Field Validation of Laboratory Tests Used in Screening Port-Orford-cedar For Resistance to *Phytophthora lateralis*

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I understand that my project will become part of the permanent collection of Oregon State University and the Bioresource Research Program. My signature below authorizes release of my project to any reader upon request.

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Introduction

Port-Orford-cedar (POC) (*Chamaecyparis lawsoniana (*A. Murl.) Parl) is an important tree species native the coastal ranges of southern Oregon and northern California. The tree is a false-cedar in the cypress (*Cupressaceae*) family and is used for timber and planted as an ornamental. The tree in most of its native range is now being threatened by the exotic pathogen *Phytophthora lateralis*. Since it's introduction into the wild in the 1950s and '60s, *P. lateralis* has spread over much of the natural historic range (Jules et al. 2002). Starting in the late 1980's, a resistance breeding program was started to preserve POC as a valuable species of tree. The resistance screening program is still operating and has been successful in finding and producing resistant seed stock. This thesis focuses on the resistance screening techniques used and evaluating their effectiveness at predicting tree survival in the wild.

<u>Ecology</u>

Port-Orford-cedar fills a unique niche in the forests of southern Oregon, where it not only grows as a riparian species but is unique in its ability to grow on the nutrient poor serpentine soil outcroppings. The high levels of metals in serpentine (ultramafic) soils are toxic to most plants; however, this creates a unique environment for POC, where it can out-compete other trees to become the dominant tree species. POC is often planted on these sites because of its ability to grow and produce a timber crop where other trees might not survive.

Port-Orford-cedar is readily found in the swamps and riparian areas of its range. In the steep canyons of the coast range, it is found growing in and around water, where it functions to provide cooling shade and aquatic structure to seasonal and permanent streams. The loss of POC from these environments, especially in areas with serpentine soils, results in decreased water quality for the drainage, since few other species survive there.

One area of concern is in the Kalmiopsis Wilderness of southern Oregon, where the Biscuit Fire of 2003 destroyed thousands of acres of unique POC. An objective in controlling the Biscuit Fire was to prevent spread of the pathogen into the wilderness making regeneration of Port-Orford-cedar impossible in its historic range.

Economics/Timber

Port-Orford-cedar is valuable in the domestic and export log markets. Domestically it is used to make siding and its straight grain results in high quality arrow shafts. Boughs are cut from trees in the wild for use in the decorative and floral market. As a timber product, it has been known to demand as much as $1,350 per thousand board foot, for export quality logs (Log Price Information, 1977). Even though export of POC has dropped dramatically in the last fifty years there is still a niche market of nearly 3 million board feet. Most of the exported logs are shipped to Asia where the wood is valued for its light color and straight grain. (Barnes and McLean, 1999)

Phytophthora Root Disease of Port-Orford-cedar

The pathogen that causes root disease in POC is *Phytophthora lateralis*. *P. lateralis* is an Oomycete or water-mold, which closely resembles fungi in its form. The name *Phytophthora* means "plant-destroyer" in Greek and is fitting since pathogens belonging to this genus are responsible for many plant diseases around the world, the most famous of which is, potato late blight (*P. infestans),* the pathogen which was the cause of the Great Potato Famine. *P. lateralis* can persist in the wild for several years in the form of specialized asexual spores called chlamydospores (Goheen, 2003, p. 33-45). The ability of chlamydospores to survive desiccation allows the pathogen to be viable after being carried for long distances in mud. Infected soil movement has been identified as the main mechanism by which *P. lateralis* has spread between watersheds (Jules et al. 2002). All vehicles and equipment used on federal land where the root disease is found are required to be washed with water to remove adhering mud before being moved to a different site to help prevent spread. In the case of firefighting all water used had to be treated with bleach to kill the pathogen before it was spread. During active asexual, sporulation swimming spores called zoospores develop and are attracted to the fine roots of POC. Zoospores are the main propagule of *P. lateralis* within a watershed. The spores from infected POC are washed into streams or swamps by surface water, where they can move downstream to infect other trees. Upon contact with the roots, the spores germinate and send hyphae into the root's vascular tissue; the pathogen then grows until it moves up and girdles the trunk, killing the tree. Hyphal growth is rapid in the tree and can be seen as reddish-brown stain in the cambium layer. (Hansen et al. 1989).

Since the spread of the pathogen follows the flow of water and road traffic, most infection centers are found along roads and downstream of road crossings. Currently, many roads within the natural range of POC are locked and gated during the rainy seasons to prevent the spread or introduction of *P. lateralis.* During the dry season, when the risk of mud is lessened, these roads are reopened. In particularly sensitive and high value areas, there has been permanent road closure on federal lands. Lawsuits have been filed to force the Forest Service and BLM to prepare environmental impact statements and range wide management plans concerning the spread of *P. lateralis* into natural stands (Hansen et. al. 2000).

Resistance Testing

Late in the 1980's The USDI Bureau of Land Management and the USDA Forest Service started a program to identify resistant Port-Orford-cedar in the wild. The goal of the resistance breeding program was to provide resistant seedlings to be planted to replace natural stands and to aid in the reforestation of previous POC range (Sniezko, 2001, p. 75-88). Resistant seed was made available for some breeding zones in 2002 (Hansen, Sniezko 2001). From these efforts, several families have been identified which show complete resistance or slow the rate of growth of *P. lateralis* in the tree.

Tree Selection

In the wild, trees were selected to enter the resistance testing program in two ways: by either showing apparent resistance or through random roadside selection. In order to conserve the genetic diversity over the entire range of POC, six distinct breeding blocks were established. A tree selected for showing apparent resistance was chosen because it was in an area of high mortality and at high risk for infection, yet remained healthy while adjacent trees were killed (Hansen 2005). These trees were often found away from the road in streams or swamps. Trees selected at random along a roadside were not chosen based on any premonition of resistance, and often were picked at a certain interval along the road (Hansen 2005). By picking trees at random along a road system, a greater amount of genetic diversity is included in the resistance breeding program. These trees were usually located within 20 feet of the road. In each case, the tree was marked and a detailed log was kept so the tree could be found again. Several branches were cut from the tree and taken to the lab to be used in resistance tests. The trees included in my study were initially selected between the years 1995 and 1999.

Lab Tests

The lab tests were completed in conjunction with Dorena Genetic Resource Center and Everett Hansen's lab at OSU. When taken back to the lab the cut ends of 12-inch cuttings were submerged in a solution containing *P. lateralis* zoospores to ensure uniform infection and then removed. After 21 days, the stems were observed to note the distance up the stem the lesion caused by *P. lateralis* had traveled. The lesion appears as an area of brown staining with a distinct margin (Hansen et al. 1989). The results of the stem dip inoculations of candidate trees were then compared to cuttings from a high resistance control and a low resistance control. A stem in which the spread of the pathogen was kept to a minimum was considered a stem dip winner.

The top percent (~10%) of the stem dip winners then underwent another test called the rooted cutting inoculation test. Stems from the parent trees were allowed to root and were grown as seedlings in super-cells. The super-cells were then dipped into a solution containing *P. lateralis*. The percent survival after 9-12 days of the family of rooted cuttings exposed to the pathogen is considered its Rooted Cutting (RC) test score (if 7 out of 10 trees survive the score would be 70%); the top trees in this test then entered seed production (Hansen and Sniezko, 2001). There are discrepancies between the results of the two tests indicating that different trees display different mechanisms of resistance (Hansen 2005).

Risk

In this study, a dead tree is listed as dead for one reason, being susceptible and dying in response to *P. lateralis*. However, a live tree has two reasons for explaining its health; either it is resistant, or it has never been exposed to the pathogen (escape.) As a way to discriminate against resistant and escape trees, factors contributing to exposure were recorded at each tree. Since the pathogen is spread by water, mud on vehicles and root-to-root contact, the risk factors which were measured included: distance to the road, distance to a stream and distance to dead POC (Jules et al. 2002, Hansen 2005). Vehicles are known to be a major mode of transportation of infected soil; therefore a tree which is close to the road should be at greater risk of being exposed than a tree which sits a long distance from a road (Jules et al. 2002). Trees with roots extending to a stream will be at higher risk for catching an infection by water born spores than trees that are not near a stream. Port-Orford-cedar cedars form root grafts with neighboring trees which allow partial sharing of vascular tissue (Jules et al. 2002). If a tree has root-to-root contact with an infected tree, its probability of being exposed is far greater than a tree without root-to-root contact.

Statement of Purpose

The purpose of this research project is to evaluate the effectiveness of the current methods used to test resistance in POC. The focus will be on comparing a tree's field survival to survival in the rooted cutting inoculation test. Trees with high test scores are expected to survive better in the field than trees with low test scores.

Objectives

- Compare rooted cutting scores to field survival
  - Hypothesis: Trees with higher test scores will have better field survival than trees with low test scores.
- Observe and record factors contributing to exposure to *P. lateralis*
  - Use risk factors to eliminate possible escape trees from analysis
- Create a model to describe the relationship between RC test score, risk factors and field survival

Methods

Tree Revisits

The parent trees which have been revisited were selected from the top ten percent of the stem dip test, the list included trees from three different regions: Roseburg BLM, Medford BLM and Powers Ranger District. The list of trees was provided by the people at Dorena Genetic Resource Center. The road logs containing tree location information were gathered from the J. Herbert Stone Nursery in Central Point, OR. These logs allow relocation of parent trees through a pattern of roads or a pattern of individual trees. Every tree has a tag or placard identifying it as part of the study; most trees also had a stripe painted on the bole.

Several points of data were taken from each tree (Appendix A):

- Height and diameter
- GPS location
- Tree location and location notes

- Tree status and cause of death
- Dead date
- Distance to a road, stream and infected POC
- Roadside sanitation
- Observation of surrounding area

Analysis

After all of the data was collected, it was entered into a spreadsheet (Appendix B) containing the tree number, its status and the distance to each of its risk factors. The corresponding rooted cutting test scores were added to this spreadsheet to make a working copy. When gathering the data on risk, each tree was classified as either near the risk factor or not. If the tree was near, then a distance value was entered. If the tree was not near, then an arbitrary distance of 200 feet was entered. Two hundred feet was chosen, because at this distance the affect of a risk factor would be inconsequential to the probability of a tree being exposed.

Results

Of the 254 trees on the list to be found, 179 trees were relocated. The remaining 75 are listed as "Did Not Find" (DNF) or "killed." Those trees were not relocated for one of three reasons; time constraints, poor accessibility or missing trees. Accessibility was a problem in some areas due to road closures or impassability, particularly within the perimeter of the 2003 Biscuit Fire. Most trees which are listed as DNF were done so because they were not found at the location indicated in the logs, and often this would be along a road where heavy equipment was used to clear brush. A tree would be described as "killed" if it was found dead and down and its pre-cut condition not evident. The term "dead" was reserved for trees in which the cause of death was POC root disease. Since data from the DNF and "killed" trees would not be helpful in this study, those trees were eliminated from the analysis. The dead date for each tree was estimated based on how long the tree appeared to have been dead.

The focus of this research was on the relationship between a tree's health in the wild and its performance in a survivability test done in a laboratory situation. The tree's health in the field was either alive or dead, while the performance in lab tests are given as a percent of survival. The first analysis was a comparison of laboratory survival percentages (RC test score) and tree survival in the field. The average laboratory survival percentage for trees found to be alive in the field was 46.5%, while the average RC score for trees found to be dead was 36%. The average RC test score for all trees found was 44.6% (Figure 1, Table 1). This shows that trees found to be dead in the field have a lower average survival percentage in the laboratory tests than trees found to be alive. The relationship in this case is not strong, but it does show that the two categories support the hypothesis that trees with higher test scores will also have higher survival in the field.

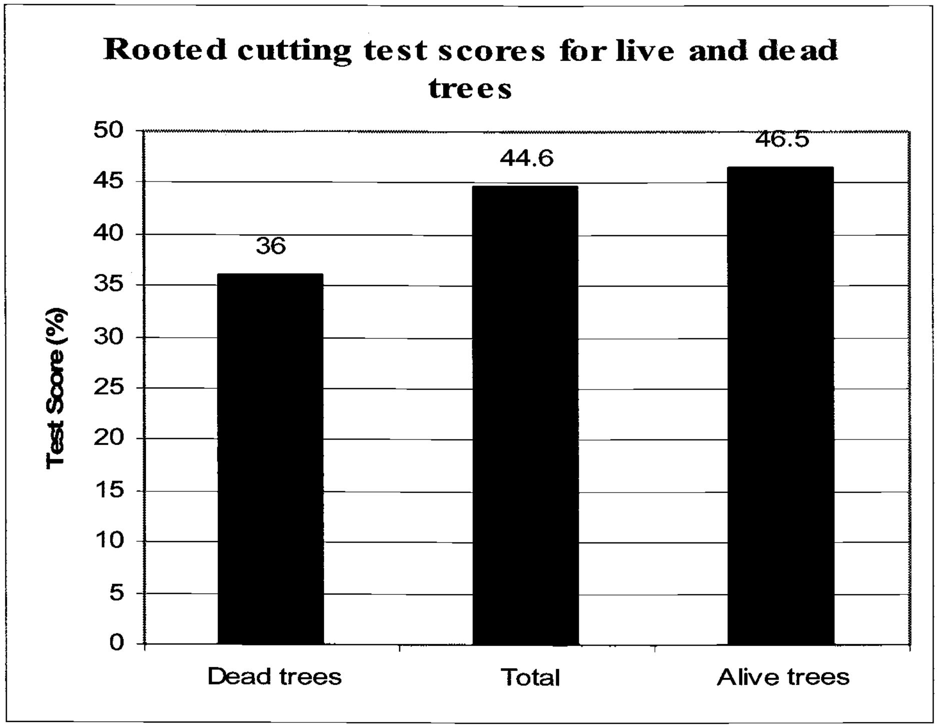

Figure 1. Average RC score for trees found to be dead or alive in the field

To show a stronger correlation between test score and survival in the field, the two extremes, 0 and 100% from the test scores, were compared. This analysis included 26 trees with test scores of 100% and 42 trees with scores of 0%. The percentage of trees alive or dead was tallied from the two categories. It was found that among the trees with a 100% test score, 92.3% were alive in the field, and for trees with a 0% test score, 76.2% were alive (Figure 2, Table 1). These results indicate that trees with a RC score of 100% are more likely to be alive in the field than trees with a score of 0%. Rooted cutting scores were split into 25% intervals to show a distribution among all of the trees analyzed. Without incorporating the risk data, a positive correlation between field survivorship and RC score is seen (Figure 3).

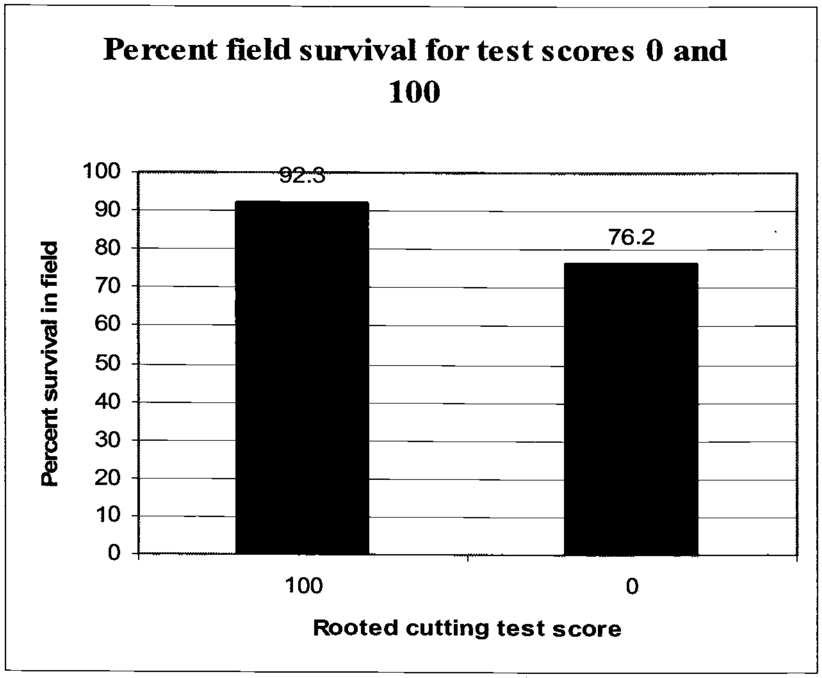

Figure 2.
Percent field survival as a factor of the extremes of RC test score.

Status	Count	Avg. RC Score	Percent with RC Score of 100%	Percent with RC Score of 0%
Alive	147	46.5	92.3	76.2
Dead	32	36	7.7	23.8
Total	179	44.6	100	100

Table 1.Results of trees found related to average rooted cutting (RC) test score, and the extremes of RC test scores.

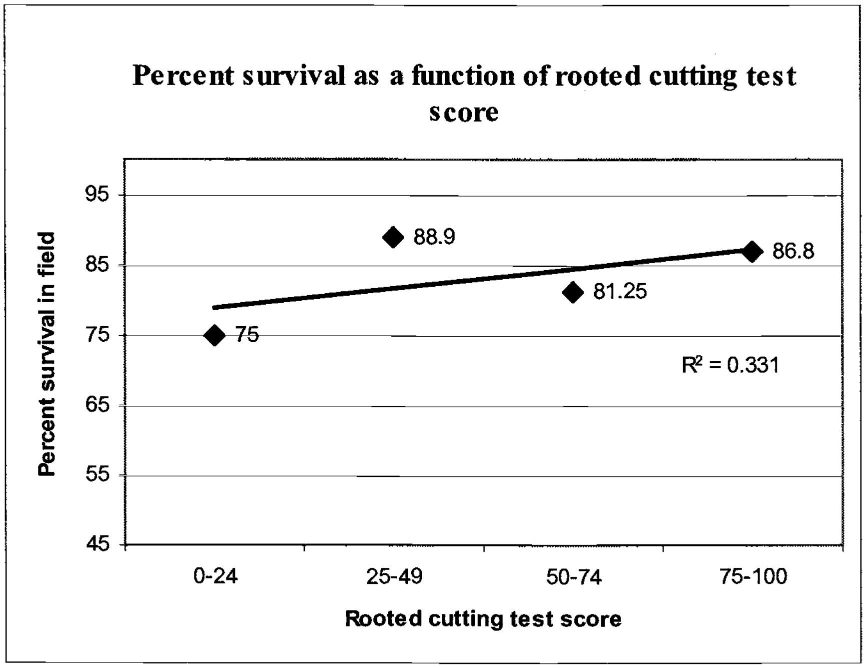

Figure 3. Percent survival compared to a range of RC test scores.

How Risk Affects the Results

Since only trees which have likely been exposed to the pathogen are useful in determining resistance, the high risk trees must be separated from the low risk trees. A method for separating high from low risk is needed to interpret the results more accurately. From what is known about the relationship between Port-Orford-cedar and *P. lateralis,* arbitrary distances have been estimated to separate the high from the low risk trees. The distance from a stream considered to be high risk is 20 ft, this distance will allow for root growth and high water flows (Table 2). High risk trees will also be considered to be within 15 ft of an infected POC, allowing for root-to-root contact (Table 2). The distance from a road considered to put a tree at high risk is 15 ft, which takes into account water runoff from the road (Table 2).

Status	Count	Avg. RC score	% of trees
Trees within 20 ft of a stream			
Dead	16	27%	34%
Live	31	44%	66%
Trees within 15 ft of infected POC			
Dead	25	27.3%	14%
Live	59	42.5%	86%
Trees within 15 ft of the road			
Dead	15	43.3%	14%
Live	93	49.5%	86%

Table 2. Average RC test scores for dead and live trees considered to be within the confines of high risk.

A high risk tree is then defined as being within 15 ft of an infected POC and within 20 ft of a stream. Distance from a road was not included, because the average RC scores for live, 43.3%and dead, 49.5% trees stayed similar at a distance considered critical for exposure to the pathogen (Table 4). Of the 179 trees found, 100 are considered high risk.

When the survival of only high risk trees is compared to their RC test score, we see a positive correlation (Figure 4). This correlation is most evident in the field survivorship of trees with RC scores of 100% or 0%. Among these high risk trees, those with an RC score of 100% had a field survivorship of 91% (Figure 4, Table 3). Trees with an RC test score of 0% had a field survivorship of 66.7%. The use of risk analysis has reduced the percent of live trees that tested at 0%, allowing the tests to be considered more accurate by integrating risk data. (Figures 3,4).

Status	Count	Avg. RC Score	Percent with RC Score of 100%	Percent with RC Score of 0%
Alive	75	43.7	91%	66.7%
Dead	25	32.6	9%	33.3%
Total	100	41	100%	100%

Table 3. Rooted cutting test scores among high risk trees.

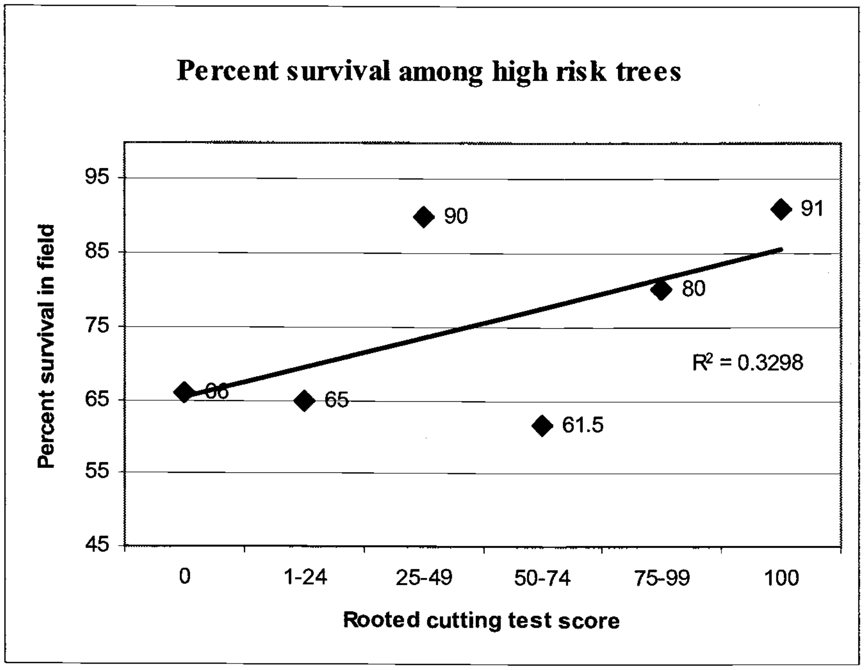

Figure 4
Percent survival for high risk trees compared to a range of RC test scores.

The Model

The model created uses logistic regression to calculate how different factors contribute to produce a certain outcome (dependent variable). In this, case the variables are the risk factors and the rooted cutting inoculation score; and the outcome is tree status. By using logistic regression, a value is assigned to each variable; the larger that number the more important it is to tree survival in the field. Previously it was determined that high risk trees are within 15 feet of dead/infected POC or within 20 feet of a stream; therefore, the logistic regression was completed using these 100 trees. The regression was run using StatGraphics software.

The following model was created using only the high risk trees with the factors of distance to dead, distance to stream and RC score, with a dependent variable set as tree status.

The distance to dead/infected trees was given the most weight with a value of 0.1102, the rooted cutting score was the next most important with a value of 0.00916, the least important factor in this model is distance to stream with a value of 0.00359. A high value here means that the risk factor is more detrimental to the outcome of the model.

Regression Model: $E(\text{logit}) = -0.630-0.1102*\text{Dead}+0.00359*\text{Stream}+0.00916*\text{Score}$

The average E-values described by this equation for dead and live are -0.76 and -2.76 (Table 4). There are six outliers included in this analysis causing the standard deviation to be quite large; if they are removed, the standard deviation is reduced from 4.89 to 1.37 and the average overall E-value is reduced by more than half, -2.26 to –1.11, (Table 5).

Status	Count	Avg. E-value	Std. deviation
Dead	25	-0.76	0.79
Alive	75	-2.76	5.55
Total	100	-2.26	4.89

Table 4. Results of the regression model.

Status	Count	Avg. E-value	Std. deviation
Dead	25	-0.76	0.79
Alive	75	-1.23	1.51
Total	100	-1.11	1.37

Table 5. Results of regression model with outliers removed.

The trees were then split into five categories based on E-value, where the first category consists of the lowest 20% of the trees, the second contains the next 20% and so on giving 20 trees in each category. From Table 6, we see trees in the top 20% show the greatest field survival. Figure 5 shows the relationship between field survival and E-value; trees with a lower (more negative) E-value are more likely to be found alive in the field.

Category	Count of alive	Percent alive	Ave RC score
1	18	90%	38.3
2	16	80%	22.9
3	11	55%	25.8
4	16	80%	36.2
5	12	60%	81.66
Totals	73	73%	40.9

Table 6. Relationship between E-value (from regression model) and field survival.

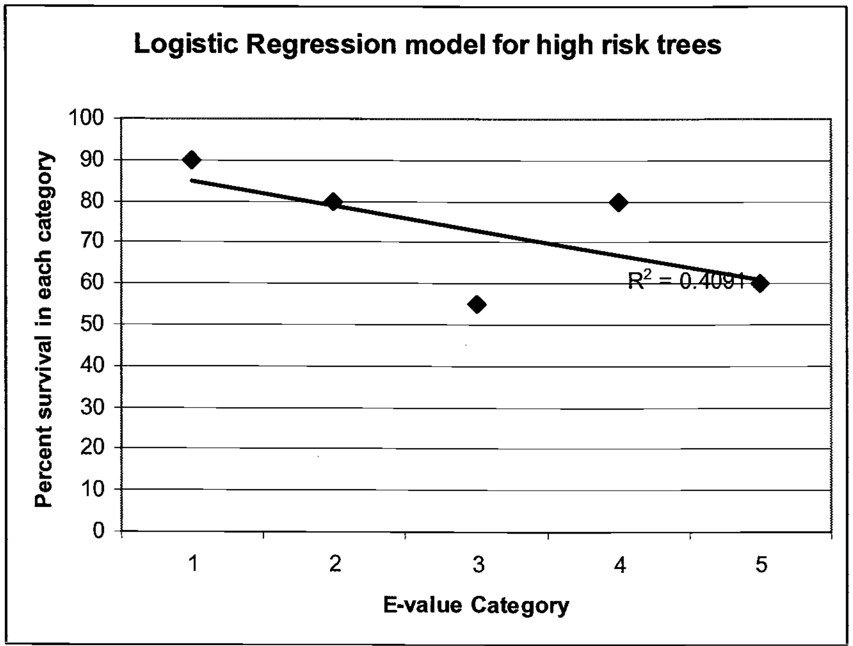

Figure 5. Percent survival from categories in Table 6 compared to regression model E-values.

Discussion

The purpose of this research project was to evaluate the effectiveness of the Port-Orford-cedar resistance screening program. Three methods were used to compare the laboratory tests to the field results: 1) rooted cutting inoculation test score compared to field survival, 2) analysis of risk factors to eliminate escape trees from comparison and 3) the creation of a model to explain how risk factors and RC scores affect tree survival. In all three cases, analyses were hindered by inadequate sample size. More time was needed to complete the relocation of trees and to expand the search into older selection years. Hopefully a more complete sampling of wild trees will lead to a more conclusive correlation.

The first analyses show that trees which are still alive in the field have a higher average RC test score than trees which are dead in the field (Figure 1), supporting the hypothesis. It was also found the trees with 100% RC test score were more likely to be alive in the field than trees with a 0% test score (Figure 2). These results mean there is a positive correlation between test score and survival in the field, thus validating the laboratory tests. However, the correlation is slight and some trees which showed complete resistance in the greenhouse were found dead in the field, indicating the tests may misrepresent or under represent the resistance mechanisms Port-Orford-cedar uses in a natural pathogen attack.

An analysis of the risk factors showed distance to road was not as important as distance to an infected POC or to a stream, with distance to infected POC being the only definitive way of knowing if *P. lateralis* is present. By eliminating a portion of the possible escape trees, the higher risk trees show a stronger correlation between field survival and RC score (Figure 4).

The model was used to integrate the risk factors and the rooted cutting scores to create an equation which can predict the probability of a tree surviving in the wild (Figure 5). Using this model, one can understand the relationships between the different factors relating to tree survival in the field. Since it predicted that rooted cutting test scores are important to the final outcome, the model also helps to support the idea that rooted cutting test scores are an important part of testing resistance in the wild. The model is valid in that it correlates to the expected and actual results of the other analyses, but it also needs a greater population to draw from to eliminate the outliers and inconsistencies present in the sampling. Further research would look at a set of trees initially selected in 1989 to provide a longer term correlation between rooted cutting test scores and field survivorship

Conclusions

- Trees with higher rooted cutting test scores are more likely to survive in the field.
- A stronger correlation between test score and field survival was found when possible escape trees were eliminated from analysis.
- The use of a model provides a way to assess the probability of a tree surviving in the field.

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Appendix A

Example of the data sheet

AREA: DATE: CREW:

YR	TREE #	CROWN	HEIGHT	DBH	DEADATE	LAT	LNG	TS	RNG	SEC
2004										

Location notes:

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Tree condition: Live Symptomatic Dead

Likely cause of death: ______________________________

____

Risk factors:

Roadside? Yes No

Distance to road ______________________________

Road sanitized? Yes No

Streamside? Yes No

Distance to stream ______________________________

Infected POC? Yes No

Distance to Dead POC ______________________________

Other risk factor? ______________________________

Notes: ______________________________

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Appendix B

Spreadsheet with all data
Including DNF and Killed
Without arbitrary distances

Tree #	Distance to road	Distance to Dead POC	Distance to stream	Roadside sanitation	Dead date	Status	RC Survival %
10065	5			No		Alive	66.67
10087	15	70		No		Alive	100
10142						DNF	50
10143						DNF	16.67
10145	4			No		DNF	58.33
10150	4	40		No		Alive	0
10152	4			No		Alive	16.67
10178						DNF	83.33
10183						DNF	0
10187	8			No		DNF	66.67
10208	6		20	No		Alive	33.33
10209	30		10	No		Alive	16.67
10218				No		Alive	16.67
10225	12		1	No		Alive	33.33
10231	10	15		No		Alive	0
10278						Killed	83.33
10281		1	1	No		Alive	0
10319						DNF	33.3
10375	20	12	10	No		Alive	100
10381	30	3		No		Alive	100
10384	8	15		No		Alive	0
10388	10	4	40	No		Alive	100
10409	10	100	1	No		Alive	33.33
10428	60	4	30	No		Alive	33.33
10435	20	3	15	No	2002	Dead	16.67
10440	40	8	15	No	2002	Dead	66.67
10444	100	4	1	No	2003	Dead	100
10455	100	15	10	No		Alive	16.67
10486	200	15	10	No	2001	Dead	16.67
10492	20	15		No	2002	Dead	0
10525	25	15	10	No		Alive	83.33
10526	20	4	20	No	2001	Dead	0
10539	5			No		Alive	0
10542		3		No		Alive	0
10544	6			No		Alive	0

10643	10	10		Yes	2000	Dead	0
10644	8	3	25	Yes		Alive	0
10650	250	30	40	Yes	2000	Dead	0
10657		15	3	Yes	2000	Dead	0
10710		7	1	Yes		Alive	0
10714		2	1	No	2000	Dead	16.67
10716		3	4	No		Alive	16.67
10749						Killed	0
10770						Killed	83.33
10801		8	15	No	2002	Dead	0
10803		8	40	No		Alive	16.67
10806		50	20	No		Alive	83.33
10812						DNF	100
10866	20	20	5	No		Alive	83.33
10890	30	30	60	No		Alive	0
10899	15	1	1	No		Alive	33.33
10979						DNF	100
11007						DNF	41.67
11059	300	4	1	Yes		Alive	100
11072	400	1	1	Yes	2002	Dead	50
11105	50	20	20	No		Alive	33.33
11106	50	6		No		Alive	16.67
11108	25	6		No		Alive	66.67
11109	40	6	200	No		Alive	16.67
11119						DNF	66.67
11138						DNF	50
11141						DNF	100
11151						DNF	41.67
11189						DNF	16.67
11196						DNF	0
11205						DNF	0
11273						DNF	33.33
11319	100			No		Alive	100
11326				No		Alive	0
11328	100			No		Alive	0
20069	20	20		No		Alive	33.33
20070	30	4	20	No		Dead	16.67
20073	40	20		No		Alive	0
20078	15	3		No		symptomatic	16.67
20097	25	10		No		Alive	33.33
20100	50	15		No		Alive	50
20134						DNF	50
20185						DNF	25
20199						DNF	100
20321	10	8		No		Alive	83.33
20341						DNF	0
20361						DNF	16.67
20383						DNF	16.67

20438						DNF	33.33
20490						DNF	16.67
20512						DNF	16.67
20553						DNF	66.67
40632	20	100		No		Alive	0
40637	8			Yes		Alive	0
40658	12			No		Alive	0
40673						DNF	0
40822	8	200		Yes		Alive	0
40831	20			Yes		Alive	0
40846	15	60				Alive	14.29
40854	15	40	1	Yes		Alive	16.67
40877	25	40	60	Yes		Alive	25
40891	12	40	8	No		Alive	33.33
40927	15	15	5	Yes		Alive	33.33
40944						DNF	42.86
40956	6	80	80	Yes		Alive	50
40969	5	150		Yes		Alive	50
40975	10			Yes		Alive	50
40976	8			Yes		Alive	50
40980	25	30		Yes		Alive	50
40981	6		80	Yes		Alive	50
40984	15	180	120	Yes		Alive	50
40990	8		25	Yes		Alive	57.14
40991	8			No		Alive	66.67
41000	15			Yes		Alive	66.67
41009	6	80		Yes		Alive	66.67
41012	10	18		Yes		Alive	66.67
41043	8	8		No		Alive	83.33
41057	10			No		Alive	83.33
41061	10		200	No		Alive	83.33
41068	10	30	15	Yes		Alive	83.33
41073	15	10	50	Yes		Alive	83.33
41077	10			Yes		Alive	83.33
41083	10			Yes		Alive	83.33
41101	10			Yes		Alive	85.71
41106	12			Yes	2000	Dead	100
41119						DNF	100
41121	12		12	Yes		Alive	100
41122						DNF	100
41130						Killed	100
41131						Killed	100
41132						Killed	100
41134	8		100	Yes		Alive	100
41142	10			Yes		Alive	100
41145	12			Yes		Alive	100
41164	12			Yes		Alive	100
41182	8	70	20	No		Alive	100

41343	4	15		Yes		Alive	0
41419						DNF	0
41427	10	5	50	No		Alive	0
41491	8	10	2	Yes		Alive	0
41492						DNF	0
41514	15	80	100	Yes		Alive	0
41532						DNF	0
41550	8			Yes		Alive	0
41551	7			Yes		Alive	0
41558						Killed	0
41561	8	30	20	Yes		Alive	16.67
41563	30	80		Yes		Alive	16.67
41564	60	15		Yes		Alive	16.67
41565	40	20		Yes		Alive	33.33
41567	100	30		Yes		Alive	33.33
41570	80	8		Yes		Alive	33.33
41585						DNF	50
41590						DNF	50
41591	8	30		Yes		Alive	50
41632						DNF	50
41643						DNF	50
41650	8	60		Yes		Alive	66.67
41656	35	50	6	Yes		Alive	66.67
41659	15	1	20	Yes		Alive	83.33
41670	8	40		Yes		Alive	83.33
41671	8	15		Yes		Alive	83.33
41689	17	50		Yes		Alive	83.33
41712	10	30		No		Alive	83.33
41714						DNF	83.33
41721	5	1		Yes	2001	Dead	83.33
41729						DNF	83.33
41797	12			Yes		Alive	83.33
41807	20	20		Yes		Dead	83.33
41809	50	10		Yes		Alive	100
41811						DNF	100
41824						Killed	100
41832	20	20		Yes		Alive	100
41881						DNF	100
41888						DNF	100
41897	15	30		No		Alive	100
41901	25	20		No		Alive	100
41923						DNF	100
41937	15	10		No		Alive	100
41941	8			No		Alive	100
41948	10	8		No		Alive	100
41972	12	50		No		Alive	100
41975	10	50		No		Alive	0
42041						DNF	0

42047	10			Yes		Alive	0
42064	15	20		Yes	2000	Dead	0
42079	6	10		Yes		Alive	0
42090	5	8	50	Yes		Alive	0
42105						DNF	0
42109						DNF	0
42131	30	20		Yes	2000	Dead	0
42139	8			Yes		Alive	0
42145	15	10		Yes	2000	Dead	16.67
42150	10	20	10	Yes		Alive	16.67
42154	20	10		Yes		Alive	16.67
42209						DNF	16.67
42217						DNF	33.33
42266	15	20	50	Yes		Alive	33.33
42271	20	4		Yes	2002	Dead	33.33
42318	30	2		Yes		Alive	33.33
42334	30	6		Yes		Alive	33.33
42336	100	3	1	Yes		Alive	33.33
42337	120	15	5	Yes	2000	Dead	50
42345	20	1		Yes		Alive	50
42345	25	3		Yes		Alive	50
42347	20	3	2	Yes	2000	Dead	50
42349	30	5	2			Alive	50
42362	4	2		Yes	2001	Dead	66.67
42366	4	20		Yes		Alive	66.67
42371	3			Yes		Dead	66.67
42374	4			Yes	2001	Dead	83.33
42376	8	4		Yes	2001	Dead	83.33
42400	6	80		Yes		Alive	83.33
42408	8	5		Yes		Alive	83.33
42416	6	50		Yes		Alive	100
42428	20	4		Yes		Alive	100
42449	7	80	100	Yes		Alive	100
42461						DNF	100
42468						DNF	100
42490						DNF	100
42495						DNF	100
42502	12	30		Yes		Alive	0
42528	6	10	5	No	2001	Dead	0
42535	10	1	10	Yes	2001	Dead	0
42541	150	15	1	Yes		Alive	0
42551	6	1	60	Yes		Alive	16.67
42590	25		20	Yes		Alive	16.67
42555	5	10		Yes	2001	Dead	16.67
42582	8	5		Yes		Alive	33.33
42595	20	7	30	Yes		Alive	33.33
42611	50	20	5	Yes		Alive	50
46262	15	10	50	Yes		Alive	50

42633	6	10	1000	Yes		Alive	66.67
42638	10	80	80	Yes		Alive	66.67
42665	15	10		Yes		Alive	83.33
42672	10	4		No	2001	Dead	83.33
42686						DNF	83.33
42691						DNF	100
42711						DNF	100
42712						DNF	100
42713						DNF	0
42741	8	10		No		Alive	0
42744	10	12		Yes		Alive	0
42755	8	6	20	No	2001	Dead	16.67
42756						DNF	16.67
42761	10		50	No		Alive	16.67
42770	10	15	30	Yes		Alive	33.33
42773	15	4	6	Yes		Dead	33.33
42777	6	15		Yes		Alive	41.67
42792	10	50		Yes		Alive	41.67
42794	20	10		Yes		Alive	41.67
43423	12	10		Yes		Alive	83.33
43501						DNF	83.33
43516						DNF	100
43525						DNF	100
43529						DNF	100
43531						DNF	100
43534	8	50		Yes		Alive	100
43539						DNF	100