Economic Analysis for the Impact of *Phytophthora ramorum* on Oregon Forest Industries

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Introduction

The signs of the previously unknown invasive pathogen, *Phytophtora ramorum*, the cause of Sudden Oak Death and Ramorum leaf and shoot blight, were first observed in California in the mid 1990's (Rizzo et al 2005). By the time the disease was identified in 2000, the pathogen had spread to many coastal counties in California causing large-scale mortality in California's iconic oaks and a wide range of other ecological damages. *P. ramorum* has also been responsible for millions of dollars of economic damages in California. These economic damages can be broken down in to two categories: direct and indirect costs. Examples of direct economic costs include loss of resources from mortality, diminished property values, increased fire damage and costs incurred in the removal of dead trees. Indirect economic costs are those incurred as a result of the policies put into place to manage the pathogen, for example nursery inspections, destruction of infected host plant material, cleaning of equipment, and other measures to prevent spread.

Shortly after the identification of *P. ramorum* in 2000, the state of Oregon began a detection program to monitor for signs of the pathogen, which were first observed in a localized area in south west Oregon in 2001. Immediately after its discovery in Oregon, an aggressive multi agency control program was put into place (Hansen 2007), led by the US Forest Service (USFS), the Oregon Department of Forestry (ODF), the Oregon Department of Agriculture (ODA), and Oregon State University (OSU). Although the suppression effort has not eradicated the pathogen from Oregon wildlands and nurseries, the spread rate in Oregon is significantly lower than the rate in California and the disease has been contained to a small area in southwest Oregon (Kanaskie et al 2008).

The ecological and economic implications of the pathogen for the state of Oregon are different from those in California due to the differing ecological and economic conditions of the two states. So far, the bulk of the costs associated with the pathogen in Oregon are as a result of policies put into place to manage it, specifically the control program mentioned above, and the quarantine zone put into place by the federal Animal Health and Plant Protection Services agency (APHIS) and ODA. Due to the limited resources available for the management of this pathogen, and the potential for a negative impact on Oregon's economy, it is important that these costs be considered in an analysis of *P. ramorum* policy.

Quarantines restrict the movement of some host species and often require businesses that will be exporting host species out of quarantine areas to perform phytosanitary measures in order to prevent the artificial spread of a pathogen (Federal Register 2007). These requirements negatively impact businesses by decreasing the potential market for some goods and increasing production costs. By limiting the quarantine size, fewer businesses are impacted by the quarantine restrictions, and spread of the pathogen by way of human movement of host species is limited to a smaller area.

In general, APHIS has quarantined entire counties upon the discovery of *P. ramorum*. However, as long as the control program is in place in Oregon, APHIS has agreed to limit the size of the quarantine below the county level to an area that encompasses the infestations, currently 162 square miles. This distinction in quarantine policy has both economic and ecological implications to be considered in policy decisions regarding the current control program in Oregon.

Purpose

The objective of the study is to inform in-state decision makers of some of the economic implications of three different *P. ramorum* policy scenarios identified by the Oregon Department of Forestry in order to assist with the creation of a *P. ramorum* control strategy in Curry County. The three policy options being considered are 1) to continue the current control program, 2) to increase control efforts in an attempt to eradicate *P. ramorum* from Oregon wildlands, and 3) to eliminate the *P. ramorum* control program all together.

The current control program control program has a monitoring program in place, and once an infected plant is discovered, it and all host plants within a 100m radius are removed and destroyed (Kanaskie et al., 2008). This practice would be eliminated under the no control policy scenario, however the state would still be required to maintain a monitoring program to track the pathogen's spread. The eradication policy scenario would increase the level of control and monitoring with the intent to completely eliminate the pathogen from Oregon wildlands in five years.

The assessment looks specifically at the impact of the three policy options on the forest products industry in Oregon and includes estimated costs and benefits to forest industries in at-risk counties. At-risk counties include those that are considered to be at medium to high risk of *P. ramorum* infection according to Kelly at al. (2007) and Entrix (2008), and that are within reach of the pathogen at the spread rates assumed under each policy scenario. Assumptions about the implication of the three policy scenarios were determined by the Oregon Department of Forestry.

The cost estimates include control program costs and costs as a result of the quarantine regulations. This analysis does not attempt to quantify any ecological losses as a result of the spread of the pathogen nor the ecological costs of the control policies, which should also be considered in control policy analysis.

Methodology and Assumptions

In order to estimate the costs and benefits associated with each policy, both the control program costs and the costs incurred by the forest products industry in Oregon are projected out 20 years for each policy scenario using a 4% discount rate. Benefits of the control program are described as the foregone damages that would occur should the program be eliminated; therefore cost and benefit values are closely related.

Current Control Policy Scenario

The current control policy consists of a monitoring program and a control program that removes and destroys host plant material within 100 m of infected plants. Under the current control program, ODA and APHIS have not increased the quarantine zone size on a county by county basis. Instead, the quarantine zone size encompasses an area 8 km beyond the general area of infestation, currently approximately 42 000 ha, which is about 10% of Curry County. Expected values for quarantine costs under the current control policy scenario are calculated based on the probability each year that the quarantine is breached and then extended out another 8 km, to approximate the current policy.

Probability and rate of spread for the current control policy scenario are based on data from Hansen et al. (2008). Following Entrix (2008), the probability that the pathogen will breach the quarantine zone each year is calculated by interpolating data provided by Hansen et al. (2008) describing the frequency of observed distances between new infections and old ones each year. The percentage of new infestations occurring at a given distance is used as a proxy for the probability that the pathogen will travel that distance in a year.

Table 1. Frequency and probability distributions for *P. ramorum* spread under current control policy scenario

Distance between new and prior infections (km/year)	Proportion of *P. ramorum* infections at this distance	Years required to travel 4.8 km	Probability of traveling 4.8 km	Years required to travel 8 km	Probability of traveling 8 km
0.2	10%	24	0.000000	40	0.000000
0.3	10%	16	0.000000	27	0.000000
0.4	10%	12	0.000000	20	0.000000
0.5	10%	10	0.000000	16	0.000000
0.6	10%	8	0.000000	13	0.000000
0.9	10%	5	0.000004	9	0.000000
1.2	10%	4	0.000094	7	0.000000
1.8	10%	3	0.002073	4	0.000036
2.25	5%	2	0.001611	4	0.000024
2.75	5%	2	0.005187	3	0.000164
3.7	9%	1	0.043138	2	0.005482
4	1%	1	0.003846	2	0.000100

In order to calculate the probability that the pathogen will breach the quarantine, the proportion of spores traveling a given distance in a year is raised to the number of years required for that

group of spores to travel the distance needed to breach the quarantine. These probabilities (shown in Table 1) are a measure of the probability that the particular group of spores will breach the quarantine after a given number of years. Therefore, to calculate the cumulative probability that the quarantine will be reached in a given year, the probabilities of breach for all time periods less than or equal to the given year are summed up. For example, the cumulative probability that the quarantine will be breached after 2 years when the boundary is 4.8 km from the nearest infestation is:

$$0.003846+0.043138+0.005187+0.001611=0.053782$$

Currently the distance between the quarantine boundary and nearest infection is 4.8 km, however once the quarantine is breached it will be extended out 8 km, therefore both probability distributions are calculated and used when appropriate. These cumulative probabilities are displayed in Table 2. After 8 years the cumulative probability that the pathogen travels 4.8 km increases by a negligible amount and is assumed to remain constant. The cumulative probability of spores traveling 8 km remains constant after 4 years.

Table 2. Cumulative probability that quarantine will be breached after given number of years under current policy scenario

Year	4.8 km to quarantine boundary	8 km to quarantine boundary
1	0.046984	0.000000
2	0.053782	0.005582
3	0.055856	0.005769
4	0.055950	0.005805
5	0.055950	0.005805
6	0.055950	0.005805
7	0.055950	0.005805
8	0.055954	0.005805

The model assumes that the quarantine zone boundary will be extended out the year after the pathogen breaches the quarantine. After the quarantine zone has been breached once, it would take a minimum of two years for the pathogen to travel the 8 km required to breach the quarantine (see Table 1). Therefore, the quarantine boundary will be expanded a maximum of 9 times in 20 years. Under these conditions, only Curry, Coos, Josephine and Douglas counties are at risk of being included in the quarantine in the 20 year period projected in this model under the current control policy.

In order to estimate the quarantine costs associated with each boundary extension, the percentage of each county included in the zone after every expansion is determined in GIS (displayed in Table 3) and that percentage is multiplied by the total increased harvest costs per county shown in Table 4. The assumptions behind these costs are described below in the "No Control Policy Scenario" section below.

Table 3. Percent of county that falls under quarantine for each increase in quarantine size resulting from *P. ramorum* spread under the current control program.

Number of Breaches	Distance Quarantine Expanded (km)	County			
		Curry	Josephine	Coos	Douglas
0	0	9.93%	0.00%	0.00%	0.00%
1	8	20.68%	0.00%	0.00%	0.00%
2	16	33.87%	0.00%	0.00%	0.00%
3	24	47.95%	1.54%	0.00%	0.00%
4	32	55.82%	11.44%	0.00%	0.00%
5	40	63.80%	23.24%	0.00%	0.00%
6	48	72.72%	36.53%	0.00%	0.00%
7	56	80.95%	51.68%	1.98%	0.00%
8	64	89.04%	68.46%	5.81%	0.00%
9	72	95.98%	85.87%	11.11%	0.58%
Total area in each county (ha)		422510	425436	416530	1310572

Table 4. County harvest levels and increased harvesting costs as a result of *P. ramorum* quarantine

County	10 year avg harvest (mbf)	Total harvest costs at $175/mbf	5% Increase in Harvest Costs	10% Increase in Harvest Costs	20% Increase in Harvest Costs
Benton	124,637	$21,811,475	$1,090,574	$2,181,148	$4,362,295
Clackamas	122,527	$21,442,278	$1,072,114	$2,144,228	$4,288,456
Clatsop	286,914	$50,210,003	$2,510,500	$5,021,000	$10,042,001
Columbia	193,420	$33,848,535	$1,692,427	$3,384,854	$6,769,707
Coos	312,204	$54,635,735	$2,731,787	$5,463,574	$10,927,147
Curry	79,081	$13,839,175	$691,959	$1,383,918	$2,767,835
Douglas	451,534	$79,018,363	$3,950,918	$7,901,836	$15,803,673
Hood River	28,601	$5,005,123	$250,256	$500,512	$1,001,025
Jackson	117,050	$20,483,785	$1,024,189	$2,048,379	$4,096,757
Josephine	37,563	$6,573,543	$328,677	$657,354	$1,314,709
Lane	505,927	$88,537,243	$4,426,862	$8,853,724	$17,707,449
Lincoln	158,745	$27,780,305	$1,389,015	$2,778,031	$5,556,061
Linn	255,458	$44,705,063	$2,235,253	$4,470,506	$8,941,013
Marion	75,726	$13,252,120	$662,606	$1,325,212	$2,650,424
Multnomah	10,046	$1,757,998	$87,900	$175,800	$351,600
Polk	147,918	$25,885,563	$1,294,278	$2,588,556	$5,177,113
Tillamook	154,199	$26,984,755	$1,349,238	$2,698,476	$5,396,951
Washington	147,038	$25,731,720	$1,286,586	$2,573,172	$5,146,344
Yamhill	109,275	$19,123,160	$956,158	$1,912,316	$3,824,632
Total	3,317,863	$580,625,938	$29,031,297	$58,062,594	$116,125,188

The annual value currently spent on the control program is $1,600,000. This value is assumed to increase by 2% each year under the current control program policy scenario. Both the control program costs as well as the costs to the forest industry as a result of the quarantine are projected out for 20 years and included in the cost estimate of the current control program.

Eradication Policy Scenario

The eradication policy scenario would increase the level of control under the current control program in an attempt to eradicate the pathogen from Oregon wildlands within 5 years. Program costs provided by Peter Daugherty (ODF) and Ellen Goheen (USDA Forest Service) are used to calculate the control program costs under the eradication policy scenario. These costs are shown in Table 5. It is assumed that the pathogen will not spread beyond the current quarantine area and that it will be eradicated completely in 5 years. It is also assumed that the control program will begin in one year, after an environmental impact statement is performed.

In addition to program costs, regulatory costs to the forest products industry in the quarantined area are considered for a total of 7 years. This 7 year time period included the 5 years until the pathogen is eradicated as well as 2 additional years. An additional 2 years is added because APHIS requires that an area be pathogen-free for a minimum of 2 years before it will lift the quarantine restriction.

Table 5. Eradication program cost summary

Cost Category	
Environmental impact statement (first year only)	$300,000
Annual Costs Associated with Eradication Program	
Early detection	$650,000
Treatment of infested sites	$3,200,000
Tanoak removal	$2,800,000
Lab support/research	$375,000

No Control Policy Scenario

The no control policy scenario eliminates the control program currently in place, however the state would still be required to maintain a monitoring program in order to track the spread of the pathogen. The study assumes that in the absence of the current control program, the quarantine zone increases on a county by county basis, as is the standard APHIS protocol for most pathogens and is the case in California. The county falls under quarantine the year after the pathogen is projected to reach the county. The potential spread rates projected under this policy scenario are: 75km per year (based on the average spread rate in California), 37.5 km per year, and 19km per year. These spread rates correspond to the rates used in the partner ODA study focusing on the impact of *P. ramorum* on the nursery industry in Oregon. An additional spread rate is also included to reflect the rate of spread observed in Humboldt County, CA where the disease spread from a single point in 2001 to an area 26km away (estimated) in 2008. This corresponds to a 3.7 km/yr spread rate.

Most of the counties at medium to high risk of infection in western Oregon are projected to fall under quarantine within 20 years under the 75 km/year spread rate. Fewer counties are expected to fall under quarantine in the same period under the 19 km/year and 3.7 km/year assumptions,

and most counties fall under quarantine later when the spread rate is lower, as is illustrated in Table 6.

Once a county is under quarantine, producers in the forest products industry are assumed to experience a 10% increase in production (harvest) costs. A sensitivity analysis is performed on this assumption, estimating increased costs as a result of the quarantine at 5% and 20% of current production costs as well. Current production costs in the timber industry are estimated to average $175 per mbf (thousand board feet, Gary Lettman, Personal communication 2008). Annual timber harvests, as reported by the Oregon Department of Forestry, over the period extending from 1997 to 2007 were used to estimate average annual harvest by county. These estimates for the increase in harvest costs per county are shown in Table 3. No treatment costs are incurred under this policy option, but a $100,000 per county annual monitoring costs is assumed.

In order to calculate the costs to the forest products industry, the number of years until the county falls under quarantine is calculated for each spread rate and the increased production costs as a result of the quarantine as described above are included from that year until year 20.

Table 6. Number of years until county falls under quarantine for 3 different spread rates in the absence of a *P. ramorum* control program.

Spread Rate	75 km/yr	37.5 km/yr	19 km/yr	3.7 km/yr
County				
Benton	5	8	14	n/a
Clackamas	6	10	19	n/a
Clatsop	7	12	n/a	n/a
Columbia	7	12	n/a	n/a
Coos	2	3	4	16
Curry	1	1	1	1
Douglas	2	3	5	20
Hood River	7	12	n/a	n/a
Jackson	3	4	5	n/a
Josephine	2	2	3	7
Lane	4	6	11	n/a
Lincoln	5	8	14	n/a
Linn	5	8	14	n/a
Marion	5	9	17	n/a
Multnomah	7	12	n/a	n/a
Polk	5	9	16	n/a
Tillamook	6	10	18	n/a
Washington	6	11	n/a	n/a
Yamhill	6	10	18	n/a

Results

Current Control Policy Costs

The program costs associated with the current control program over the next 20 years are estimated to have a present value of $26,261,573 and make up the bulk of the costs attributed to this policy. The present value of costs to the forest products industry over the same time period range between $1,285,400, at an assumed 5% increase in production costs to $7,202,166, assuming a 20% increase in harvest costs. Combining both the program costs and the costs to the forest products industry as a result of *P. ramorum* quarantine, results in a present value estimate of between $27,546,973 and $33,463,740 in expenses associated with the current control program over 20 years.

Table 7. Present values of costs associated with *P. ramorum* under the current control program projected over a 20 year period.

	5% Increase in Harvest Costs	10% Increase in Harvest Costs	20% Increase in Harvest Costs
Control Program Costs	$26,261,573	$26,261,573	$26,261,573
Quarantine Costs to Industry	$1,285,400	$2,570,800	$7,202,166
Total	$27,546,973	$28,832,373	$33,463,740

Eradication Program Policy Costs

The costs as a result of the eradication program are primarily a result of the control program itself. The estimated present value of these costs over the 5-year period until the disease is eradicated totals $30,252,650. The costs to the industry as a result of the quarantine program range from $462,876 to $1,851,505, depending on the percent increase in harvest costs. The most likely estimate of the combined costs associated with the eradication program is $31,178,402, but this value could range between $30,715,526 and $32,104,155.

Table 8. Present values of costs associated with *P. ramorum* under the eradication program projected over a seven year period (until the quarantine is lifted).

	5% Increase in Harvesting Costs	10% Increase in Harvesting Costs	20% Increase in Harvesting Costs
Program Costs	$30,252,650	$30,252,650	$30,252,650
Quarantine Costs to Industry	$462,876	$925,752	$1,851,505
Total	$30,715,526	$31,178,402	$32,104,155

No Control Policy Costs

Under the no control policy scenario, expenses to the forest products industry as a result of the quarantine are the primary driver of the costs associated with the pathogen. These values are estimated to range from between $18,900,614 to $1,219,200,207, depending on the spread rate and percent increase in harvesting costs. Monitoring costs also play a role and could range between $2,441,045 and $19,374,509, depending on the spread rate. Considering both the costs to the forest products industry as well as monitoring program costs, the present value of costs as a result of a policy that does not control *Phytophthora ramorum* in Oregon is likely to fall between $21,341,660, assuming a conservative spread rate of 3.7 km/year and increased

expenses at 5% of harvest costs, and $1,238,574,716, assuming a spread rate of 75 km/year (as seen in California) and increased expenses of 20% of harvest costs; a somewhat conservative estimate being $292,787,962 at the assumed 10% increase in harvest costs and 19 km/year spread rate.

Table 9. Present values of costs associated with *P. ramorum* with no control program, projected over a 20 year period.

Spread Rate	Cost Category	5% Increase in Harvest Costs	10% Increase in Harvest Costs	20% Increase in Harvest Costs
75km/year	Increased Harvesting Costs	$304,800,052	$609,600,104	$1,219,200,207
	Monitoring Costs	$19,374,509	$19,374,509	$19,374,509
	TOTAL	**$324,174,560**	**$628,974,612**	**$1,238,574,716**
37.5 km/yr	Increased Harvesting Costs	$241,966,585	$483,933,170	$967,866,339
	Monitoring Costs	$14,840,055	$14,840,055	$14,840,055
	TOTAL	**$256,806,640**	**$498,773,225**	**$982,706,395**
19 km/yr	Increased Harvesting Costs	$142,368,259	$284,736,518	$569,473,036
	Monitoring Costs	$8,051,444	$8,051,444	$8,051,444
	TOTAL	**$150,419,703**	**$292,787,962**	**$577,524,480**
3.7 km/yr	Increased Harvesting Costs	$18,900,614	$37,801,228	$75,602,456
	Monitoring Costs	$2,441,045	$2,441,045	$2,441,045
	TOTAL	**$21,341,660**	**$40,242,274**	**$78,043,502**

Benefits Associated with Control Programs

The benefits associated with the two policy options that control *P. ramorum* (the current program and the eradication program) are measured as the foregone policy costs that would be incurred in the absence of a control program, and are displayed in Table 10. The estimated range in benefits for the current control program is -$6,205,313 to $1,205,110,976 and for the eradication program it is -$9,079,080 to $1,207,072,785. These values consider program costs and foregone quarantine zone costs to businesses.

Table 10. Summary of benefits associated with control programs

Control Program	Cost	Benefit
None	$21,341,660 to $1,238,574,716	$0
Current	$27,546,973 to $33,463,740	-$6,205,313 to $1,205,110,976
Eradication	$30,420,740 to $31,501,931	-$9,079,080 to $1,207,072,785

Discussion

The wide range in estimates of the benefits associated with *P. ramorum* control policy in the study reflects the great level of uncertainty associated with the potential impact of *P. ramorum* in Oregon. Most of this uncertainty stems from the lack of knowledge about what would happen should *P. ramorum* be allowed to spread with no control policy in place. The only spread data currently available for Oregon are data collected since the control program has been in place. The closest example of spread under the no control policy scenario is what has been observed in California. However, the climate, ecosystems and economy in Oregon are different enough from those in California that the spread rates and damages are not likely to be the same in the two states.

The lack of data on the potential spread rate of uncontrolled *P. ramorum* in Oregon called for a wide range of spread rate assumptions under the no control policy scenario. Unfortunately, the quarantine costs associated with the lack of control are extremely sensitive to the spread rate assumption, and therefore the estimate for costs associated with this policy scenario spans a wide range. This makes it difficult to estimate the benefits associated with the two control programs (the current control program and one that attempts eradication).

The study found that the benefit of having a control program in place, whether it be the current control policy or the eradication effort, could be up to approximately $1.2 billion. However, as is shown in Table 10, there is a chance that the benefits associated with these two control programs is negative, indicating that they would incur a cost instead of benefit of approximately $6 to $9 million. The potential benefit of these two policies is far greater than their potential costs, although it is difficult to know which result is more likely without improved data. A risk averse policy maker would most likely lean toward maintaining the current control program.

Assuming a somewhat conservative spread rate of 19 km/yr, the most likely benefit associated with the current control program is $264,155,589, and $261,809,560 with the eradication program. Although these estimates are based on the best data available, they are approximate and there is uncertainty regarding their exact values. Because the benefits associated with the control and eradication programs are so close it is not possible to say which is preferable based on these values. However, the potential benefits of both of these control programs are far greater than the benefit associated with no control program.

The estimates above include control program costs and costs to businesses as a result of the quarantine zone expansion. The quarantine costs are related to the size of the quarantine zone because as the zone increases, more businesses are included and required to perform costly phytosanitary measures. The primary manner in which the control policy options affect these costs, is by altering the rate of quarantine zone increase.

A related trend that is evident in the study is that as investment in control is decreased, costs to the forest products industry increase. Considering that most of the costs of the control program are currently covered by the government, eliminating or decreasing the control program would essentially shift the costs of *P. ramorum* to private industry. Although there is uncertainty as to the precise level of these costs on private industry, the study shows that they are likely to be higher than control costs currently incurred by government agencies.

There are other costs to the forest products industry that should come into consideration but were beyond the scope of this study. For instance the non-timber forest products (NTFP) industry,

with an estimated annual value of $22 million in the state of Oregon (Alexander 2008), could be severely affected by *Phytophthora ramorum* control and quarantine policy. There are a number of specialty NTFPs produced in the state, particularly in the southwest region, where *P. ramorum* host species are especially prevalent. Examples of these non-timber forest products are wreathes, mushrooms, Christmas trees, pot-pourri and floral greenery.

If *P. ramorum* spread were left unchecked, and the quarantine zone were to increase to a much larger area, many NTFP producers would incur increased production costs. These increased costs could be a result of having to travel further to non-quarantined areas in order to harvest raw material, or having to incur the costs of phytosanitary measures. Some producers feel that these costs may increase so much that they would no longer be able to competitively price their products, which could lead the businesses to stop producing them (Mitchell 2008). Not all NTFP producers would be impacted, although some, whose businesses are centered on regulated host plants, could potentially go out of business. This may not have a significant effect on Oregon's economy as a whole, but the regional economy, which relies heavily on these types of businesses, would be impacted to a much higher degree.

Another consequence of eliminating the *P. ramorum* control program is that the Oregon forest product export market may be negatively affected by a decrease in consumer confidence. Although counties in the state may not fall under federal quarantine, international regulators may choose to restrict imports anyway, thereby reducing the state's export market. Along the same lines, importers of host plant species from Oregon may also become fearful of importing the pathogen and choose not to import these items from Oregon. Of particular concern to some people is the effect that this may have on the timber export market. In 2007, Oregon exported approximately $266 million worth of timber in the form of raw logs (Warren 2008). A percentage of this market could potentially be lost due to decreased consumer confidence and increased production costs, which would reduce the competitiveness of the Oregon timber producers.

The loss of tanoak due to mortality was also not accounted for in this study. The economic value of tanoak is complex. To many landowners, tanoak is seen as a pest because it competes with much higher valued timber for growing space. Profit maximizing landowners could potentially benefit from the decline in the tanoak population as a result of *P. ramorum*. On the other hand, many landowners rely on the tanoak market in order to make timber removal from mixed stands containing tanoak profitable (Arnold 2009). Therefore, if the quarantine were to eliminate the tanoak market, these landowners could be negatively impacted.

Ultimately the goal of quarantines is to prevent the human spread of the pathogen to areas outside of the quarantine zone, so there are both economic and ecological benefits (foregone damages) associated with the zones that are widely distributed outside of the quarantine area. Larger quarantine zones do not necessarily provide more protection to these outside areas and come at large costs as is illustrated in this study. When the quarantine zone is increased to encompass a larger area and the costs to businesses escalate, the regional economy will carry much of the burden. This study examines some of the costs and benefits to Oregon of the control programs or lack thereof, but does not look at the benefits to other areas of preventing the spread of the pathogen.

Conclusion

An economic assessment was performed on three different Phytophthora ramorum control policies in Oregon in order to inform policy makers of some of the economic implications of these three policy options. The three options being considered are 1) to continue the current control program, 2) to increase control efforts in an attempt to eradicate the pathogen, and 3) no control program. The study assumed that these policies would affect costs by altering the rate of spread and determining the rate of quarantine area increase. Costs to agencies as a result of program implementation as well as costs to the forest products industry as a result of *P. ramorum* quarantine regulation were projected out for 20 years under the three policy scenarios. These two costs categories are thought to be the primary economic costs associated with *P. ramorum* in Oregon. A variety of other costs would also be incurred as a result of the pathogen but these were beyond the scope of this study. These other costs include a reduction in Oregon's forest product export market, a reduction in the non-timber forest product market, and increased production costs for producers utilizing *P. ramorum* host plants

The costs associated with the eradication program are expected to be approximately $28,832,373, approximately $31,178,402 with the current control program, and $292,787,962 in the absence of a control program. Uncertainty about the spread rate conditions under no control policy created a wide range in the estimate for the costs projected under this policy scenario. Improved data on the spread rate in Oregon in the absence of a control policy would narrow this range and produce a more precise estimate of the benefits associated with *P. ramorum* control.

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