Economic Analysis for the Impact of *Phytophthora Ramorum* on the Oregon Nursery Industry

Economic Analysis for the Impact of *Phytophthora Ramorum* on the Nursery Industry

ORPIN 603-1177-08

Submitted to

Oregon Dept. of Agriculture
635 Capitol St. NE
Salem, OR 97301-2532

by

ENTRIX, Inc.
12009 N.E. 99th Street, Suite 1410
Vancouver, Washington 98684-2497

October 20, 2008

Table of Contents

Introduction

Nursery stock represents nearly a billion dollar industry in Oregon and is the state's most valuable agricultural commodity. The 2,100 registered nursery and greenhouse grower operations in Oregon export out of state more than 75 percent of the nursery stock produced. The total economic impact of the nursery and greenhouse industry in Oregon in 2002 was estimated at $1.69 billion in output, $1.04 billion in value added, and 21,554 jobs (Hall, Hodges, Haydu, 2006). The economic importance of this industry makes the discovery and spread of *Phytophthora ramorum (P. ramorum),* which causes sudden oak death and ramorum blight in many nursery plants, an extremely important issue. Optimal policies for controlling *P. ramorum* in Oregon depend on the costs of monitoring, treatment, and eradication efforts, associated risks of *P. ramorum* spread, and the benefits of avoided *P. ramorum* infection and treatment.

History of *P. ramorum* in Oregon

The pathogen *P. ramorum* has become a serious threat to Oregon's nursery industry. The first known nursery infection of *P. ramorum* in Oregon was in 2003, with six known infections. Since then, in the years 2004 to 2007, there have been an average of approximately 13.5 nurseries infected annually (see Table 1).

Table 1
Oregon Nursery Infections by *P. ramorum* by Year

Year	Number of Nurseries Infected with *P. ramorum*
2007	3
2006	13
2005	15
2004	23
2003	6

Sources: California Oak Mortality Taskforce, Year-end Newsletter Summary Reports years 2004 – 2007; Oregon Department of Agriculture, Plant Health Section Annual Report years 2003-2007, Commodity Inspection Division, http://egov.oregon.gov/ODA/PLANT/reports.shtml.

Federal rules enacted in 2004 and updated in 2007 mandate *P. ramorum* inspections for all nurseries shipping out of state and specific testing procedures for nurseries with susceptible species or in a quarantine area. Since *P. ramorum* was discovered in the forests of Curry County in 2001, the state has developed a system to monitor and quarantine the infected area in efforts to limit the pathogen's spread. The quarantine area surrounding the infected area was approximately 26.5 square miles in 2007 and grew to 162 square miles in January 2008. Although analysis of the strain of *P. ramorum* located in Curry County indicates that no nurseries have been infected from this source, if the pathogen were to spread, it is expected that this source would lead to increased nursery infection as well as increased quarantine areas.

Scope of the Analysis

Three treatment options to control *P. ramorum* in Curry County have been identified by the Oregon Department of Agriculture. In order of increasing level of control, these options are to discontinue treatment in Curry County, continue the current Curry County treatment program, and to completely eradicate the *P .ramorum* strain occurring in forests in Curry County. Under no treatment, treatment program costs would be eliminated, but the pathogen is expected to spread, resulting in plant losses and cultural costs at nurseries as well as increased costs of inspection. Under the current treatment program, costs to monitor and control the quarantine area would continue, as well as costs associated with the potential spread of the pathogen to nurseries. Under an eradication program, initial treatment costs would

be high, but would reduce future monitoring and control costs and would prevent the spread of the pathogen to nurseries and other areas.

This report provides an approximate assessment of the costs and benefits of three treatment options for *P. ramorum* control, and estimates the net benefits of each option. The analysis is confined to the assessment of *P. ramorum* impacts on the nursery industry, all other industries (timber, specialty forestry products, blueberries, etc) are excluded from the analysis. To account for costs and benefits over time, the analysis covers a 20-year time period. Furthermore, the analysis only reviews costs associated with the containment or spread of the *P .ramorum* located in the quarantine area of Curry County, and does not analyze the impact associated with other sources of *P. ramorum.*

Due to the data and timeframe limitations, the results presented in this report represent approximate estimates of the expected costs and benefits of the three treatment options.

Report Organization

There are three remaining sections of the report. First, an overview is provided of the costs and benefits associated with *P. ramorum* control. Second, the specific costs and benefits associated with each of the three proposed levels of control are presented, along with the assumptions and methodology used to derive the estimates. The final section summarizes the results and presents them in net present value terms for comparison.

Methodology to Estimate Costs and Benefits of *P. ramorum* Control

Overview of Costs and Benefits

The costs of *P. ramorum* include such factors as the expenditure on the control and treatment program, as well as the direct costs to the nursery industry (changes to cultural practices, and costs for federally required inspections) and indirect costs to the nursery industry (impacts on markets and consumer confidence). Benefits of a treatment program arise as avoided costs. In other words, if a treatment program results in reduced spread of the pathogen, the benefit to nurseries is the avoided direct and indirect costs that they would have otherwise incurred absent the program. Recognizing that all impacts of *P. ramorum* are costs, and to avoid confusion resulting from a cost becoming a benefit based on the treatment program, all estimates are presented in terms of cost of *P. ramorum.* In the last section of the report, the benefits of the two treatment program options are measured as the difference in total *P. ramorum*-associated costs of treatment versus no treatment.

Methodology to Estimate Spread of *P. ramorum*

Central to the analysis of costs, is the acreage affected by the spread of *P. ramorum.* An analysis of spread of *P. ramorum* over 20 years (2009-2028) was conducted for both the no treatment option, and for the current treatment option. It was assumed that the eradication treatment option would be successful, resulting in no spread of the pathogen.

The information for estimating the future probability of spread of *P. ramorum* infection to other Oregon counties is from Hanson et al. (2008). Hanson et al. recorded dispersal of *P. ramorum* spores between 2001 and 2006 and found 50 percent of new infections to be within 122 meters of trees with prior infections and 79 percent of new infections to be within 300 meters of prior infections. More distant infections located more than 2.75 kilometers (km) from prior infections were observed only in year 2006 and at very low frequencies. The farthest observed travel distance over one year was four km. This analysis assumes a travel distance of 4.83 km. This is the assumed distance between infected trees and the northernmost quarantine boundary, and is used to calculate the probability and time required for spores to travel outside the Curry County quarantine.

Interpolating from Hansen et al., a frequency distribution is generated (shown in Table 2). The cumulative frequency distribution is obtained by taking each of the annual percent distribution values and raising it to the power of the number of years required to travel 4.83 km. Then, to obtain the interpretive values for the probability of spores infecting trees outside the quarantine boundary, the estimated values for "years required to travel 4.83 km" were rounded to the nearest whole value. Probability of spread in the first year is based on the 9 percent and 1 percent of spores each year that take 1.3 and 1.2 years, respectively, to travel 4.83 km. Summing their respective cumulative probabilities of .0431 and .0038, results in a probability of .0469, which is our estimated probability that spores will breech the quarantine in the first year. Thus, from the frequency distribution, rounding to two significant digits, it is estimated under the current protocol that *P. ramorum* will travel outside the quarantine area in one year with 0.047 probability, in two years with 0.054 probability and within three years with 0.059 probability. Beyond three years, the annual increased risk infection from spores outside the quarantine area is not expected to increase significantly above 0.059.

Spread of infection was analyzed on a county by county basis, with the exception of Douglas and Lane Counties. Douglas County was divided into northwest, south, and east areas, and Lane County was divided into east and west areas. The spread probabilities are assigned to be the SOD infection probabilities for Coos, Douglas (south) and Josephine counties. For Jackson County, Lane County, and the remainder of Douglas County, SOD infection is assumed to require a spore travel distance of 40 km and infection probabilities are obtained in a similar fashion. The estimated values are small, less than 1 in 1 billion and thus not reported here.

Table 2
Frequency Distribution for Spread of *P. ramorum*

% Distribution of *P. ramorum* Spores	Km travelled per year	Years required to travel 4.83 km	Cumulative probability of traveling 4.83 km
10%	0.2	24.2	0
10%	0.3	16.1	0
10%	0.4	12.1	0
10%	0.5	9.7	0
10%	0.6	8.1	0
10%	0.9	5.4	0
10%	1.2	4	0.0001
10%	1.8	2.7	0.0021
5%	2.25	2.1	0.0016
5%	2.75	1.8	0.0052
9%	3.7	1.3	0.0431
1%	4	1.2	0.0038

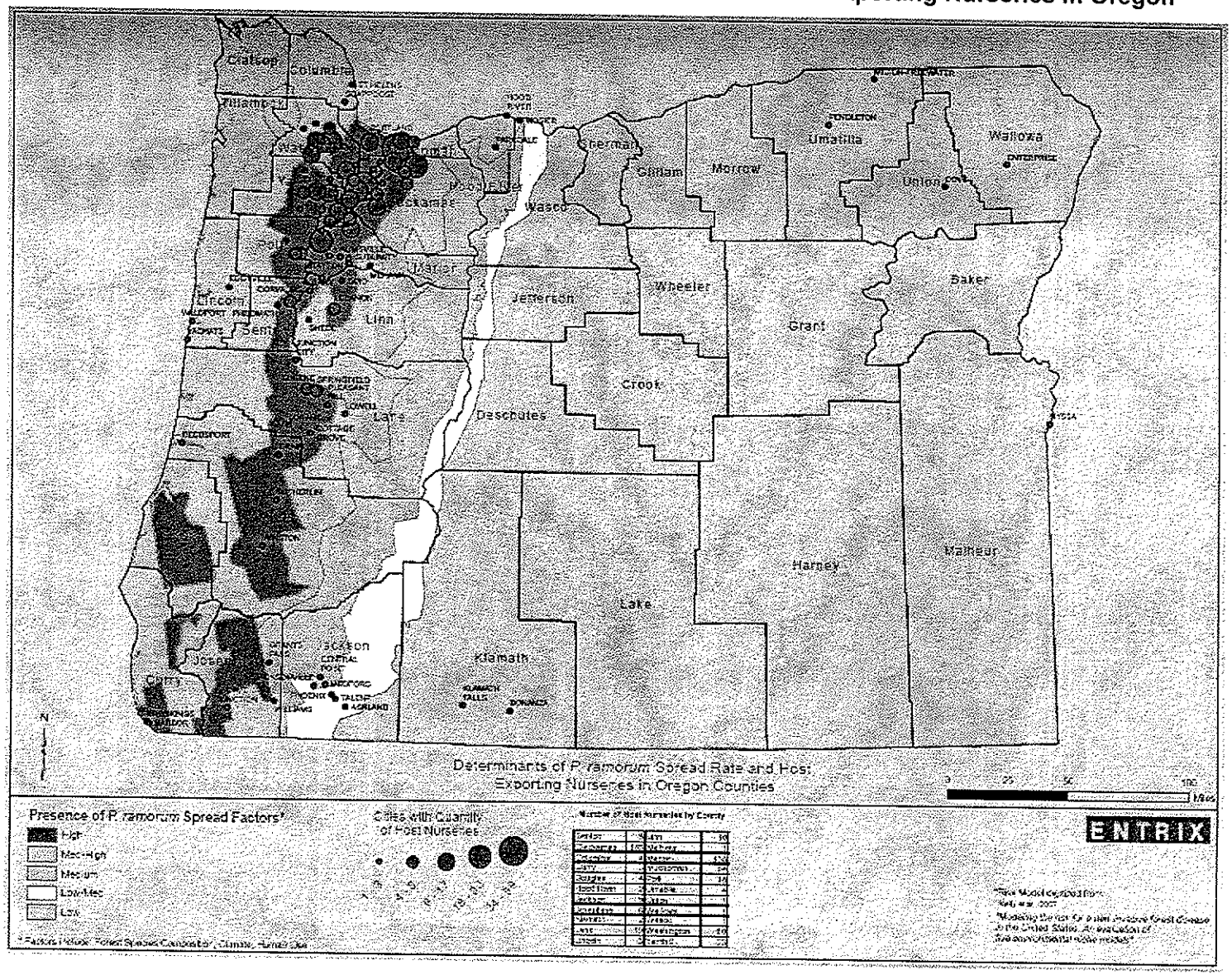
Hypothetical spread of *P. ramorum* infection to Oregon counties without the current protocol in place is simulated from the observation of *P. ramorum* spread through California. Death of tanoaks in California from sudden oak death (SOD) was first recorded in 1995 (California Oak Mortality Taskforce, 2008). By 2004, the disease had inundated the California coastline extending 750 km (Meentenmeyer et al., 2004). Based on this information, it is estimated that the disease spread through California at an average rate of at least 75 km per year over ten years. Three spread rates are estimated for this scenario:

1. If the disease is allowed to spread through Oregon, and infection occurred at the same rate of 75 km per year, we estimate that all of the susceptible counties along the Oregon coast would become infected by SOD five years after the current protocol ends. This is equivalent to nearly 100 percent infection by 2013.
2. At a slower rate of spread of 37.5 km per year, it would take approximately 10 years for the disease to inundate Oregon tanoaks, or 100 percent infection by 2018.
3. At a more conservative rate of spread of 19 km per year, the pathogen would reach Oregon's northern-most counties in 20 years (2028).

For both the current treatment protocol and the no treatment option, the spread model predicts the probability that the *P. ramorum* pathogen will spread from Curry County to another county (determinants of spread rates are presented in Figure 1). For simplicity, it is assumed that once *P. ramorum* reaches a county, a quarantine area is established of the same size as the 2007 quarantine area in Curry County (26.5 square miles). Costs of pathogen spread are based on this quarantine area, and on the likelihood that nurseries will be located within the quarantine area.

The likelihood that a nursery will be located within a quarantine area differs based on the treatment option. Under the no treatment option, Animal Plant Health Inspection Service (APHIS, of the U.S. Department of Agriculture) regulations require an entire county be quarantined if there is an infection in the county. However, under the current treatment option, a smaller area of the county surrounding the infected area may be quarantined. To estimate the nurseries located in the quarantined area under the current protocol, it is assumed that nurseries are evenly distributed throughout a county. So if five percent of a county is quarantined, it is assumed that five percent of nursery acreage is quarantined.

Figure 1
Determinants of *P. ramorum* Spread Rate and Distribution of Host Exporting Nurseries in Oregon



Data Sources, Assumptions, and Estimation Methods by Cost Category

The data sources, assumptions, and estimation methods used to estimate each type of *P. ramorum* cost are outlined below. Costs associated directly with a treatment option are presented first, and then costs to nurseries associated with the spread of *P. ramorum* are discussed.

Monitoring / Treatment Costs

Most of the current *P. ramorum* control effort in Curry County is conducted by the Oregon Department of Forestry (ODF) with state and federal funds. ODF provided annual data on expenditures for monitoring and eradication efforts since the pathogen was discovered in 2001.[1] ODF also provided data regarding the estimated minimum and maximum cost associated with a six-year complete eradication program of the Curry County infestation.

The cost of the current monitoring and treatment program is based largely on the size of the quarantine area. Although provided recent expenditures for controlling *P. ramorum* in Curry County under the current protocol, it is necessary to project future treatment costs if the pathogen were to spread (2008a). To do this, a simplifying assumption was made that if *P. ramorum* spreads to other counties under the current protocol, quarantining the area in the other Counties will result in the same treatment and control costs ($1.6 million) as reported for Curry County in 2007. Although the size of the quarantine area in Curry County has increased since 2007, this analysis assumes that future Curry County control costs remain at $1.6 million/year. The cost of the current control protocol in future years is summarized below.

A = Annual Cost of Curry County Quarantine = $1,604,000 (Curry County *P. ramorum* control cost 2007)

B = Number of counties with risk of *P. ramorum* infection

C = Probability of an infection occurring in a given county (varies by county by year)

Annual Monitoring & Treatment costs = $1,604,000 * B * C

Quarantine Inspection Costs

The Animal Plant Health Inspection Service (APHIS, of the U.S. Department of Agriculture) regulations provide a strict protocol for Oregon nurseries that ship their products out of state (7 CFR Part 301, 2007). The specific protocol applies only to nurseries that ship out of state, but differs depending on whether a nursery grows *P. ramorum* host plants and whether a nursery falls within a quarantine boundary. All nurseries shipping products outside Oregon are required to register with APHIS. If *P. ramorum* spreads, and more nurseries fall within quarantine boundaries, additional expenditures will be required to comply with APHIS regulations.

Specifically, nurseries within a quarantine boundary that ship out of state and grow host plants will be subject to 12 additional *P. ramorum* inspections annually. Nurseries that ship out of state but do not grow host plants will be subject to one extra inspection annually. Previous research on the cost of inspections at Oregon nurseries indicates that, on average, each additional inspection costs $833[2] (Griesbach, 2008; Osterbauer, 2008). To calculate the number of additional annual inspections needed as *P. ramorum* spreads, estimates were derived for how many host and non-host nurseries are projected to be located within a quarantine area. This figure is then multiplied by the number of additional annual inspections required by host and non-host nurseries, respectively. The total cost of additional inspections was derived

---

1 Based on information provided by Peter Daugherty at Oregon Department of Forestry, October 6, 2008.

2 Personal communication with John Griesbach, October 8, 2008 and Nancy Osterbauer, October 20, 2008. Oregon is currently required to inspect, sample, and certify 1,000 HAP (Host and Associated-host Plants) nurseries that ship out-of-state. They also do a second inspection at 300 so-called "high risk" nurseries that grow Rhododendron and/or Camellia. These two total up to 1500 inspections. Data from Oregon Department of Agriculture (ODA) indicates that inspections are done with roughly $800,000 in APHIS funding and $450,000 in ODA funding, for an average of $833 per inspection.

by multiplying the number of additional inspections necessary in each county by the assumed average cost per inspection.

A = Cost per inspection = $833

B = Additional annual inspections for host exporting nurseries in quarantined areas = 12 inspections

C = Additional annual inspections for non-host exporting nurseries in quarantined areas = 1 inspection

D = Number of host exporting nurseries in quarantined counties

E = Number of non-host exporting nurseries in quarantined counties

Annual quarantine inspection costs = $833 * 12 * D + $833 * 1 * E

Nursery Cultural Costs (Prevention)

If *P. ramorum* spreads in Oregon, nursery owners within a quarantine area are expected to respond by spraying crops to prevent infestations and prevent loss in consumer confidence. Previous research indicates that preventative spraying costs roughly $3,000[3][4] per acre annually (Griesbach, 2008; Pschiet, 2008). It is assumed that 20 percent of export nursery acreage is in host species. Furthermore, it is assumed that nurseries not shipping out of state will also spray acres of host species, which are assumed to comprise five percent of their acreage. Exporting nurseries that do not grow host plants are assumed to not spray. The estimation of preventive spraying costs for nurseries located in quarantine areas is summarized below:

A = Per acre cost of preventative spraying = $3,000

B = Number of nursery acres in quarantine area

C = Percent of Oregon nursery acres grown for export, assumed to be equal to percent of nursery gross sales from exports = 74 percent

D = Percent of exporting nurseries that are host nurseries

E = Percent of host exporting nurseries acreage that is host species= 20 percent (assumption)

F = Percent non-exporting nurseries acreage that is host species= 5 percent (assumption)

Preventative spraying costs = ($3,000 * B * 74% * D * 20%) + (A * B * (1-74%) * 5%)

Nursery Infected Plant Costs

Spread of *P. ramorum* in the natural environment will lead to increased risk of infections at nurseries, or to increased costs of preventative action at nurseries. Estimating the full cost of both will result in at least some double counting of costs. This analysis conservatively assumes that preventative spraying by nursery owners results in no increased *P. ramorum* infection in nurseries caused by the pathogen spread

[3] Personal communication with John Griesbach October 6, 2008 and OSU professor Jay Pscheidt October 24, 2008. Mr. Griesbach noted that if the pathogen were to spread to the natural environment growers would likely alternate spraying two chemicals, mefenoxam and dimethomorph each month throughout the year. Chemicals are applied on a preventive basis as no spray can cure plants of *P. ramorum* infections. Mr. Pscheidt added that growers would likely reduce the intensity of spraying when the pathogen is less active, roughly 6 months per year. If growers were to spray Phostrol or Alude during when the pathogen is less active, and use the regime Griesbach identified the other six, the annual preventative spraying costs would be roughly $3,000 per acre.

in the natural environment.[5] However, since an increased risk of infection is possible, it is worth noting the costs to nurseries associated with additional *P. ramorum* infections. Dart and Chastagner's 2007 study of 32 Washington State nurseries where outbreaks occurred provides an estimate of the economic losses to nurseries of *P ramorum* infections. The authors report that the average cost from crop loss was $13,220 per nursery between 2004 and 2005. In addition, owners of a typical nursery estimated that a single outbreak cost them an additional $30,000 in labor, disposal fees, and mitigation measures.

Nursery Marketing/Consumer Confidence Costs

If *P. ramorum* were to continue spreading in Oregon's forests, consumers may become wary of purchasing product from nurseries near quarantine areas, and may seek other sources of nursery products. Given the size of Oregon's nursery industry, and its heavy reliance on exports, eroding consumer confidence is a serious concern for nursery owners. Despite the importance of consumer confidence in the nursery market, there is very limited information available regarding market and consumer response to pathogen infestation. In this analysis, it is assumed that nurseries in a quarantine area experience a 10 percent loss in net revenue due to decreased market share and/or consumer confidence.

A = Gross nursery sales in the quarantine area

B = Profit margin for nurseries (Oregon State, 2008) = 30%

C = Percent loss in sales due to loss in consumer confidence = 10%

Cost of lost market share / consumer confidence = A * 30% * 10%

Table 3 provides an overview of analytical assumptions used to estimate costs.

Table 3
Overview of Oregon Nursery Data and Analytical Assumptions

Measure	Value
Non-host exporting nurseries in OR	420
Host exporting nurseries in OR	601
Nursery operations in OR	2100
Cost per inspection	$833
Spray cost (per acre)	$3,000
Additional inspections per quarantined nursery:	
Non-host exporting nurseries (per year)	1
Host exporting nurseries (per year)	12
Cost of a Quarantine in each County	$1,604,000
Percentage of OR nursery stock sold in-state	26%
Percentage of OR nursery stock sold out of state	74%
Percentage host acreage at export nurseries	20%
Percentage of acres that non-host exporting nurseries spray when inside or near a quarantine area	0%
Percentage host acreage at non-export nurseries	5%

[5] According to personal communication with John Griesbach, mefenoxam and dimethomorph offer protection from infection for 2-6 weeks but it is unknown if spraying will completely prevent infection.

Measure	Value
Area of county quarantined if infected (sq mi)	26.5
Profit margin for nurseries	30%
Percent loss in sales if in a quarantine area	10%

Estimated *P. Ramorum* Related Costs of Each Treatment Option

This section summarizes the approximate costs associated with each level of treatment. As costs vary over time by treatment option, the analysis assesses the total costs incurred over a 20-year timeframe. Total costs over 20 years are calculated as a present value, which represents the current value of the future stream of costs.[6] For this project a discount rate of 3 percent was used in the present value calculation.

No Control

If no efforts to control the *P. ramorum* population in Curry County were undertaken in future years, there would be no costs associated with monitoring or treatment. However, costs associated with spread of the pathogen would escalate annually. These costs would primarily be associated with increased preventive spraying costs at nurseries and in erosion of consumer confidence. In this scenario, *P. ramorum* is anticipated to result in approximately 300,000 quarantined square miles by year 2028.

Inspection, cultural, and consumer confidence costs were estimated using the assumptions and methodology outlined in the previous section. The spread rate of *P. ramorum* was modeled using three different spread rate assumptions. Costs associated with each rate of infection are presented in Tables 4, 5, and 6. Costs in Tables 4 through 6 also reflect the expectation that with no control in place, the discovery of *P. ramorum* in a county would lead to the quarantine of the entire county (as occurred in California, when it failed to actively control the spread of *P. ramorum*). The total present value cost over 20 years of opting for no control of the Curry County *P. ramorum* is expected to range from $64.93 million to $652.30 million.

Table 4
Summary of Costs associated with No Treatment
Low Spread Rate Scenario (Millions $)

Cost Category	Cost 2009	Cost 2028	Average Annual Cost	Present Value Cost 2009 through 2028
Monitoring / Treatment Costs	$0	$0	$0	$0
Quarantine Inspection Costs	$0.03	$6.22	$0.78	$9.64
Nursery Cultural Costs	$0.06	$15.91	$1.57	$18.52
Nursery Marketing/Consumer Confidence Costs	$0.11	$28.35	$3.07	$36.77
Total Costs	$0.20	$50.48	$5.42	**$64.93**

6 In economics (and in finance) the present value of a stream of future costs is the sum of all future dollars in terms of present year dollars. This is done by discounting future monetary values because society values money in the present more than the same amount of money at a future date.

Table 5
Summary of Costs associated with No Treatment
Medium Spread Rate Scenario (Millions $)

Cost Category	Cost 2009	Cost 2028	Average Annual Cost	Present Value Cost 2009 through 2028
Monitoring / Treatment Costs	$0	$0	$0	$0
Quarantine Inspection Costs	$0.03	$6.24	$4.01	$53.41
Nursery Cultural Costs	$0.06	$15.94	$10.10	$133.88
Nursery Marketing/Consumer Confidence Costs	$0.11	$34.26	$21.34	$282.18
Total Costs	$0.20	$56.44	$35.44	**$469.47**

Table 6
Summary of Costs associated with No Treatment
High Spread Rate Scenario (Millions $)

Cost Category	Cost 2009	Cost 2028	Average Annual Cost	Present Value Cost 2009 through 2028
Monitoring / Treatment Costs	$0	$0	$0	$0
Quarantine Inspection Costs	$0.15	$6.24	$5.19	$73.18
Nursery Cultural Costs	$0.20	$15.94	$13.20	$186.01
Nursery Marketing/Consumer Confidence Costs	$0.36	$34.26	$27.99	$393.10
Total Costs	$0.71	$56.44	$46.39	**$652.30**

Current Treatment Program

Under the current treatment program, based on the spread analysis described above, it is estimated that the area in quarantine will grow very slightly between 2009 and 2028. Given the estimated cumulative probability over time that the pathogen will spread, by 2028 there is a six percent chance that the pathogen will have spread to Coos County, south Douglas County, and Josephine County. Assuming a quarantine area of 26.5 square miles in each County (the size of Curry County's quarantine area in 2007), then the expected size of quarantine areas outside of Curry County by 2028 is about 5 square miles.

Nearly all costs associated with the current treatment program are to continue monitoring and treatment of the same quarantine area in Curry County for the next twenty years, and to increase monitoring and treatment in other areas where the pathogen is expected to spread. The likelihood of the spread of the pathogen outside the current quarantine area results in small expected costs of increased inspection and marketing / consumer confidence loss. The total present value cost over 20 years under the *P. ramorum* treatment program is approximately $28.06 million.

Table 7
Summary of Costs associated with Current Treatment Program (Millions $)

Cost Category	Cost 2009	Cost 2028	Average Annual Cost	Present Value Cost 2009 through 2028
Monitoring / Treatment Costs	$1.83	$1.89	$1.88	$28.01
Quarantine Inspection Costs	$0.00	$0.00	$0.00	$0.00
Nursery Cultural Costs	$0.00	$0.00	$0.00	$0.02
Nursery Marketing/Consumer Confidence Costs	$0.00	$0.00	$0.00	$0.03
Total Costs	$1.83	$1.89	$1.89	**$28.06**

Eradication Program

Based on data from the Oregon Department of Forestry (2008b), it is estimated that the *P. ramorum* in Curry County can be eradicated in four to six years. To completely eradicate the pathogen, a series of aggressive actions are anticipated. First, detection efforts will be expanded by intensifying the efforts of stream baiting, aerial surveys, and ground surveys. Under the eradication treatment alternative, treatment of infested sites will be conducted more quickly after detection, and larger areas will be treated compared to the current control program. Finally, the eradication program will actively remove host species that are susceptible to infection and spray other host species with fungicide. These actions are expected to eradicate *P. ramorum* from Oregon in three to six years, including one year to complete an Environmental Impact Statement. The present value cost of an eradication program would vary from $19.3 (assuming four years) to $31.2 million (assuming six years). Eradication costs are presented in Table 6.

Table 8
Summary of Costs associated with Eradication Program (Millions $)

Eradication Measure	2009	2010	2011	2012	2013	2014	Present Value 2009-2012 Eradication	Present Value 2009-2014 Eradication
Early detection	$0.00	$0.65	$0.65	$0.65	$0.65	$0.65	$1.79	$2.89
Treatment of infested sites	$0.00	$3.20	$3.20	$3.20	$3.20	$3.20	$8.79	$14.23
Tanoak removal	$0.00	$2.80	$2.80	$2.80	$2.80	$2.80	$7.69	$12.45
Lab support / research	$0.00	$0.35	$0.35	$0.35	$0.35	$0.35	$0.96	$1.56
Environmental impact statement	$0.10	$0.00	$0.00	$0.00	$0.00	$0.00	$0.10	$0.10
Total	$0.10	$7.00	$7.00	$7.00	$7.00	$7.00	**$19.32**	**$31.22**

Summary of Treatment Option Benefits and Conclusion

This analysis reviewed three levels of control and treatment for *P .ramorum* in Curry County: no control, current level of control, and eradication. The rate of spread of *P. ramorum* was estimated for the no control and current level of control options (eradication is assumed to eliminate the *P. ramorum* source). Using best available data regarding the five types of costs associated with *P. ramorum* control and spread, and the estimated rate of *P. ramorum* spread associated with each treatment level, the analysis roughly estimated total costs to nurseries and to public agencies of *P. ramorum*. Findings indicate that both the current control program and the eradication program provide a high level of benefit compared to no control. Benefit is measured as the avoided cost of *P. ramorum* resulting from control and treatment efforts.

Table 6 summarizes the estimated present value of costs of each option. The difference in cost between each control option and the no control option signifies the estimated benefit of each control option. Depending on the actual length of the eradication program, either eradication or the current control program results in the smallest expected costs over 20 years of the three options. If *P. ramorum* in Curry County can be eradicated with four or five years of treatment, then eradication is expected to provide the greatest level of benefit by preventing spread of the pathogen, and eliminating future costs of monitoring and treatment. However, if the eradication program lasts the full six years, then current control is expected to provide the highest level of benefit. Using the approximate cost figures presented in Table 9 and assuming a uniform probability that the eradication program will cost at any point in the range of $19.32 million to $31.32 million, it is estimated that the eradication program will provide a greater cost savings (or higher benefit) with over 70 percent likelihood.

Table 9
Summary of Estimated Costs and Benefits of Each *P. ramorum* Control Option
(Millions $)

Cost Category	No Control	Current Control	Eradication
Present Value Cost Control	$64.93 - $652.30	$28.06	$19.32 - $31.32
Benefit of Control		**$36.87 - $624.24**	**$33.61 - $632.98**

As indicated in Table 9, compared to the no treatment alternative, significant benefits in terms of avoided *P. Ramorum* costs are expected under each treatment alternative. The figures in Table 9 include estimated costs associated with loss of consumer confidence of 10 percent of export sales in counties with quarantines. A significant portion of costs of no control is associated with loss of market share and consumer confidence, about which there is a high level of uncertainty. However, a sensitivity analysis indicates that even with no estimated loss of consumer confidence and market share, it is highly likely that both eradication and current control would result in cost savings. Assuming no lost market share / consumer confidence, the total present value of estimated costs under no control is estimated in the range of $28.16 million to $259.20 million. Assuming no cost of lost market share / consumer confidence, the estimated costs of current control are $28.03 million while projected costs under eradication are $19.32 million to $31.32 million. Using these approximate cost figures and assuming a uniform probability distribution (i.e. all costs are equally likely within the range presented for an option), it appears that there is nearly a 100 percent chance that both the current control option and the eradication program provide benefits.

References

California Oak Mortality Taskforce, 2008, "A Chronology of *Phytophthora ramorum*, Cause of Sudden Oak Death and Other Foliar Diseases," accessed online October 10, 2008 at: http://nature.berkeley.edu/comtf/pdf/PRamorumChronology.06.08.pdf

California Oak Mortality Taskforce, 2004 – 2007, "Year-end Newsletter Summary Reports years 2004 – 2007," Accessed 10/6/2008 at: http://www.suddenoakdeath.org/html/year-end_summary_reports.html.

Dart, Norman L. and Gary Chastagner, 2007, "Destruction of Plants Due to Phytophthora ramorum Quarantine Efforts in Washington State", Online, Plant Health Progress doi:10.1094/PHP-2007-0508-02-RS.

Federal Register, Vol. 72, No. 38, Tuesday, February 27, 2007, 7 CFR Part 301 "Phytophthora Ramorum; Quarantine and Regulations."

Hanson et al., 2008, "Epidemiology of *Phytophthora ramorum* in Oregon Tanoak Forests," *Can J. For.* Res., 38:1133- 1143.

Kelly, Maggi, Qinghua Guo, Desheng Liu and David Shaari, 2007, "Modeling the Risk for a New Invasive Forest Disease in the United States: An evaluation of Five Environmental Niche Models," *Computers, Environment and Urban Systems*, Vol. 31, pp. 689-710.

Meentenmeyer et al., 2004, "Mapping the Risk of Establishment and Spread of Sudden Oak Death in California," *Forest Ecology and Management,* 200:195-214.

Oregon Department of Agriculture, 2003-2005, "Plant Division Annual reports," accessed online October 21, 2008 at http://oregon.gov/ODA/PLANT/reports.shtml.

Oregon Department of Agriculture, 2004-2008, "Plant Health Section Annual Report (2003-2007)," Commodity Inspection Division, http://egov.oregon.gov/ODA/PLANT/plant_annual_report_07.shtml

Oregon Department of Forestry, 2008a, "Funding Summary for Sudden Oak Death Program in Oregon's Forests", provided by personal communication with Peter Daugherty on October 6, 2008.

Oregon Department of Forestry, 2008b, "Sudden Oak Death Eradication in Oregon Forests: The Final Phase," provided by personal communication with Alan Kanaskie from ODF on September 24, 2008.

Personal Communication with Jay Pscheidt, Professor of Plant Pathology at Oregon State University, October 24, 2008.

Personal Communication with Jon Griesbach, Ascent Agricultural Services, on October 14, 2008.

Personal Communication with Peter Daugherty, Oregon Department of Forestry, on October 6, 2008.

Personal Communication with Nancy Osterbauer, Oregon Department of Agriculture, on October 20, 2008.

USDA, National Agricultural Statistics Service, "2002 Census of Agriculture, Oregon county level data, Table 34, Nursery , Greenhouse, Floriculture, Mushrooms, Sod and Vegetable Seeds Grown For Sale: 2002 and 1997," accessed online on October 8, 2008 at: http://www.agcensus.usda.gov/Publications/2002/Volume_1,_Chapter_2_County_Level/Oregon/st41_2_034_034.pdf

USDA, National Agricultural Statistics Service, Oregon Field Office, 2007, "Oregon Nursery and Greenhouse Survey 2007", accessed online on October 6, 2008 at: http://www.nass.usda.gov/Statistics_by_State/Oregon/Publications/Horticulture/nursery2008.pdf