Only the lower 8,000 feet of Ramsey Creek within the Forest is listed for temperature. Water temperature standards are based on the 7-day average maximum temperature (a running average over seven days is used instead of the daily average temperature). Core, cold water habitat and salmon and trout rearing habitat standards must be met regardless of the time of year, whereas the 55 ºF salmon and steelhead spawning criteria only applies during spawning periods, which vary by species and stream.

By direction of the CWA, where water quality is limited, DEQ develops Total Maximum Daily Load (TMDL) plans to improve water quality to support the beneficial uses of water. For water quality limited streams on National Forest System lands, the USDA Forest Service provides information, analysis, and site-specific planning efforts to support state processes to protect and restore water quality. To date, two TMDL plans have been completed (Sandy River in 2005 and West Hood Subbasin in 2002) while the other basins on the Forest and Scenic Area are planned for completion in the next two years. Once the TMDL plans are completed, streams would be removed from the 303(d) list and stream recovery would be achieved through an implementation plan. USDA Forest Service requirements for the two completed TMDL plans are to follow Northwest Forest Plan and Forest Plan measures that protect and restore water quality. Actions associated with this project would be consistent with both of the TMDL plans.

In addition, a Water Quality Restoration Plan (WQRP) has been prepared for Fish Creek (Clackamas River watershed) and a draft WQRP has been prepared for the headwaters of Fivemile Creek, Eightmile Creek, Fifteenmile Creek and Ramsey Creek by the USDA Forest Service. The purpose of the WQRP is to identify sources and causes of pollution, make recommendations for Best Management Practices (BMP) and restoration to reduce levels of potential pollutants, display any new monitoring that is pertinent to the 303(d) listing parameters and a proposed time-table for completing the restoration work. Information from the WQRP is often used by DEQ to develop their TMDL plan.

The original water temperature 303(d) listing for Fish Creek is based on water temperature monitoring data. The WQRP recommended riparian planting where existing stream shading was insufficient and also riparian thinning to promote more rapid forest growth and shade recovery along streams.

The original 303(d) listing for the other segments is based on information contained in the 1994 Miles Creek Watershed Analysis (USDA Forest Service, 1994a). According to the draft WQRP, fine sediment levels have been reduced in all sample sites in Eightmile Creek and all but one sample site in Fifteenmile Creek between 1994 and 2000. The WQRP attributes the reduction, at least in part, to the implementation of a number of restoration projects that occurred after 1994. The draft WQRP makes several recommendations including continued restoration as funding allows, continued fine sediment monitoring, and implementation of BMP for Forest management activities.

Groundwater

Groundwater is found throughout the Forest and Scenic Area. Groundwater depths vary considerably and range from a few feet to hundreds of feet from the ground surface. Geologic conditions, soil type and precipitation are a few factors that help determine groundwater characteristics. The direction and speed with which groundwater moves are controlled by the slope of the water table and aquifer permeability. Aquifer permeability is a measure of how easy it is for groundwater to move through the geologic material that makes up the aquifer. The steeper the slope of the water table and the higher the aquifer permeability, the faster groundwater would move through a geologic formation. Depending on conditions, it can take anywhere from several hours to many decades for groundwater to move through an aquifer. Groundwater traditionally comes in contact with surface streams, lakes or ponds in the form of seeps or springs. These seeps or springs can be sources of high quality water due to their clean, cold condition.

Riparian Conditions

Native riparian vegetation plays a key role in forming aquatic habitat for fish and other aquatic species. Roots help stabilize stream banks, preventing accelerated bank erosion and providing for the formation of undercut banks, important cover for juvenile and adult fish. Riparian areas with native vegetation could supply downed trees (large wood) to streams. In turn, downed trees in streams influence channel morphology characteristics such as longitudinal profile; pool size, depth, and frequency; channel pattern; and channel geometry. Turbulence created by large wood increases dissolved oxygen in the water needed by fish, invertebrates and other biota. The extent of the hyporheic zone (place where ground water meets stream water) adjacent to and under the stream surface is increased by large wood in streams. Invasive plants could slow down or prevent the establishment of native trees, decreasing or delaying the future supply of large wood in stream channels.

Riparian forest canopy protects streams from solar radiation in summer, and could moderate minimum winter nighttime temperature, preventing the incidence of anchor ice or freeze-up in streams (Beschta et al., 1987). Changes in water temperature regime could affect the survival and vigor of fish, and affect interspecies interactions (FEMAT, 1993).

Riparian areas are dynamic. Disturbances characteristic of uplands such as fire and windthrow, as well as disturbances associated with streams, such as channel migration, floods, sediment deposition by floods and debris flows, shape riparian areas (FEMAT, 1993). Frequently disturbed ground in riparian areas makes these areas especially vulnerable to plant invasion.

The rapid growth and propagation characteristics of many invasive plants allow them to out-compete native vegetation. This competitive advantage results in the loss of functional riparian communities, loss of rooting strength and protection against erosion, decreasing slope stability and increasing sediment introduction to streams, and impacts on water quality (Donaldson, 1997). Invasive plants are especially difficult to control in riparian areas since invasive plants thrive in the moist environment and treatment measures are sometimes limited.

Knotweed species are an example of an invasive plant with potential effects to riparian areas. Knotweed species leaves fall off in a short period in the fall, leaving soil beneath the plants relatively unprotected from rain, leading to potential for some increased erosion and sediment delivery to streams. In addition, if a relatively large number of knotweed leaves are decomposing in a small stream at any one time, there could be a local increase in biological oxygen demand and a reduction in the amount of dissolved oxygen for other organisms in the stream (USDA Forest Service, 2005a).

3.9.2. Effects Analysis & Methodology

The water quality effects analysis utilizes research and relevant monitoring to provide a context for effects of each of the alternatives. In addition, herbicide concentrations derived from herbicide risk assessments completed by SERA (SERA 2001b, 2003a, 2003b, 2003c, 2004a, 2004b, 2004c, 2004d, 2004e, 2004f) and associated worksheets areused as a general indication of the potential delivery of herbicides to adjacent surface water. These concentrations were modified in the worksheets to reflect some specific site conditions for each of the treatment areas. A complete description of how this information was used in the aquatics analysis can be found in Section 3.10 – Aquatic Organisms and Habitat, and in the Water Quality Specialist Report.

3.9.3. Direct/Indirect Effects

Alternative 1 – No Action Alternative

Under this alternative management of invasive plants would only occur in areas that are covered under existing NEPA. Invasive plants would continue to grow on sites where their treatment is currently not authorized by a NEPA analysis. Invasive plants are often less effective for stream bank stabilization than deeper rooted native plant species. Most invasive plants also provide less stream-shading than native hardwoods and conifers. Increased water temperatures resulting from reduced shading due to invasive plants are possible in streams that have the following conditions:

- Stream channel is moderately wide (10 feet to 20 feet);
- Stream channel has an east-west orientation;
- Slopes next to the stream are greater than 30 percent;
- Limited groundwater input
- Riparian area has the potential for larger coniferous or hardwood streamside riparian vegetation; and,
- Site has a large contiguous block of short invasive plants along the south edge of the stream.

The likelihood that the adjacent stream has some increased stream temperature resulting from shade loss increases as the number of these conditions increase at a treatment site. In reality, any stream temperature increase would likely be very localized and small due to the localized nature of most of the infestations and the low probability that all of the conditions described above are found at any one site. It is anticipated that most of the infestation areas have an insignificant effect on water temperature due to meeting very few of the above conditions.

Where invasive plants provide less effective ground cover and a shallow root system than native plants, there is a greater potential for a surface erosion, bank erosion, and in-stream sediment delivery during high intensity rainfall events. This situation is similar to the stream temperature description above, in that most of the sediment increase to adjacent surface water is anticipated to be insignificant, due to the localized infestation of invasive plants. Infestations do have the potential to introduce small, localized amounts of sediment in areas that have highly erosive banks that are covered with a large (approximately 50 feet or more along the edge of the stream) contiguous block of shallow rooted invasive plants. Talmage (2004) found that if a shallower rooted invasive plant species such as knotweed species completely occupy an unstable stream bank, the potential for stream bank instability during high flows is much greater than if the same site was occupied by deeper rooted native vegetation. Invasive plants also could complicate restoration by preventing the re-establishment of native vegetation that is more effective for providing stream shading, stream bank/soil stability, and ground cover.

The localized effects of invasive plants out competing more beneficial native plants on key sites such as stream banks and riparian areas would continue. Invasive plants are likely to spread in areas that do not have an active eradication, containment, and control program. The potential adverse effects to water quality and soil stability would continue to mount.

In addition to the effects of invasive plant infestations described above, effects associated with the current invasive plant eradication program are part of this alternative. The program utilizes manual, mechanical and herbicide treatments to treat a variety of areas in the Forest and Scenic Area. From 1999 to 2003, 3,894 acres of invasive plant infestations have been treated under existing programs, with a typical yearly program treating approximately 1,200 acres (acreage treated in 2003). Of these treated acres, roughly 50 percent are sprayed with herbicides, 40 percent are treated by mechanical means and 10 percent are treated manually. Table 3-23 shows the number of acres of invasive plant treatment within riparian reserves that has occurred from 1999 to 2003 on the Forest and Scenic Area.

Indirect, direct and cumulative effects to the aquatic environment for current treatment programs are contained in each of the existing NEPA documents (USDA Forest Service, 1993a; 1996c; 1998b; BPA, 2001). These documents also contain applicable project design criteria and/or mitigation measures aimed at minimizing introduction of pollutants, such as herbicides and sediment. In general, these documents do not anticipate any indirect, direct or cumulative effects to the aquatic environment.

Table 3-23: Number of acres of invasive plant treatments within riparian reserves that has occurred from 1999 to 2003 on the Forest and Scenic Area under the No Action Alternative (Alternative 1).

Fifth-Field Number	Fifth-Field Watershed Name	Acres Treated in Riparian Reserves
1707010502	Fifteenmile Creek	3.4
1707010503	Fivemile Creek	4.9
1707010506	East Fork Hood River	16.2
1707010507	West Fork Hood River	206.7
1707010508	Lower Hood River	25.2
1707010512	Middle Columbia/Grays Creek	48.7
1707010513	Middle Columbia/Eagle Creek	10.8
1707030605	Beaver Creek	3.1
1707030607	Middle Deschutes River	29.7
1707030609	Tygh Creek	8.3
1707030610	White River	135.4
1708000102	Zigzag River	18.0
1708000107	Columbia Gorge Tributaries	767.5
1708000108	Lower Sandy River	609.1
1709001102	Upper Clackamas River	3.8
1709001103	Oak Grove Fork Clackamas River	18.6
1709001104	Middle Clackamas River	191.0
	Total	**2100.4**

Alternative 2 – The Proposed Action

The Proposed Action would implement invasive plant treatments on up to 13,000 acres within the Forest and Scenic Area. In addition to these 13,000 acres, other acres may be treated as part of the EDRR described in Chapter 1 and Chapter 2 of this document. Effects of this program on water quality are displayed in the EDRR portion of this analysis shown below. Table 3-24 shows the number of acres of invasive plant treatment within riparian reserves on the Forest and Scenic Area. The numbers include herbicide, manual, mechanical, and cultural treatment methods prescribed in this alternative (see Table 2-3).

Table 3-24: Acres of invasive plant treatments within riparian reserves on the Forest and Scenic Area for Proposed Action (Alternative 2). Acreage numbers include herbicide, manual, mechanical, and cultural treatment methods. Also shown are the differences in acres treated between Alternative 2 and Alternative 1. Values in bold represent a reduction in acres treated in riparian reserves between Alternative 2 and Alternative 1.

Fifth-Field Number	Fifth-Field Watershed Name	Acres Treated in Riparian Reserves	Acre Change Between Alternative 1 & Alternative 2
1707010502	Fifteenmile Creek	17.6	14
1707010503	Fivemile Creek	65.7	61
1707010504	Middle Columbia/Mill Creek	45.1	45
1707010506	East Fork Hood River	416.5	400
1707010507	West Fork Hood River	511.0	304
1707010508	Lower Hood River	57.1	32
1707010512	Middle Columbia/Grays Creek	41.1	**-8**
1707010513	Middle Columbia/Eagle Creek	16.0	5
1707030605	Beaver Creek	2.3	**-1**
1707030607	Middle Deschutes River	46.9	17
1707030609	Tygh Creek	56.9	49
1707030610	White River	646.7	511
1708000101	Salmon River	63.3	63
1708000102	Zigzag River	150.3	132
1708000103	Upper Sandy River	505.4	505
1708000104	Middle Sandy River	27.4	27
1708000107	Columbia Gorge Tributaries	639.0	**-128**
1708000108	Lower Sandy River	816.5	207
1709001101	Collawash River	38.1	38
1709001102	Upper Clackamas River	246.0	242
1709001103	Oak Grove Fork Clackamas River	55.6	37
1709001104	Middle Clackamas River	600.7	410
	Total	**5065.2**	

Fifth-field watersheds with the largest increase in treatments within the riparian reserves are the White River (+511 acres), Upper Sandy River (+505 acres), Middle Clackamas River (+410 acres), East Fork Hood River (+400 acres), West Fork Hood River (+304 acres), Upper Clackamas River (+242 acres), Lower Sandy River (+207 acres) and Zigzag River (+132 acres).

The potential adverse effects of the Proposed Action on stream turbidity, dissolved oxygen, water temperature, peak flows, low flows, water yield, and water chemistry are discussed below.

Soil Disturbance, Turbidity and Fine Sediment

Invasive plant eradication has the potential to temporarily leave treatment areas with reduced ground cover which in turn has the potential for increased erosion and resulting sedimentation. In addition, equipment used in plant treatment has the potential to disturb or displace soil, making the soil more vulnerable to erosion. Herbicide treatments do not kill all invasive plants immediately. Repeated treatments over several successive years are needed for invasive plant eradication, containment, and control. As treated vegetation dies there is the potential for surface erosion from exposed soil surfaces and loss of root holding strength. As stated in Section 3.8 – Soil Productivity, there should be a net reduction in soil erosion risk with this alternative when compared to Alternative 1, because desirable native plants that provide long-term soil stability and proper function would eventually reoccupy the treated sites. Short term erosion would be mitigated by creation of a restoration plan that would identify specific measures to ensure protection against erosion and resulting sedimentation. These measures would be implemented as part of the project. A reduction in associated sedimentation is also expected from the reduction in erosion risk since the two are strongly related.

Proposed manual, mechanical, and cultural treatment measures such as pulling, mowing, weed wacking, or grazing by goats are not likely to cause much soil disturbance or increase the potential for measurable surface erosion/sedimentation (see Section 3.8 – Soil Productivity). Hand-pulling involves manually pulling the invasive plant/roots out of the ground. When invasive plants are pulled, some surface soil may be exposed during the process, but the amount of off-site sediment movement is expected to be insignificant due to the small amount of soil exposure expected.

Where invasive plant control measures result in the reduction of area ground cover (e.g. vegetation, duff, litter, or rocks) as called for in the Mt. Hood Forest Plan standard and guideline FW-082 and FW-082, PDC would be implemented to further reduce the risk of erosion and sedimentation. These PDC would be tailored to reduce erosion based on site specific conditions in the treatment areas. Typical PDC such as application of mulch, hydroseeding with soil binding agents or erosion control blankets may be used to reduce the potential for soil detachment from raindrop impact and create a favorable environment for native vegetation to re-establish faster in the treatment area.

It is expected that streams would meet turbidity standards because implementing the PDC would reduce erosion and sediment delivery; the proposed treatments would not create significant amounts of ground disturbance; and most of the invasive plant treatment sites are already adjacent to disturbed areas such as roads (82 percent of the treatment acres). Supporting information regarding the potential effect of proposed invasive plant eradication, containment and control efforts on soil disturbance and ground cover is located in Section 3.8 – Soil Productivity.

Dissolved Oxygen and Nutrients

The herbicide, manual, mechanical, and cultural treatments proposed would not result in significant amounts of plant material or nutrients entering streams or other water bodies at once. Invasive plant treatments would occur at different times and in different places, so the probablity of large amounts of plant material entering surface water all at once is very low. In addition, streams on the Forest and Scenic Area have naturally vegetated riparian areas that provide large amounts of organic matter including tree leaves and needles. Due to the natural high input of organic matter into streams and the small amount of invasive plant material entering the water, a negligible adverse effect on in-stream dissolved oxygen levels is anticipated.

There are few stream reaches that exhibit symptoms of excessive levels of nitrogen or phosphorus (e.g., large mats of algae) that would stimulate primary production. One short stream reach where algae are common is in Clear Branch just below Clear Branch Dam on the Hood River Ranger District. This short section of stream (about one quarter-mile long) has little shade and the water released from the reservoir is thought to be phosphorous rich. The combination of additional nutrients and additional sunlight has stimulated algae growth. Further downstream, once the stream enters a wooded, well-shaded area, the algae disappear rapidly. This combination of sunlight and high nutrient levels is very uncommon in streams on the Forest and Scenic Area.

Virtually all streams have some algae and/or aquatic macrophyte growth as natural components of the ecosystem. The growth of this flora is controlled primarily by water temperature, sunlight, and available nutrients. The relative lack of algae and macrophyte presence is due to cool, well shaded water that is naturally low in available nutrients in most areas. Fertilizer use on the Forest and Scenic Area is uncommon as are the presence of other chemicals that could accelerate (or retard, in some cases) aquatic flora growth.

Water Temperature

Conditions such as stream aspect, streambank slope and riparian vegetation play a role in the rate at which solar energy reaches small forested streams (Brown, 1983). Most invasive plants provide little or no shade to streams, the exception being knotweed species and blackberry in sites that have a very narrow perennial stream channel (less than five feet wide). Temporary loss of knotweed and blackberry vegetation in these small channels has a higher potential for short term water temperature increase when compared to other invasive plant types, because this vegetation is providing shade. As described above, several other physical factors including stream orientation, existing topographic shading and groundwater input play a part in determining whether loss of stream shading would result in water temperature increase. All of the other plants currently provide very little stream shading due to their height and density, so there would be a negligible effect on in-stream temperatures resulting from invasive plant treatment efforts. Any loss of stream shade that may occur is expected to be temporary, until native vegetation reaches and surpasses the height of the invasive plants that are removed. Native shrub recovery (passive restoration) could be relatively rapid (several years), while the length of time for deciduous and coniferous trees to reach maturity could take many years.

On treatment areas where re-vegetation (active restoration) is proposed after herbicide, manual, mechanical, and cultural treatments, re-establishment of native plants would take place more quickly. This could be expected to have positive effects on stream bank stability and stream shading, and potential long-term reduction in water temperature. An insignificant effect on instream water temperature is expected as a result of implementing proposed invasive plant treatment efforts.

The risk for adverse effects to shade-producing native vegetation is relatively low with direct hand/selective and spot spraying (e.g., backpack sprayer) techniques that would be used near waterbodies. Spot spraying enables the applicator to target specific invasive plants, thereby minimizing the potential for overspray to native plants.

Peak Flows/Low Flows/Water Yield

The methods used during the herbicide, manual, mechanical, and cultural treatments of invasive plants are expected to have a negligible or no effect on water infiltration into the soil and surface runoff. Compared to the total watershed, the actual area to be treated by all invasive plant treatment methods is very small (Table 3-26). Herbicide treatment methods would not alter soil parameters that would reduce water infiltration. Soil compaction from manual (hand pulling), mechanical (mowing, etc.), or cultural (grazing by goats) treatment methods is expected to be very minor and localized so increased surface runoff would be insignificant. Eighty-two percent of the proposed treatment acres are located adjacent to roads that already have considerable soil disturbance and compaction. As a result, an insignificant effect on peak flows, low flows, or water yield is expected.

Riparian Structure

Invasive plant treatment and removal in riparian areas is intended to provide the opportunity for the eventual return of native vegetation and corresponding restoration of natural riparian structure. Some desired future conditions for B7 General Riparian Areas identified in the Forest Plan are: "dynamic, multi-aged communities . . ." that consist of a "multi-latered canopy including large tall green trees, dead snags, intermediate size trees and understory vegetation." When invasive plants occupying riparian sites are eradicated, the length of time before suitable native vegetation (passive restoration) returns to perform important riparian functions, such as stream shading and streambank stability, would vary across the Forest and Scenic Area. On invasive plant treatment areas where native vegetation would be planted (active restoration) riparian structure would return more rapidly. In general, improved long-term riparian structure and function due to invasive plant treatment would benefit water quality and listed aquatic species, due to long-term improvements in stream shading, vegetative stream bank stabilization, and in-channel large wood inputs.

Water Chemistry

Herbicides used to control terrestrial invasive plants for the Proposed Action could enter water through spray drift, surface water runoff, percolation and groundwater contamination. This has the potential to reduce water quality due to introduction of herbicides and associated adjuvant and impurities. Some of these adjuvants may also alter water quality characteristics such as pH (Bakke, 2003a). The primary pathway for potential herbicide introduction into surface water depends on a variety of factors including: application method, timing and amount of herbicide application, herbicide properties, soil properties, site conditions and management practices. Once on the ground or plant surface, herbicide fate is controlled by numerous biological, physical and chemical processes including: ingestion by animals, insects, worms or microorganisms; movement downward in the soil; adherence to or dissolved in soil particles; degradation into less (or more) toxic compounds; movement by runoff water on the soil surface; or transported by eroding sediment. Needless to say, herbicide delivery and fate is a very complex situation. Detailed discussions about herbicide delivery and fate are contained in the herbicide risk assessments completed by SERA (SERA 2001b, 2003a, 2003b, 2003c, 2004a, 2004b, 2004c, 2004d, 2004e, 2004f). This information is also summarized in Appendix Q – Herbicide Information Summary and PDC Crosswalk.

Soil type and chemical stability, solubility, and toxicity could determine the extent to which an herbicide would migrate and impact surface waters and groundwater. Some herbicides such as glyphosate strongly adsorb to soil particles, which prevents it from excessive leaching. Other herbicides such as picloram are highly soluble in water and more mobile. The herbicide risk assessments completed by SERA (SERA 2001b, 2003a, 2003b, 2003c, 2004a, 2004b, 2004c, 2004d, 2004e, 2004f) and associated worksheets utilize modeling to predict potential concentrations reaching surface water take these physical characteristics into account. These concentrations were estimated and utilized along with several other factors in Section 3.10 – Aquatic Organisms and Habitat to help determine risk of herbicide treatment to aquatic organisms for specific sites outlined in this EIS.

As stated above, due to its chemical nature picloram has one of the highest potentials of all of the herbicides analyzed in the EIS to leach into groundwater. Some studies have looked at the potential of groundwater contamination from picloram. Neary and others (1985) monitored two springs approximately 140 meters (450 feet) downslope of two 5-acre plots that were treated with picloram applied at the rate of 4.4 lb/ac. The study took place in the Coweta Watershed in North Carolina which has an average annual rainfall of approximately 80 inches. Picloram residues were detected in “trace amounts” 82 days after the initial herbicide treatment. During the 40 weeks that the two springs were monitored, picloram residues were present in only “trace levels” for a period of 18 days. According to the study: “In terms of water quality impacts, there was no adverse effect on the quality of the springs.” It should be noted that the concentration of picloram applied in this study is almost 13 times higher that the application rate that would be allowed for picloram in this EIS.

Bovey et al. (1975) conducted an investigation to determine the concentration of 2,4,5-T and picloram in subsurface water after spray applications to the surface of a seepy area in Texas. A 1-to-1 mixture was sprayed at 2.5 lb/ac every six months on the same area for a total of five applications. Supplemental irrigation in addition to a total of 85.5 cm natural rainfall was used to leach picloram into the subsoil. Seepage water was collected on 36 different dates, and one to six wells in the watershed were sampled at 10 different dates during 1971, 1972, and 1973. Concentration of 2,4,5-T and picloram in seepage and well water from the treated area was extremely low (less than 1 ppb) during the 3-year study. Again, it should be noted that the application rate of this study was considerably higher than the rate proposed in this EIS for picloram.

By contrast, triclopyr BEE (ester formulation) is one of the more potentially toxic herbicides proposed for use in this EIS; however, it is somewhat immobile in soils and tends to rapidly breakdown into the less toxic triclopyr acid (Ganapathy, 1997). In soil, triclopyr BEE hydrolyzes to triclopyr acid with a half-life of three hours (Bidlack, 1978) while in water BEE converts to acid in less than a day (Somasundarm and Coates, 1991; Bidlack, 1978). Triclopyr acid is also photodegradable. A study of photolysis found the half-life of triclopyr acid on soil under mid-summer sun was two hours (McCall & Gavit, 1986). Photodegradation can be particularly important in water. Johnson et al. (1995) found triclopyr acid dissolved in water had a half-life due to photolysis of one to 12 hours.

In a 1990 field study, Stephenson et al. examined the soil dissipation of triclopyr on both sandy and clay soils and its potential for vertical movement. The researchers found triclopyr to be rapidly degraded in both sand and clay soils; 50 percent and 90 percent disappearance of the compound was observed after two and four weeks, respectively. An average of 90 percent or more of the triclopyr did not leach below the organic layer at the two sites over a one year period; 97 percent or more of the triclopyr was recovered within six inches of the soil surface. The authors also found little lateral movement of triclopyr, detecting less than 1 ppb triclopyr in runoff samples from one to 105 days after treatment with 2.7 lbs ai/ac (this application rate is almost three times higher than what is proposed in this EIS). They concluded: "...our field studies of actual triclopyr persistence and mobility confirm earlier laboratory results and indicate that environmental problems are very unlikely to occur because of excessive triclopyr persistence and/or mobility in soil." In contrast, studies conducted for Dow Chemical classified triclopyr as mobile (Hamaker, 1975). This apparent contradiction in soil mobility may be explained by a study that showed that triclopyr sorption to soil increases with time, decreasing the potential for leaching (Buttler et al., 1993).

Several studies have focused on the fate of triclopyr in runoff from forested sites. Thompson et al. (1995) studied triclopyr BEE and triclopyr acid in first order streams. The authors injected a 3.6 lb ai/ac solution (over three times stronger than what is proposed in this EIS) of triclopyr BEE directly into a small stream at two locations at different depths. Sediment, invertebrates and periphyton were sampled at seven locations at different time intervals. As the herbicide pulse moved downstream, the BEE degraded to the less toxic triclopyr. The study concluded that triclopyr had almost no adverse effects on the drifting and benthic invertebrates. Periphyton growth increased after herbicide introduction possibly due to nutrient enrichment from components in the formulation. Periphyton conditions returned to control levels three months after herbicide introduction.

Newton et al. (1990) studied an application of triclopyr, picloram and 2,4-D to brush in southwestern Oregon. Both triclopyr TEA, and triclopyr BEE were applied to 100 by 200 meter plots at the rate of 2.0 and 3.9 lb ai/ac for the TEA and 1.5 and 2.9 lb ai/ac for the BEE. At 37 days after application, 24 and 51 percent of the applied triclopyr was present in the surface soil. The largest decrease in soil residue occurred between 37 and 79 days after application. As a result of the monitoring, the researchers concluded that due to the immobile nature of triclopyr in soil-water, the herbicide would only move very short distances in forest subsurface flow.

In summary, research indicates that both triclopyr TEA and triclopyr BEE rapidly convert to triclopyr acid which, in the case of triclopyr BEE is considerably less toxic to aquatic organisms. Triclopyr exhibits very little horizontal and vertical movement through soils and degrades fairly rapidly (average half life of several hours to 30 days).

Water runoff during rain events could transport herbicides to waterways, and convey them to aquatic species habitat directly adjacent and downstream of the treatment site. Two factors that help determine herbicide concentrations delivered to aquatic organisms include the amount of herbicide reaching surface water and the dilution of the herbicide once it reaches water. While potential herbicide concentrations delivered to water are discussed above and in other resource sections in this Chapter, these discussions focused on a single herbicide application during the course of a year. In some cases, there is a potential of having multiple applications of an herbicide on a singe site in a year, so there is a chance that some residual herbicide would still be stored in the soil when the next application occurs. The potential of having higher herbicide concentrations delivered to surface water would be highest for those herbicides that have a high persistence in soil and a high mobility through soil. This higher concentration would be most evident in a “first flush” situation, where multiple herbicide applications occur prior to the first fall rains. A table displaying these particular attributes can be found in Section 3.8 – Soil Productivity. Only three herbicides are rated moderate to high in both persistence and mobility categories – picloram, chlorsulfuron and metsulfuron methyl. PDC that include limiting the application of picloram to once per calendar year per site and limiting application of picloram, chlorsulfuron and metsulfuron methyl to soil types that do not encourage persistence and mobility are designed to reduce the likelihood of increased herbicide concentration from the first flush.

As mentioned above, the other factor influencing delivery to aquatic organisms is dilution of herbicide in water. The mixing zone size needed to reduce or dilute downstream herbicide levels below any threshold effect concentration is a critical parameter. Mixing zone size can vary greatly and can depend upon the volume of herbicide input, the volume of the water body, the entry point (e.g., gravel bar inundation or drift deposition), and turbulence, which is generally greater for small but steep headwater streams. Hydrologically complex waterways with meanders, pools, riffles, and eddies that accelerate mixing and dilution are more likely to disperse contaminants than simplified waterways with consistent channel velocities that allow contaminants to maintain a more consolidated profile (Jobson, 1996; Lee, 1995; Heard et al.,2001; as cited in USDC NOAA, 2003). Streams on the Forest and Scenic Area have high channel complexity (wood, pools, boulders), so it is expected that mixing of chemicals would occur rapidly and there would be a rapid decrease of concentration with time. Mixing distances are also usually shorter in smaller streams (Heard et al., 2001; as cited in USDC NOAA, 2003).

Information about downstream mixing and dilution for herbicides used in forestry is relatively limited. Evans and Duseja (1973) sprayed picloram at the rate of one and two lb/ac over areas that ranged between one and two acres. They took runoff samples from a drainage ditch at a distance of 5, 10, 100 and 1,000 meters downstream of the treatment area. The site experienced a 1.5 inch rainstorm within the first week after spraying. Picloram concentrations were diluted 85 percent to 98 percent within 100 meters below the treatment areas and were diluted to concentrations below detection levels in all but one site 1,000 meters below the treatment areas. After 12 weeks all concentrations were ≤ 0.001 ppm and within a year picloram was not detectable. It should be noted that concentrations used in this study are three to six times greater than the concentration proposed in this EIS. In addition, the sample site was a drainage ditch which represents a simplified waterway with a low mixing potential when compared to complex streams found on National Forest land.

Johnsen and Warskow (1980) directly injected 1.5 lbs of picloram at a concentration of 6.258 ppm into a 1.3 cfs stream in Arizona and sampled water at 400, 800, 1,600, 3,200, 6,400 and 9,700 meter intervals along the stream. The original 6.258 ppm solution had been diluted to a concentration of 0.282 ppm (96 percent reduction in concentration) by the time it reached 1,600 meters downstream and 0.10 ppm (99.9 percent reduction in concentration) by the time it reached 3,200 meters downstream. Two days after the picloram injection, concentrations were at or near the detection limit of 0.001 to 0.004 ppm at the 400 to 1,600 meter sample points. It should be noted that the original concentration of 6.258 ppm of picloram that was introduced into the stream by this study is approximately 560 times more concentrated than the highest picloram concentration predicted by the herbicide risk assessments completed by SERA (SERA 2001b, 2003a, 2003b, 2003c, 2004a, 2004b, 2004c, 2004d, 2004e, 2004f) and associated worksheets for any of the treatment sites analyzed in this EIS.

PDC are utilized to reduce or eliminate negative effects of management activities on resources. A detailed discussion of specific aquatic-related PDC and how they would reduce or eliminate herbicide introduction into water is included in Section 3.10 – Aquatic Organisms and Habitat and a list of PDC and how they would address specific effects from herbicide application is summarized in Appendix Q – Herbicide Information Summary and PDC Crosswalk. As described in Section 3.10, the amount of herbicide reaching surface water by spray drift is expected to be minimal considering the restrictions of no broadcast boom spraying within 100 feet of surface water and when wind speeds are outside the range described in the PDC (Section 2.2) as well as using coarse spray, low nozzle pressure spray heads. Herbicides entering surface water through surface runoff are also expected to be minimal, since among other things, targeted spot spraying techniques that reduce the total amount of herbicide applied would be used within 100 feet of surface water (PDC F.1.), application of herbicides is restricted if rainfall is expected immediately after application (PDC C.3.). This would minimize the amount of herbicide reaching the ground surface as well as minimize the potential for herbicide drift.

The potential routes of herbicide entry described above should result in insignificant short term and long term indirect effects to water quality. As discussed above and in Section 3.10 – Aquatic Organisms and Habitat, PDC would be employed to minimize the potential for introduction of herbicides into area surface and groundwater. The likelihood of herbicide drifting would be substantially reduced by: 1) no aerial application of herbicides; 2) limited broadcast spraying outside of the aquatic influence zone; 3) selective application techniques only within the aquatic influence zone; and 4) use of coarse spray, low nozzle pressure spray heads. PDC that would limit the total amount of herbicide applied next to water features by only utilizing selective application techniques, not allowing use of more toxic and mobile herbicides and adjuvants next to water features, restricting application of herbicides if rainfall would occur immediately after application and treating sites to minimize erosion would reduce the likelihood of secondary herbicide introduction. As indicated by the mixing and dilution studies cited in the paragraphs above, any trace amount of herbicide that may reach surface water would be quickly diluted.

Summary of Indirect/Direct Effects

Table 3-25 below is a summary of the potential pathways of effects on water quality from proposed herbicide, manual, mechanical, and cultural treatments of invasive plants. This table is a summary of the information provided above.

Table 3-25: Potential pathways of effects to water quality from treatment methods. (I = Insignificant estimated effect; B = Potential long-term beneficial effect.)

Treatment Methods	Potential Pathways of Effects					
	Soil Disturbance, Turbidity, and Sedimentation	Dissolved oxygen and nutrients	Stream Shade and Water temperature	Peak flows, low flows, water yield	Riparian structure	Water Chemistry
Cultural	I	I	I	I	I	N/A
Manual	I	I	I	I	I/B	N/A
Mechanical	I	I	I	I	I/B	N/A
Herbicides and adjuvants	I	I	I	I	I/B	I
Restoration[1] (revegetation)	B	I	B	B	B	N/A

[1] Restoration (Revegetation) would be done on selected invasive plant treatment sites.

N/A – Not Applicable

The potential adverse effects of the Proposed Action on aquatic organisms/plants and drinking water quality are discussed in the Section 3.5 – Human Health and Safety and Section 3.10 – Aquatic Organisms and Habitat.

Cumulative Effects – Alternative 2

Most proposed invasive plants treatment areas on the Forest and Scenic Area are upstream of other sources of herbicides and sediment on both non-Federal and Federal lands. Where streams migrate and flow downstream through other land ownerships (BLM, Federal, State, Tribal, or private), the potential exists for herbicides or sediments originating from invasive plant treatment sites on the Forest and Scenic Area to mix with those originating from sites being treated off-National Forest System lands. There is also the potential for herbicides and sediments from invasive plant treatment sites adjacent to the Forest and Scenic Area watersheds to mix together at some point downstream if simultaneous treatment occurs. As described in Section 3.4 of this document and Section 4.1.1 of the Invasive Plant FEIS (2005a), the effects could be additive or synergistic in nature. As described in the Water Chemistry section above, expected mixing and dilution of any trace amount of herbicide that may result from invasive plant treatment would occur quickly, making it highly unlikely that herbicide concentrations would be additive or synergistic with similar treatments at the watershed scale. Limited monitoring done by the State of California seems to support this conclusion. In response to concerns about potential contamination of drinking water from herbicide treatments on nearby private lands, numerous surface water samples were collected in the late 1990s both immediately downstream of herbicide application sites (site scale), and on larger channels potentially distant from application sites (watershed scale). Approximately 40,631 pounds of active ingredient of 13 herbicides and 19 insecticides were applied within the privately-owned watersheds upstream of locations sampled at the watershed scale (Jones et al., 2000).

One hundred eight water samples were collected at six sites on the Klamath, Trinity and Scott rivers, and Elk, Pine and Supply creeks on four occasions between September 1998 and October 1999 (Jones et al., 2000). Timing of sample collection was scheduled partially to coordinate with runoff events. The first collection, done under dry conditions in September 1998, served as background. Collections in October 1998 and 1999 sampled storm runoff. Collections in June 1999 corresponded to the end of the heaviest pesticide application season (Jones et al., 2000).

No detectable concentrations of any herbicides were identified (reliable detection limits ranged from 0.04 to 2.0 ppb). The analysis included two herbicides that are being proposed for use in this EIS, glyphosate and triclopyr. Some possible explanations for the lack of detection include several months passed between dry weather application and the first rain, potentially allowing chemical degradation or adsorption to soil. Also, dilution of streamflow between application and monitoring sites may also have contributed to the lack of positive detections (Jones et al., 2000).

Table 3-26 shows the number of acres of treatment in each fifth-field watershed to give an idea about how much treatment would actually occur on the Forest and Scenic Area. In addition, the table displays road density in each fifth-field watershed. Road density could be used as a surrogate for the amount of sediment related to human activity since roads are used to access structures, land treatment sites, and since roads themselves are sources of sediment.

Table 3-26: Ownership, acres of treatment areas and road density in each fifth-field watershed.

Watershed Name	Total Watershed Acres	Percent of Watershed in Forest/ Scenic Area Ownership	Proposed Treatment Acres	Percent of Watershed Treated	Road Density* (mi/mi^2)
Beaver Creek	10,6742.0	1%	45.5	0%	0.2
Bull Run River	88,985.0	88%	2.4	0%	2.6
Collawash River	97,421.1	99%	64.1	0.1%	2.7
Columbia Gorge Tributaries	103,926.1	43%	942.3	1%	0.4
East Fork Hood River	100,953.3	68%	1254.1	1%	1.9
Fifteenmile Creek	157,237.5	11%	227.8	0.1%	0.4
Fivemile Creek	78,190.5	24%	511.8	1%	1.0
Lower Clackamas River	117,660.7	1%	3.4	0%	0.1
Lower Hood River	51,289.3	6%	250.3	1%	1.2
Lower Sandy River	47,155.2	8%	856.6	2%	0.5
Middle Clackamas River	138,506.6	90%	747.4	1%	2.5
Middle Columbia/ Eagle Creek	84,495.2	55%	79.2	0.1%	0.3
Middle Columbia/ Grays Creek	92,722.8	31%	173.3	0.2%	0.4
Middle Columbia/ Mill Creek	130,697.6	13%	214.0	0.2%	0.4
Middle Deschutes River	195,384.6	2%	315.6	0.2%	0.1
Middle Sandy River	40,956.7	16%	40.5	0.1%	1.6
Oak Grove Fork Clackamas River	90,542.0	88%	175.8	0.2%	3.7
Salmon River	73,716.1	92%	172.8	0.2%	1.9
Tygh Creek	81,558.4	51%	298.1	0.4%	0.9
Upper Clackamas River	100,496.8	94%	484.9	1%	3.5
Upper Sandy River	34,200.9	90%	1,060.7	3%	2.5
West Fork Hood River	65,466.3	66%	1,620.5	3%	1.7
White River	176,272.2	60%	3,171.7	2%	2.3
Zigzag River	37,763.7	97%	368.7	1%	1.1

* Road density values include some roads off National Forest System lands

According to the table above, total acres treated in any fifth-field watershed exceeds two percent of the total watershed acreage in only two fifth-field watersheds. Those watersheds are Upper Sandy River and West Fork Hood River. Less than one percent of the total watershed area is proposed for treatment in the majority of the remaining fifth-field watersheds. Forest and Scenic Area ownership in these two watersheds is 89.8 percent and 65.5 percent for the Upper Sandy River and West Fork Hood River respectively. Since the major land holdings are National Forest System lands, effects of invasive plant treatments at individual sites are described in this document. Detrimental effects to water quality from each of the projects are expected to be very low due to PDC that employ measures to reduce or eliminate harmful effects to the aquatic environment. These PDC were developed using modeling, research and other documents and field experience (See Section 2.2, Subsection F: Water Quality and Aquatic Organisms). The majority of the remaining the fifth-field watersheds propose to treat less than 1 percent of the total watershed acres so no cumulative effects from proposed invasive plant treatments are expected.

Even if the invasive plant treatments are occurring at the same time on both Federal and non-federal lands, the potential for sediment-related cumulative effects is very low considering the negligible amount of sediment expected to reach perennial streams from either manual, mechanical, or cultural treatments of invasive plants. Forest streams listed on the 303 (d) list for sediment displayed in the Existing Condition section are located in the Fivemile and Fifteenmile fifth-field watersheds. Only 61 and 14 acres of additional riparian reserve treatment are being proposed in this alternative when compared to the No Action Alternative in these two watersheds. This acreage only represents 0.5 and 1.9 percent of the total riparian reserve in each of the watersheds, respectively. As described above, road density could be used as an indicator of the amount of past and present human disturbance, and the resulting levels of sedimentation. Fivemile and Fifteenmile fifth-field watersheds have road densities of 1.02 and 0.37 mi/mi^2 respectively. These watersheds have low relative road densities when compared to the other fifth-field watersheds in the analysis (14 and 20 highest road densities out of the 24 fifth-field watersheds analyzed in this document). These represent moderate to low relative road densities, which when coupled with the low amount of proposed disturbance in riparian reserves PDC to reduce erosion and sediment delivery and apparent improving trend related to sedimentation identified in the draft WQRP would result in negligible sediment related cumulative effects.

The potential for cumulative effects is negligible considering the insignificant amount of herbicide or sediment expected to reach surface water due to implementation of PDC that would minimize the amount and type of herbicides that actually reach surface water, the distance between potential treatment areas, and dilution over time and space by mixing and additional inflow from downstream tributaries and ground-water entering streams.

Alternative 3 – Restricted Herbicide Use Alternative

Herbicide treatments would be completed only on priority 1 sites under this alternative. All other sites (priority 2 through 5) only have manual, mechanical and cultural methods proposed. The potential effects of priority 1 invasive plant herbicide treatment sites is similar to those described above for Alternative 2 (Proposed Action), but the potential effects from the use of herbicides are much more limited since the number of acres potentially treated is much less.

As described in Section 3.8 – Soil Productivity, this alternative would have a lower potential for long term erosion when compared to the No Action Alternative, due to the establishment of native vegetation on treatment sites. Since the erosion potential is lower, the associated sedimentation resulting from the erosion would be lower than Alternative 1. According to the soils analysis, the primary source of erosion is from the inability of the invasive plants to protect the soil from erosion. Actual erosion and sediment production from the mechanical and manual activity is expected to be very low due to the PDC. Manual, mechanical and cultural treatment methods could be repeated yearly on invasive plant treatment areas if necessary to achieve adequate control of invasive plants. Even with the larger number of acres proposed for treatment with manual, mechanical and cultural treatment methods, the risk of adverse effects on water quality due to sedimentation is expected to be low because PDC (Section 2.2) would reduce that risk.

Cumulative Effects – Alternative 3

As described in the cumulative effects section of Alternative 2, actual treated acres comprise a very small percentage of actual fifth-field watershed acres. Since the amount of herbicide used is less than Alternative 2, concern over cumulative effects associated with herbicide application is less than Alternative 2, which is very low. This is due to less herbicide used overall, implementation of PDC that would minimize the amount and type of herbicides that actually reach surface water, the distance between potential treatment areas as well as dilution over time and space by mixing and additional inflow from downstream tributaries and ground-water entering streams. It is unlikely that herbicide exposure from invasive plant treatments would add or accumulate in-stream because the herbicides considered in this EIS do not bio-accumulate

Forest streams listed on the 303 (d) list for sediment displayed in the Exiting Condition section are located in the Fivemile and Fifteenmile fifth-field watersheds. The number of acres treated in the riparian reserve is the same as Alternative 2 (61 and 14 acres respectively) for these two watersheds, but all of these acres would be treated using manual or mechanical methods instead of manual, mechanical and herbicide. This acreage only represents 0.5 and 1.9 percent of the total riparian reserve in each of the watersheds respectively, which is a very small percentage of the total. As described above, road density could be used as an indicator of the amount of past and present human disturbance, and the resulting levels of sedimentation. Fivemile and Fifteenmile fifth-field watersheds have road densities of 1.02 and 0.37 mi/mi^2 respectively. These watersheds have low relative road densities when compared to the other fifth-field watersheds in the analysis (14 and 20 highest road densities out of the 24 fifth-field watersheds analyzed in this document). These represent moderate to low relative road densities, which when coupled with the low amount of proposed disturbance in riparian reserves, PDC to reduce erosion and sediment delivery, and apparent improving trend related to sedimentation identified in the draft WQRP would result in negligible sediment related cumulative effects.

3.9.4. Early Detection/Rapid Response Strategy

Total treatment acres for the EDRR would be similar to those outlined in Alternative 2 and 3 for each fifth-field watershed. The anticipated treatment acres are shown in Appendix J and are equivalent to what was analyzed in this document. Since this acreage is generally located in the same fifth-field watersheds, many of the physical characteristics that influence herbicide concentration and erosion would be similar for new treatment areas. The proposed program of work would periodically be reviewed to ensure, among other things, that new site meet the conditions outlined in this document (see Section 2.1.3). Due to this in conjunction with the PDC, the potential effects of EDRR herbicide, manual, mechanical and cultural effects treatments are expected to be similar to those described above for Alternatives 2 and 3.

The EDRR proposes to treat up to 13,000 acres annually across the Forest and Scenic Area and would be limited as described in Chapter1 and 2 of this document. This has the potential to create cumulative effects through repeated treatments over a long period of time. Concern from herbicide application is low, due to implementation of PDC that would minimize the amount and type of herbicides that actually reach surface water, the distance between potential treatment areas as well as dilution over time and space by additional inflow from downstream tributaries and ground-water entering streams. Exposure of ground that has been treated to remove invasive plants has the potential for erosion and resulting sedimentation. Sites that were treated in prior years would be in a variety of states of recovery ranging from full native plant re-vegetation to recently treated, seeded and mulched. According to the soils analysis (Section 3.8), erosion is expected to be less on treated sites when compared to the No Action Alternative due to the presence of new native vegetation and PDC that include seeding, mulching and restricting vehicle access. Since this erosion is less than what is present at the site prior to treatment, resulting sedimentation is expected to be less as well. The long-term result is an expectation that these sites would be closer to natural rates of erosion and sedimentation due to the recovery of native vegetation.

3.9.5. Aquatic Conservation Strategy Objectives

In order for a project to proceed, "a decision maker must find that the proposed management activity is consistent with the Aquatic Conservation Strategy objectives" (page B-10, ROD, USDA Forest Service and USDI BLM, 2001). The nine objectives are listed on page B-11 of the Aquatic Conservation Strategy ROD. The effects analysis above has focused on key parameters or indicators that make up elements of the nine Aquatic Conservation Strategy objectives, to determine if the Invasive Plant EIS project would restore, maintain, or degrade these indicators. Once this determination has been made, the indicators should be examined together to make a final determination of whether the project is consistent with the objectives. Table 3-27 displays the individual indicators and the effect this project has on those indicators at the fifth-field watershed scale.

Table 3-27: Water quality indicators and project effects at the fifth-field watershed scale.

	Effects of the Actions Alternative 1			Effects of the Actions Alternative 2			Effects of the Actions Alternative 3		
INDICATORS	**Restore[1]**	**Maintain[2]**	**Degrade[3]**	**Restore**	**Maintain**	**Degrade**	**Restore**	**Maintain**	**Degrade**
Water Quality									
Temperature		X			X			X	
Sediment		X			X			X	
Chemical Contamination		X			X			X	
Habitat Access									
Physical Barriers		X			X			X	
Habitat Elements									
Substrate		X			X			X	
Large Woody Debris		X			X			X	
Pool Frequency		X			X			X	
Pool Quality		X			X			X	
Off-channel Habitat		X			X			X	
Refugia		X			X			X	
Channel Condition and Dynamics									
Width/Depth ratio		X			X			X	
Streambank Condition		X			X			X	
Floodplain Connectivity		X			X			X	
Flow/Hydrology									
Peak/base flows		X			X			X	
Drainage Network Increase		X			X			X	
Watershed Conditions									
Riparian Reserves			X	X			X		

[1] "Restore" means the action(s) would result in acceleration of the recovery rate of that indicator.
[2] "Maintain" means that the function of an indicator does not change by implementing the action(s) or recovery would continue at its current rate.
[3] "Degrade" means to change the function of an indicator for the worse.

The following summarizes Table 3-27:

- The proposed project has a risk of adding some minor amounts of sediment and herbicides to surface water, but since the amount is insignificant and not expected to affect watershed function at the fifth-field scale, the project would maintain this element.

- It is anticipated that this project would aid in restoration of the riparian reserve conditions by allowing native vegetation to return to sites infested by invasive plants.

- Indicators other than those described in the proceeding paragraph would be maintained as outlined in the effects analysis above.

Table 3-28 displays specific Aquatic Conservation Strategy objectives and the indicators from the previous table that comprise each objective. All of the indicators that are checked for a particular objective should be evaluated together to determine whether the action maintains or enhances the specific Aquatic Conservation Strategy objective.

Table 3-28: Aquatic Conservation Strategy objectives and water quality indicators.

	Aquatic Conservation Strategy Objectives								
Indicators	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**	**#7**	**#8**	**#9**
Temperature		X		X				X	X
Sediment				X	X	X		X	X
Chem. Contamination				X				X	X
Physical Barriers	X	X						X	X
Substrate			X		X	X			X
Large Woody Debris			X					X	X
Pool Frequency			X						X
Pool Quality			X						X
Off-Channel Habitat	X	X	X						X
Refugia	X	X						X	X
Width/Depth Ratio			X					X	X
Streambank Condition			X			X		X	X
Floodplain Connectivity	X	X	X				X	X	X
Peak/base Flows					X	X	X		
Drainage Network Increase					X	X	X		
Riparian Reserves	X	X	X	X	X	X		X	X

The following is a summary of how this project compares to the Aquatic Conservation Strategy objectives (Aquatic Conservation Strategy ROD B-10):

- **ACS Objective #1.** This project would at least maintain, if not enhance the distribution, diversity and complexity of watershed and landscape-scale features because of the protection that the Riparian Reserves provide to the aquatic and terrestrial systems and restoration of the Riparian Reserves through invasive plant eradication. No new road crossings of streams or wetlands are proposed, which would maintain the current level of aquatic habitat fragmentation. Channel components that contribute to channel complexity (pool quantity and quality, substrate, flows) would be maintained due to the existence of the Riparian Reserves.

- **ACS Objective #2**. The project would maintain spatial and temporal connectivity within and between watersheds. Nothing proposed with this project would reduce the spatial and temporal connectivity.

- **ACS Objective #3**. This project would maintain the physical integrity of the aquatic system, including streambanks, side channels (refugia), and channel bottom configurations due to the protection provided to Riparian Reserves. PDC aimed at reducing soil compaction and erosion, and the lack of any new stream crossings would greatly reduce risks of increased peak flow, and resulting bank erosion and channel bed scour. There are no temporary roads entering the Riparian Reserves and insignificant short-term inputs of sediment are expected to be very localized if they occur. This project would result in long term benefits to Riparian Reserve conditions, but it is unclear whether they would be noticeable at the fifth-field scale for this objective.

- **ACS Objective #4**. This project would maintain water quality necessary to support healthy ecosystems through project design criteria and the existence of Riparian Reserves. PDC aimed at reducing erosion would maintain the overall sediment levels in the long term, but there is a low risk of a short term, limited increase. In addition, PDC aimed at minimizing herbicide introduction into surface water as described in the text above, would keep concentrations at an insignificant level. Since the amount of these is so small and not expected to effect watershed function, the project would maintain this element.

- **ACS Objective #5**. This project would maintain sediment regimes through PDC and the existence of Riparian Reserves. There is a low risk of slight inputs of sediment from treatment areas, but they are anticipated to be very small and localized.

- **ACS Objective #6.** This project would maintain in-stream flows through PDC and Riparian Reserves. As described in the effects section, no increase in peak flows would result from this project.

- **ACS Objective #7.** This project would maintain the timing, variability, and duration of floodplain inundation through PDC and Riparian Reserves. As described in the effects section, no increase in peak flows would result from this project.

- **ACS Objective #8.** This project would aid in restoration of the species composition and structural diversity of plant communities in riparian areas and wetlands through invasive plant eradication, native vegetation establishment and the existence of Riparian Reserves.

- **ACS Objective #9.** This project would aid in restoration of habitat to support well-distributed populations of native plant and riparian dependent species through invasive plant eradication, native vegetation establishment and the existence of Riparian Reserves.