

On the Economics of PVY

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Potato Virus Y

- Previous studies have shown that PVY reduces potato yields
- Tuber necrotic strains of PVY (PVY^{NTN}) can render harvested potatoes unmarketable due to PTNRD



PVY as a Seed Borne Problem

- Planting infected seed leads to spread of PVY during the growing season
- Some varieties have only mild or latent foliar symptoms while in others the symptoms are readily observed.
- Losses of up to 80% have been reported from PVY
- Nolte, et al. reported yield losses of 1.75 cwt/acre for each percentage of PVY infection in Russet Burbank potatoes



Thus, we have a problem

PVY poses a threat for producers of both seed and commercial potatoes.

Here we will examine two aspects of this problem:

1. The per acre yield and income impacts due to known levels of PVY⁰
2. The impacts that PVY has on the economy of the state of Idaho



Thus, we have a problem

PVY poses a threat for producers of both seed and commercial potatoes.

Here we will examine three aspects of this problem:

1. Infection levels present in seed stock and the relationship of emergence PVY to harvest PVY levels
2. The per acre yield and income impacts due to known levels of PVY⁰
3. The impacts that PVY has on the economy of the state of Idaho



PVY in Seed Stocks:

An Examination of data from Montana, Wisconsin and Idaho

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Seed Certification Data

As part of the SCRI PVY project, data were collected from a number of seed certification agencies

Current season mosaic readings (either visual or ELISA)

Winter grow-out readings (ELISA)

Data consistent enough for analysis were received from Wisconsin, Montana and Idaho/



Seed Certification Data

Wisconsin: 2003 – 2010

Montana: 2005 – 2010

Idaho 2009 – 2010

As many of the readings in these data are zeros, the data does not lend itself to statistical analysis. We will summarize the data by examining two events by variety.



Summary

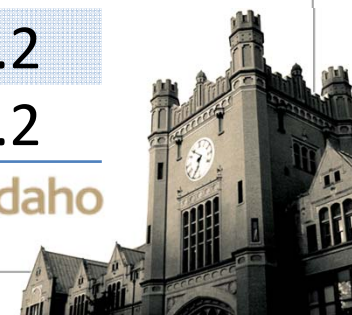
First we summarize, by variety, the incidences when the *winter grow-out tests show a higher percentage of infection* than the summer tests.

Second, we summarize, by variety, the instances when the summer tests show *readings of less than two percent mosaic while the winter grow-out tests indicate infection levels greater than two percent.*

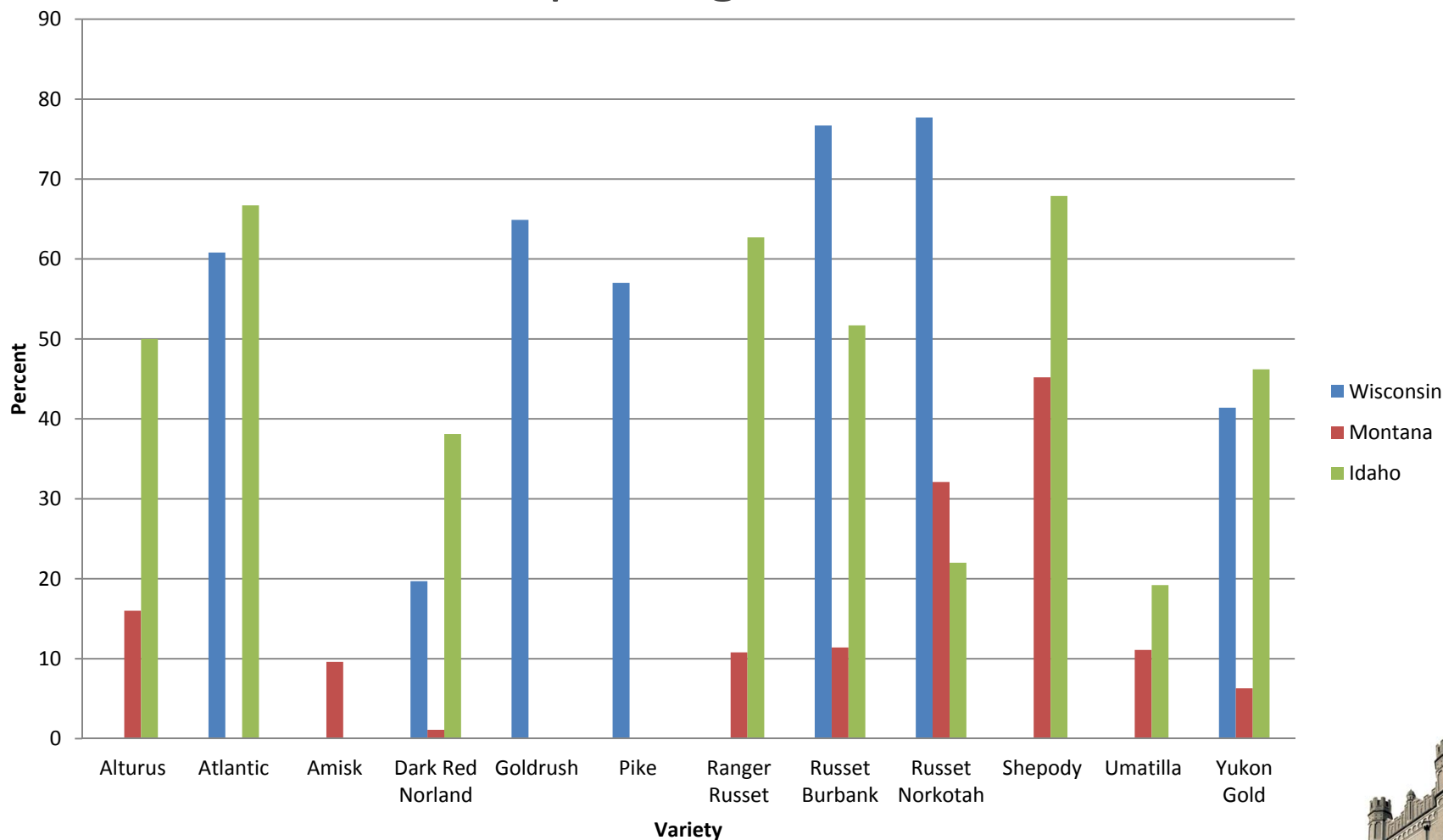


Percentage of Winter Tests with Greater PVY Readings than Corresponding Summer Tests

Variety	Wisconsin	Montana	Idaho
Alturus		16.0	50.0
Atlantic	60.8		66.7
Amisk		9.6	
DR Norland	19.7	1.1	38.1
Goldrush	64.9		
Pike	57.0		
Ranger Russet		10.8	62.7
Russet Burbank	76.7	11.4	51.7
Russet Norkotah	77.7	32.1	22.0
Shepody		45.2	67.9
Umatilla		11.1	19.2
Yukon Gold	41.4	6.3	46.2



Percentage of Winter Tests with Greater PVY Readings than Corresponding Summer Tests



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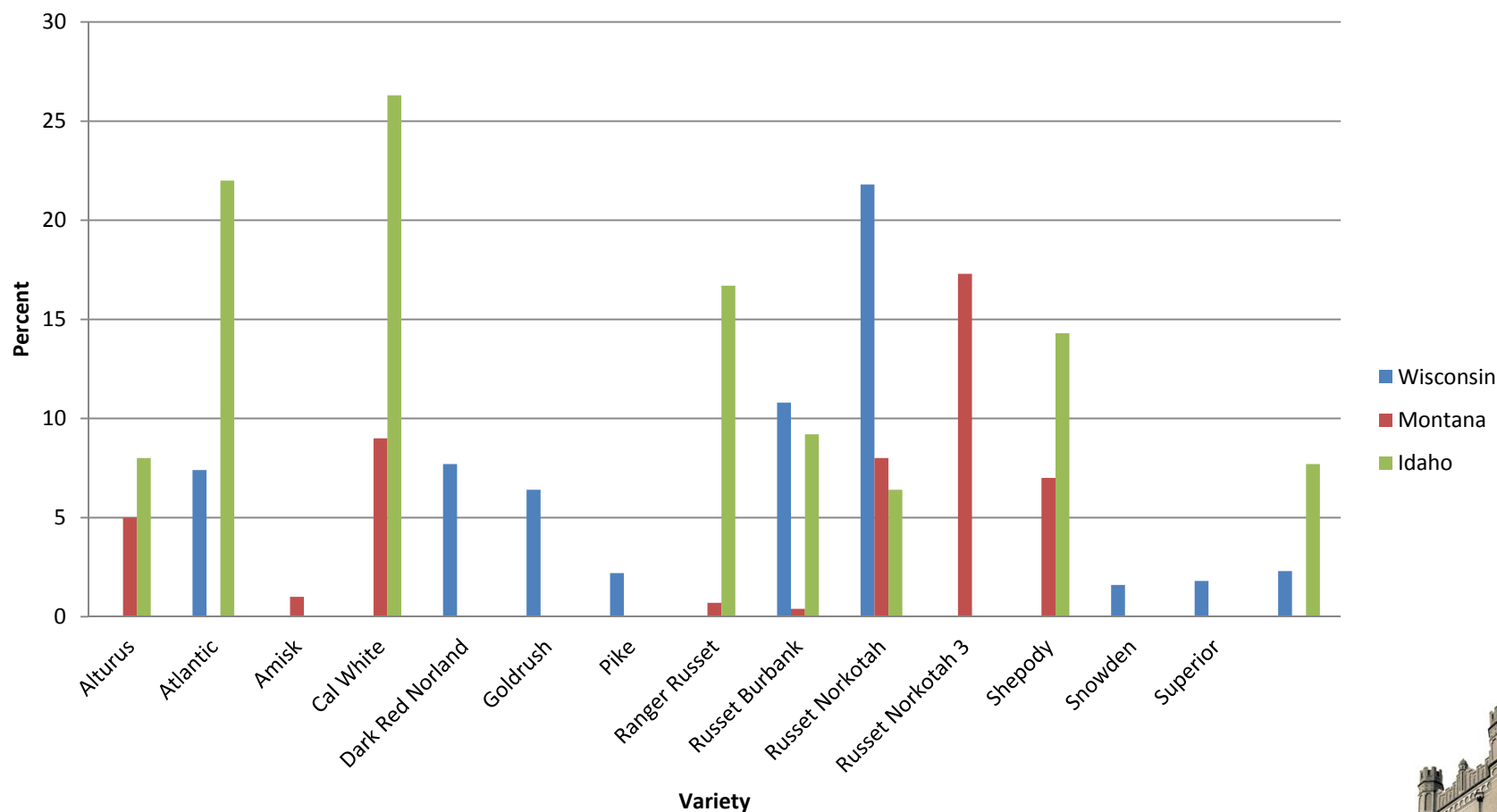


Percentage of Winter Tests with Greater than Two Percent PVY Corresponding to Summer Tests with less than Two Percent

Variety	Wisconsin	Montana	Idaho
Alturus		5.0	8.0
Atlantic	7.4		22.0
Cal White		9.0	26.3
DR Norland	7.7		
Goldrush	6.4		
Pike	2.2		
Ranger Russet		0.7	16.7
Russet Burbank	10.8	0.4	9.2
Russet Norkotah	21.8	8.0	6.4
Shepody		7.0	14.3
Yukon Gold	2.3		7.7



Percentage of Winter Tests with Greater than Two Percent PVY Corresponding to Summer Tests with less than Two Percent



Discussion

It is difficult to use summer test data to predict the amount of virus that would be found in the winter tests with any degree of confidence.

Varieties with high readings from more than one location:

Alturus

Atlantic

Dark Red Norland

Ranger Russet

Russet Burbank

Russet Norkotah

Shepody

Umatilla

Yukon Gold



Discussion

The results indicate:

- A need to check winter test results for seed that you plan to purchase
- A need to have all testing done with ELISA or other laboratory method
- Planting PVY-free seed is the best PVY management tool



PVY at Emergence vs. PVY at Harvest:

Results based on Experimental Data from Idaho

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Seed Borne PVY

Planting virus free seed remains the best option to minimize incidence of PVY.

The presence of several non-colonizing cereal aphids such as *R. maidis*, *R. padi*, and *S. graminum*, virtually insures the spread of PVY that is already present in a potato field.

Field experiments with two varieties Russet Burbank and Russet Norkotah.



Experimental Data

Data were generated in plots consisting of five treatments with four replications of each with the following target levels of PVY at emergence for years 2010 and 2011: treatment1 - 0%, treatment2 - 5%, treatment3 - 10%, treatment4 - 25%, and treatment5 - 50%.

For 2012 (RB Only): treatment1 - 0%, treatment2 - 5%, treatment3 - 10%, treatment4 - 30%,



Field Experiment

- Seed lots with PVY Identified
- Tubers ELISA tested for PVY + or –
- After ELISA, healthy & PVY + kept separate
- Same storage facility and methods to avoid physiological aging issues
- At planting + and - seed pieces cut
- PVY - and PVY + blended at desired ratios
- Planted in commercial potato field



Actual Levels at Emergence

Russet Burbank Emergence % PVY Measured by ELISA

Treatment	Target	2010	2011	2012
1	0	4.4	12.0	6.9
2	5	10.2	13.8	10.8
3	10 (15)	16.3	13.1	17.2
4	25 (30)	30.2	30.9	30.5
5	50	51.3	49.7	



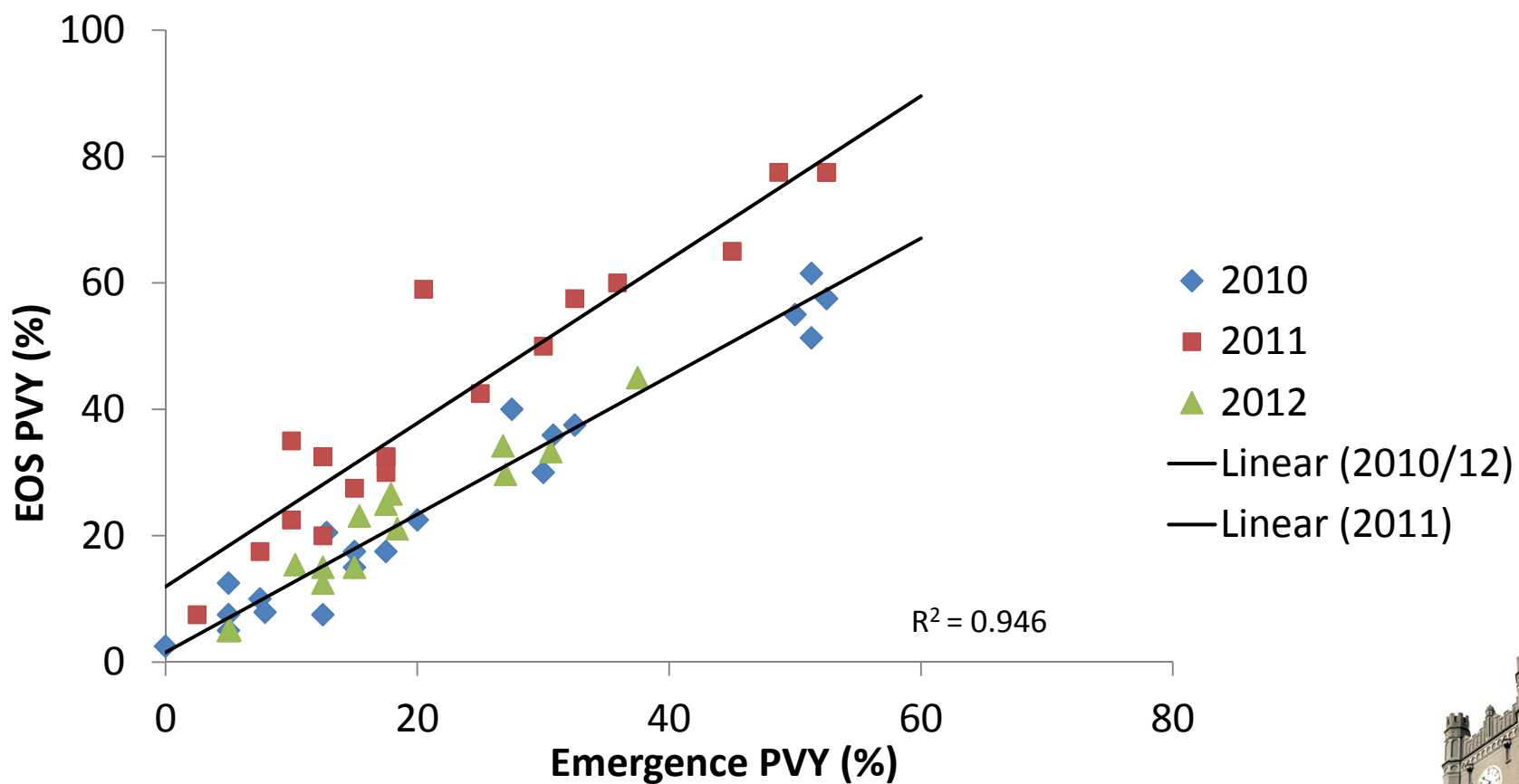
Actual Levels at Emergence

Russet Norkotah Emergence % PVY Measured by ELISA

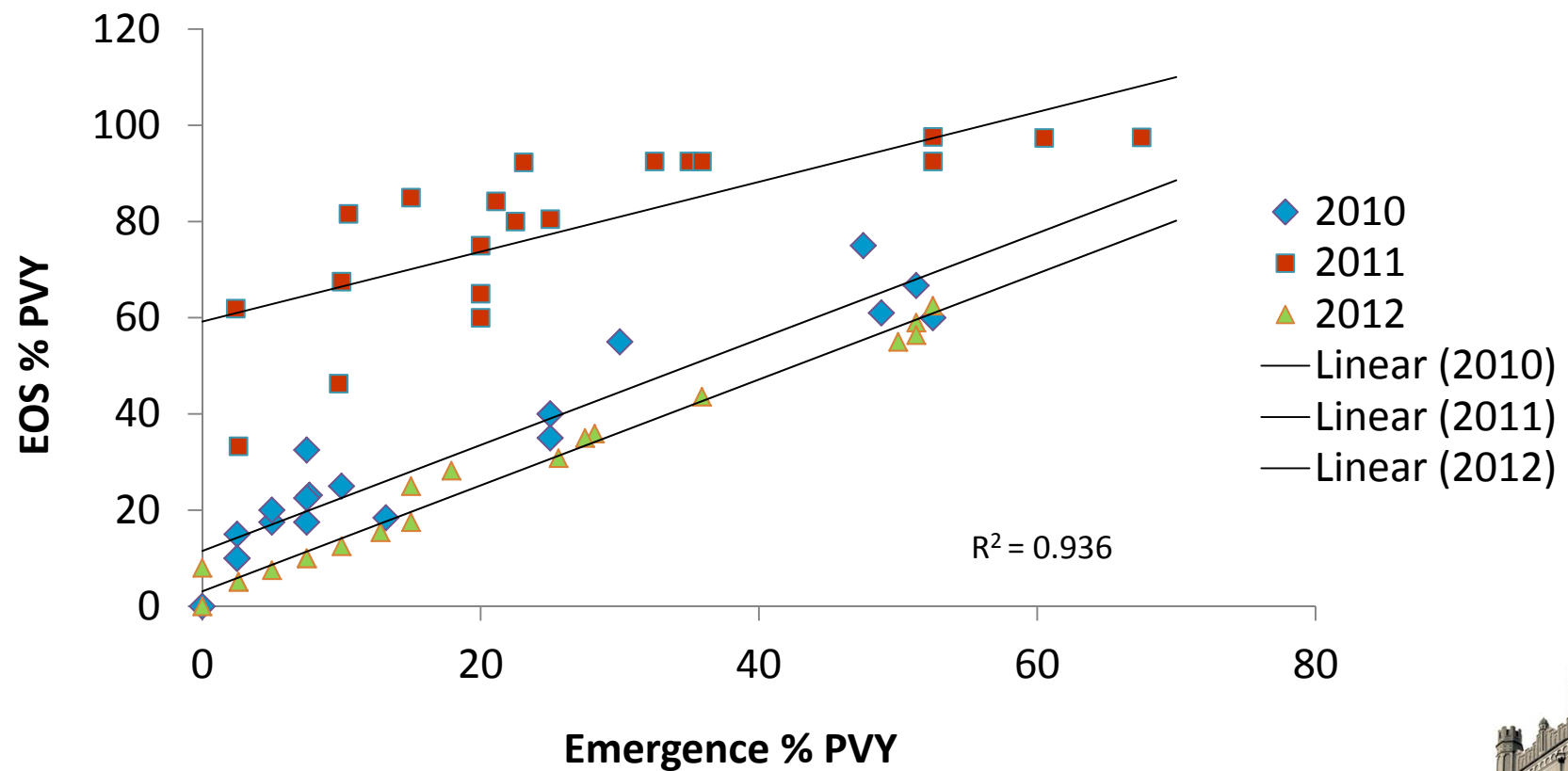
Treatment	Target	2010	2011	2012
1	0	1.9	8.2	1.3
2	5	7.7	14.7	8.2
3	10	8.1	22.0	14.5
4	25	26.3	31.5	29.3
5	50	50	58.3	51.3



Russet Burbank



Russet Norkotah



EOS PVY = f(Emergence PVY)

The relationship between end of season and emergence PVY is quite strong – even without data on aphid flights.

Russet Burbank:

2010 - 2012: $\text{EOS PVY} = 1.51 + 1.09 \times \text{BOS PVY}$

2011: $\text{EOS PVY} = 11.93 + 1.29 \times \text{BOS PVY}$

Russet Norkotah:

2010: $\text{EOS PVY} = 11.51 + 1.10 \times \text{BOS PVY}$

2011: $\text{EOS PVY} = 59.21 + 0.73 \times \text{BOS PVY}$

2012: $\text{EOS PVY} = 3.11 + 1.10 \times \text{BOS PVY}$



$$\text{EOS PVY} = f(\text{Emergence PVY})$$

Russet Burbank EOS PVY:

Emergence PVY	2010/2012	2011
1	2.60	13.22
2	3.69	14.51
10	12.41	24.83

Russet Norkotah EOS PVY:

Emergence PVY	2010	2011	2012
1	12.61	59.94	4.21
2	13.71	60.67	5.31
10	22.51	66.51	14.11



Yield Impacts

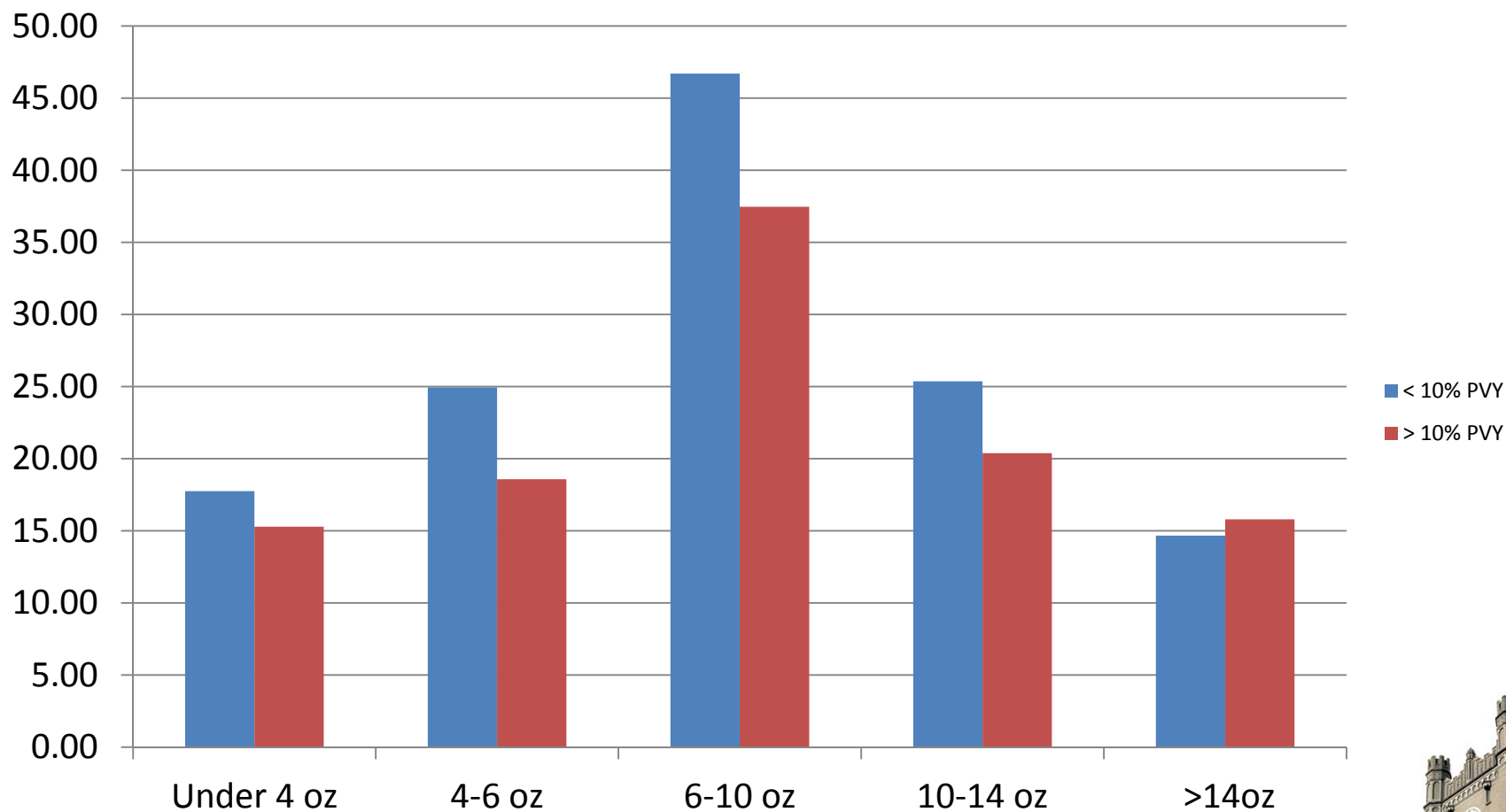
Totals for grade and size class were measured from harvested tubers

Further analysis on the harvested plots was conducted to determine the yield and income impacts of differing disease levels.

All U.S. No. 1 and U.S. No. 2 less than 4 ounces were classified as washed process grade and valued at WPG prices. All others were sized and valued at both fresh and process market prices.



Russet Norkotah

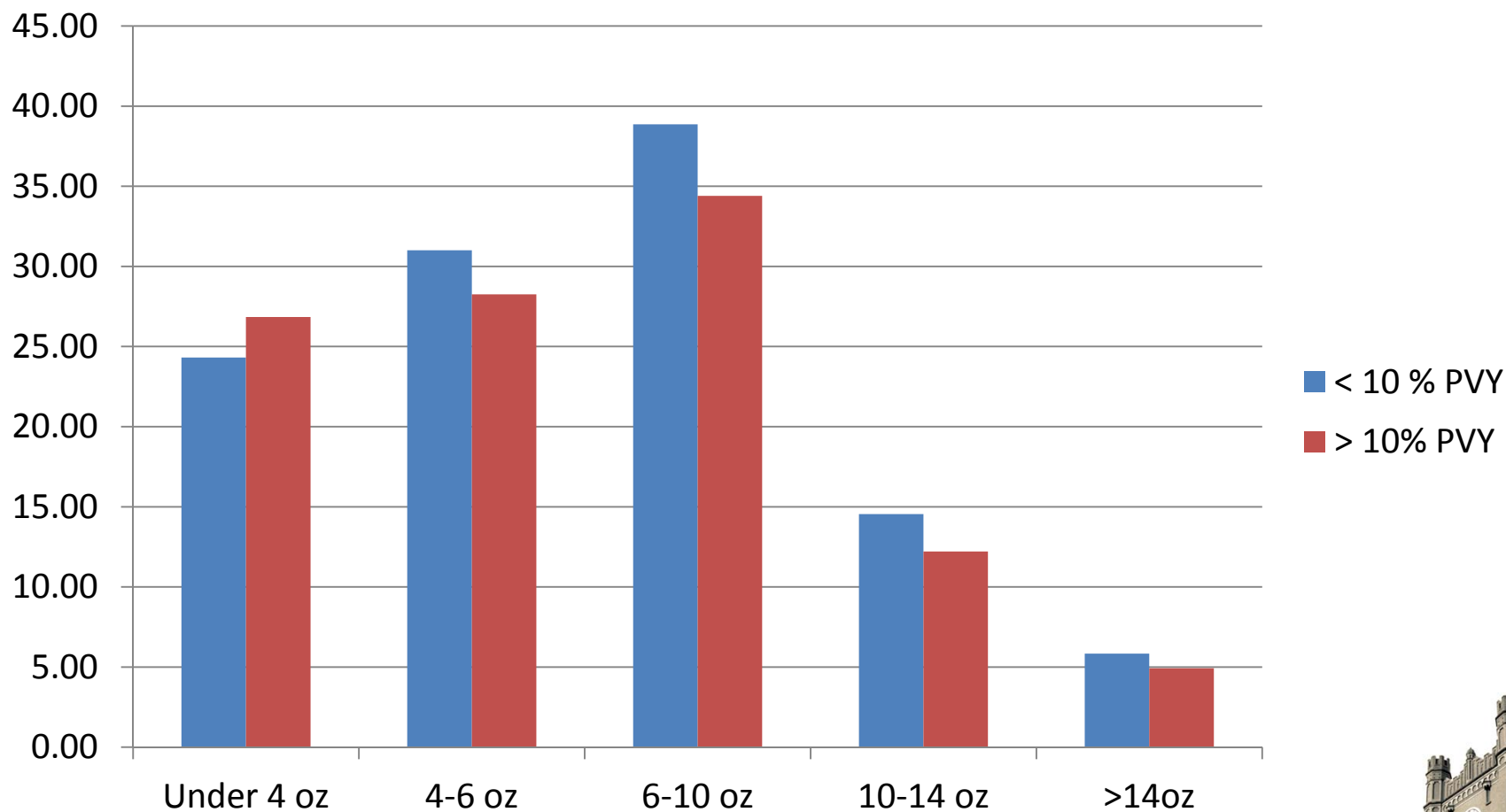


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Russet Burbank



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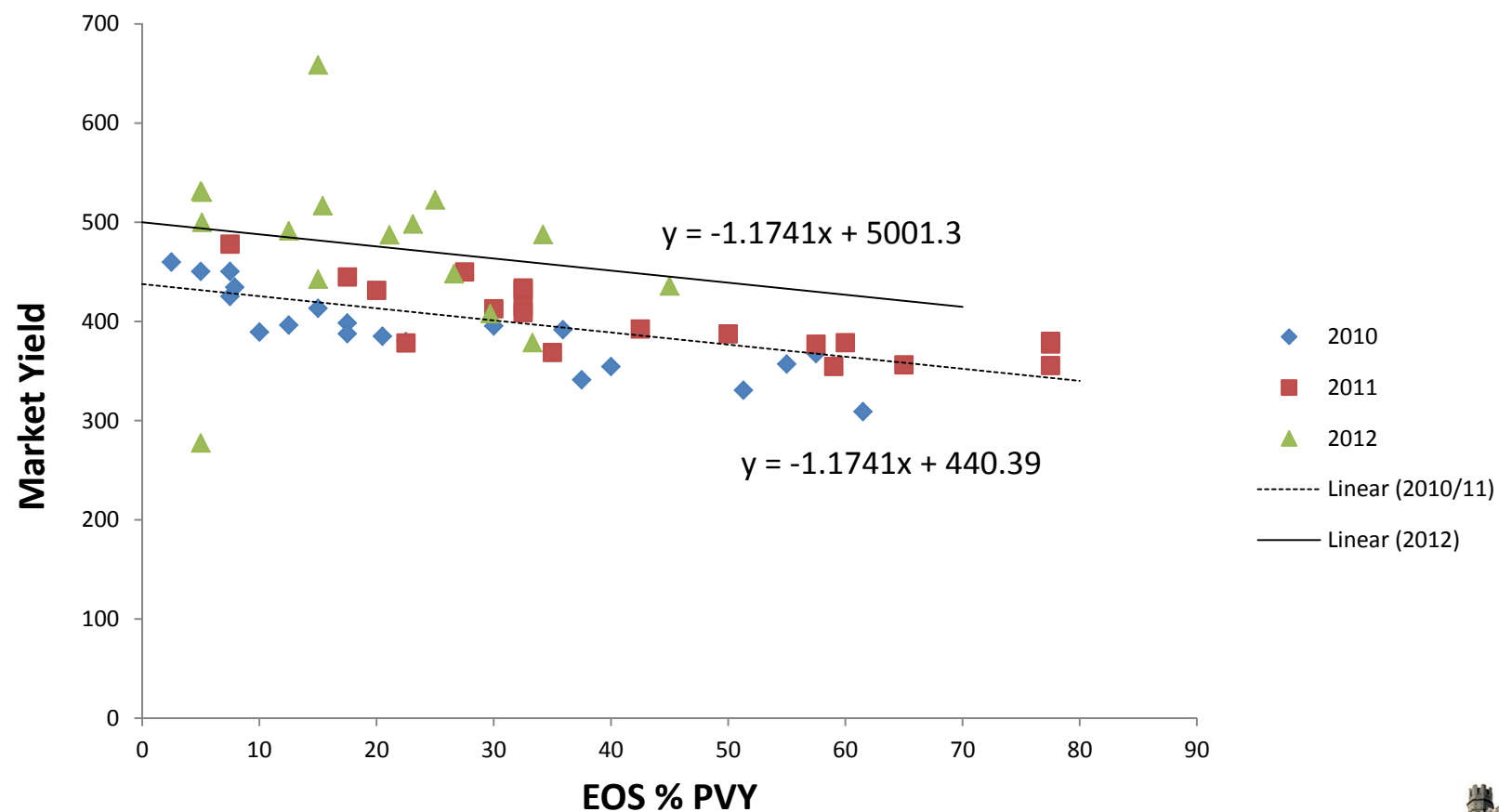
Yield Impacts

Ordinary Least Squares (OLS) regression techniques were used to estimate *Marketable Yield* (total yield minus culls) as a function of *Percent PVY (End of Season)* and *Year*.

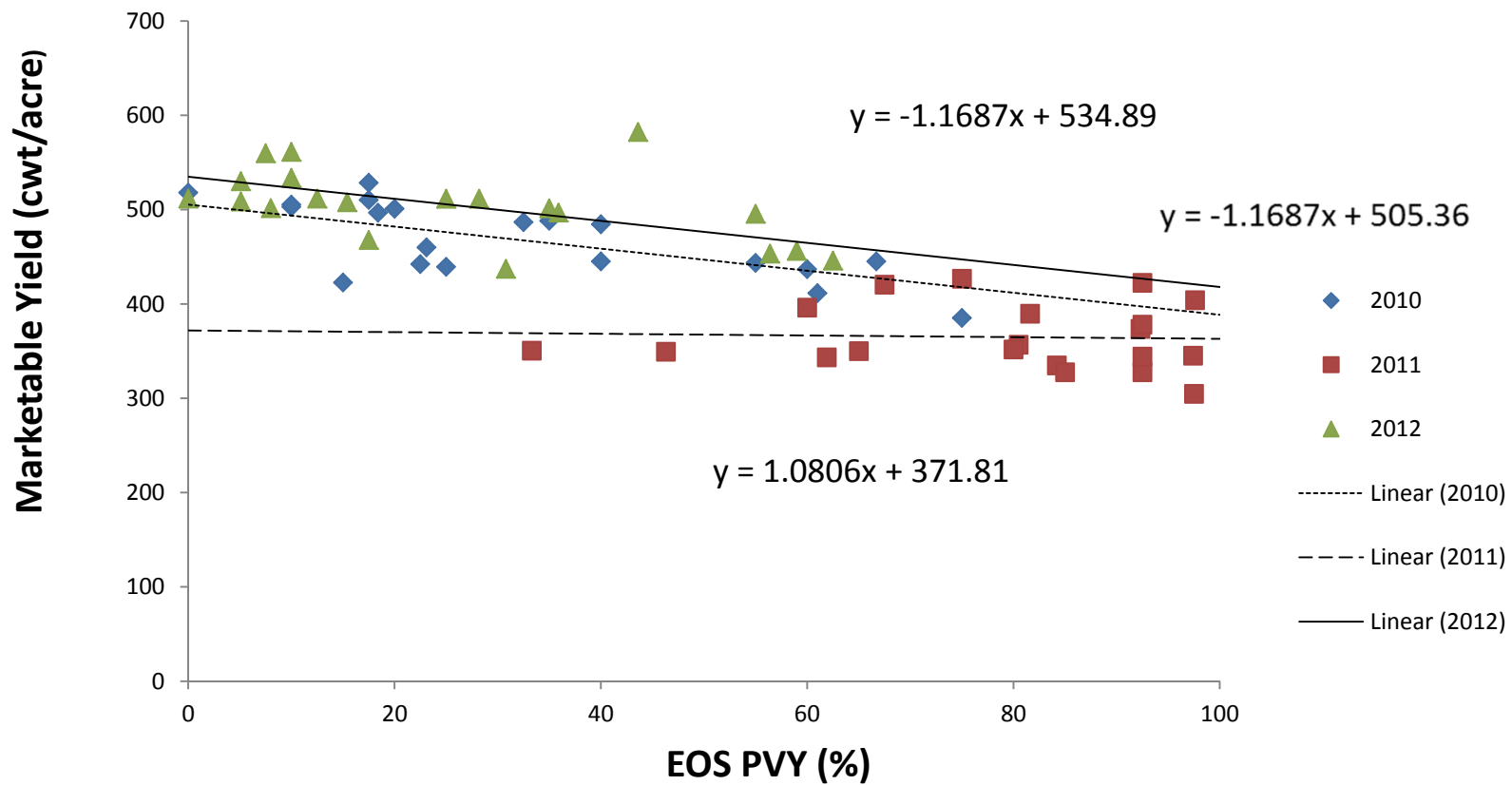
This is the approach used by Nolte, et al. (2004).



Russet Burbank



Russet Norkotah



Grower Returns by Size/Grade (\$/cwt)

Prices based on 5 year averages

Mesh 5-lb	\$6.32
Mesh 10-lb	\$6.14
Film 5-lb	\$6.79
Film 10-lb	\$6.02
40-count	\$20.41
50-count	\$20.34
60-count	\$20.31
70-count	\$19.81
80-count	\$16.89
90-count	\$13.88
100-count	\$12.55
U.S. No. 2 (6 oz min.)	\$8.33
U.S. No. 2 (10 oz min.)	\$12.69



Impacts on Marketable Yield

The marginal impact of a 1 percent level of PVY infection:

- Russet Norkotah
- 1.169 cwt/acre (based on 2010 and 2012)
- Russet Burbank
- 1.174 cwt/acre

Note that in both cases these results are statistically significant.



Dollar Impacts of PVY

The potatoes from the field experiments were evaluated using both a fresh-market and process-market in a way that accounts for the specific pack-out characteristics and changes caused by increasing levels of PVY

Fresh-Market

A net-to-grower price was calculated using a five-year average of shipping point prices for the various sizes and grades of potatoes less estimated packing costs.



Dollar Impacts of PVY

Process-Market

The gross returns for processing potatoes were obtained by multiplying the total yield by the processing price computed using potato grade and quality incentives. In calculating the incentive-adjusted processing price, the quality incentives (penalties) are added (subtracted) to (from) the base price as determined at the time of contract between the growers and processors.



Dollar Impacts of PVY

Russet Burbank – Fresh Market

Each percent PVY infection = \$**5.13** to \$**18.06** per acre loss.

With a 10% level of infection you could expect to lose \$**115.93** per acre

Russet Burbank – Processing Market

Each percent PVY infection = \$**4.26** to \$**14.08** per acre loss.

With a 10% level of infection you could expect to lose \$**91.69** per acre



Dollar Impacts of PVY

Russet Norkotah – Fresh Market

Each percent PVY infection = \$**7.24** to \$**17.30** per acre loss.

With a 10% level of infection you could expect to lose \$**122.74** per acre

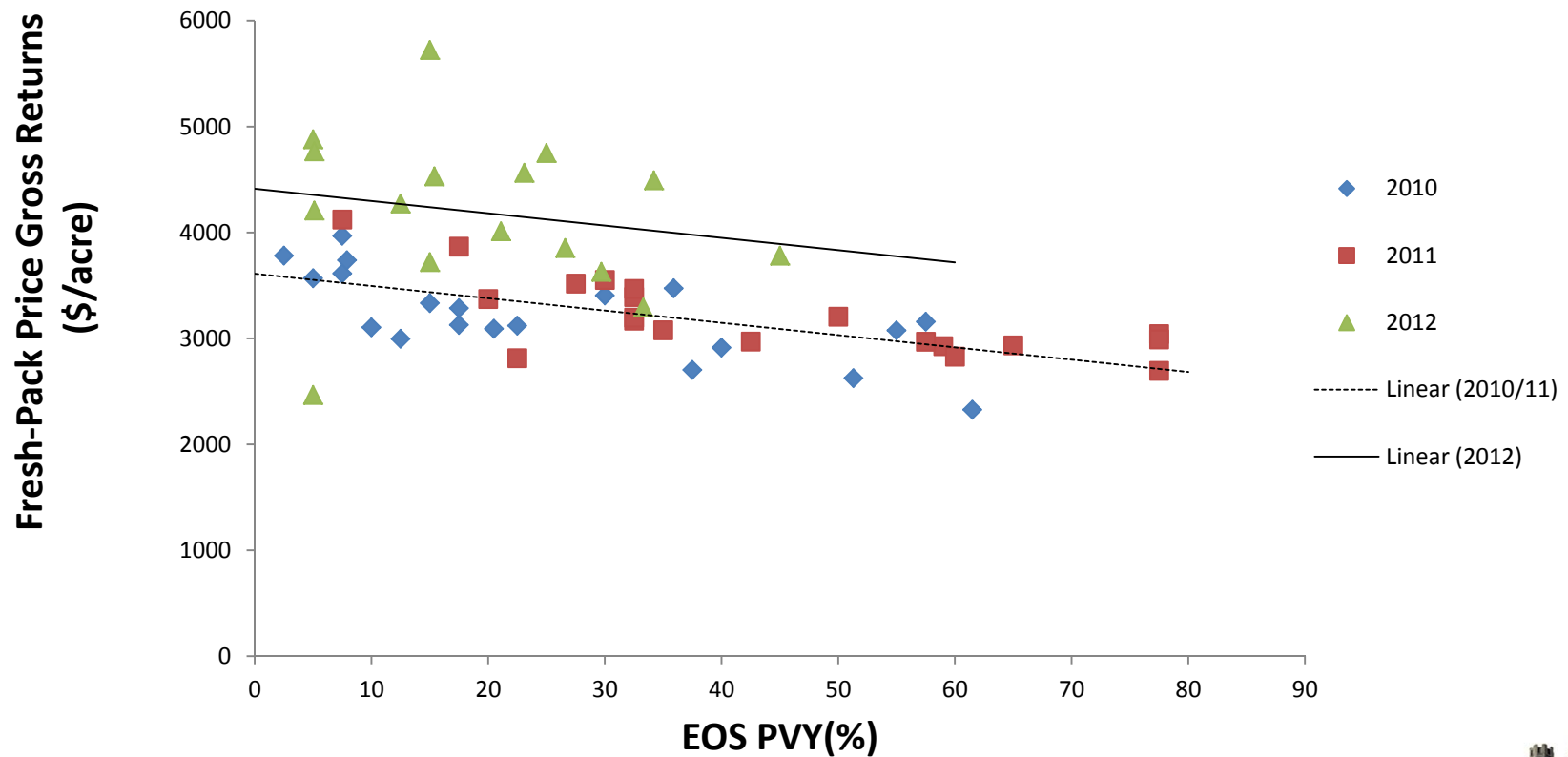
Russet Norkotah – Processing Market

Each percent PVY infection = \$**5.22** to \$**13.08** per acre loss.

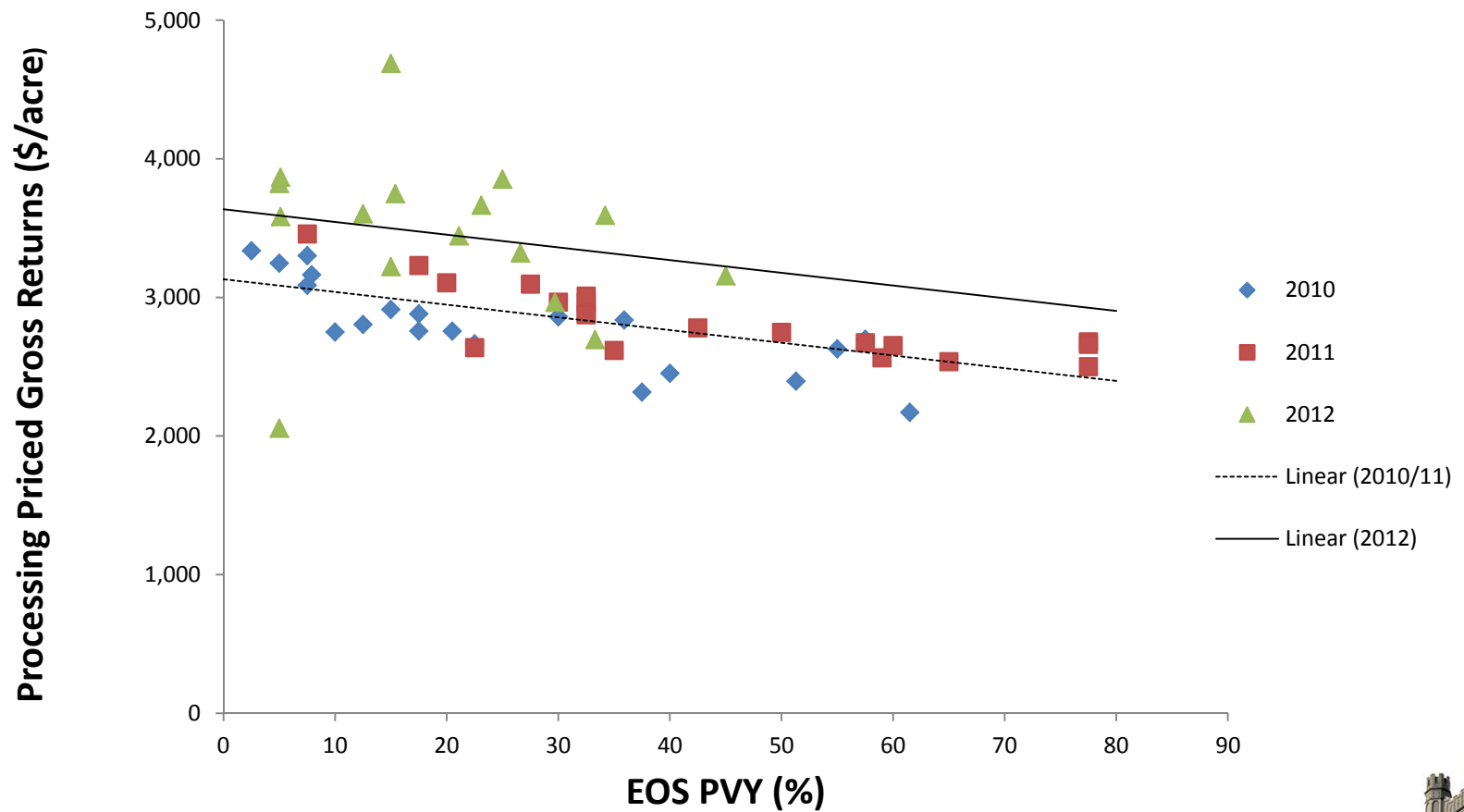
With a 10% level of infection you could expect to lose \$**91.47** per acre



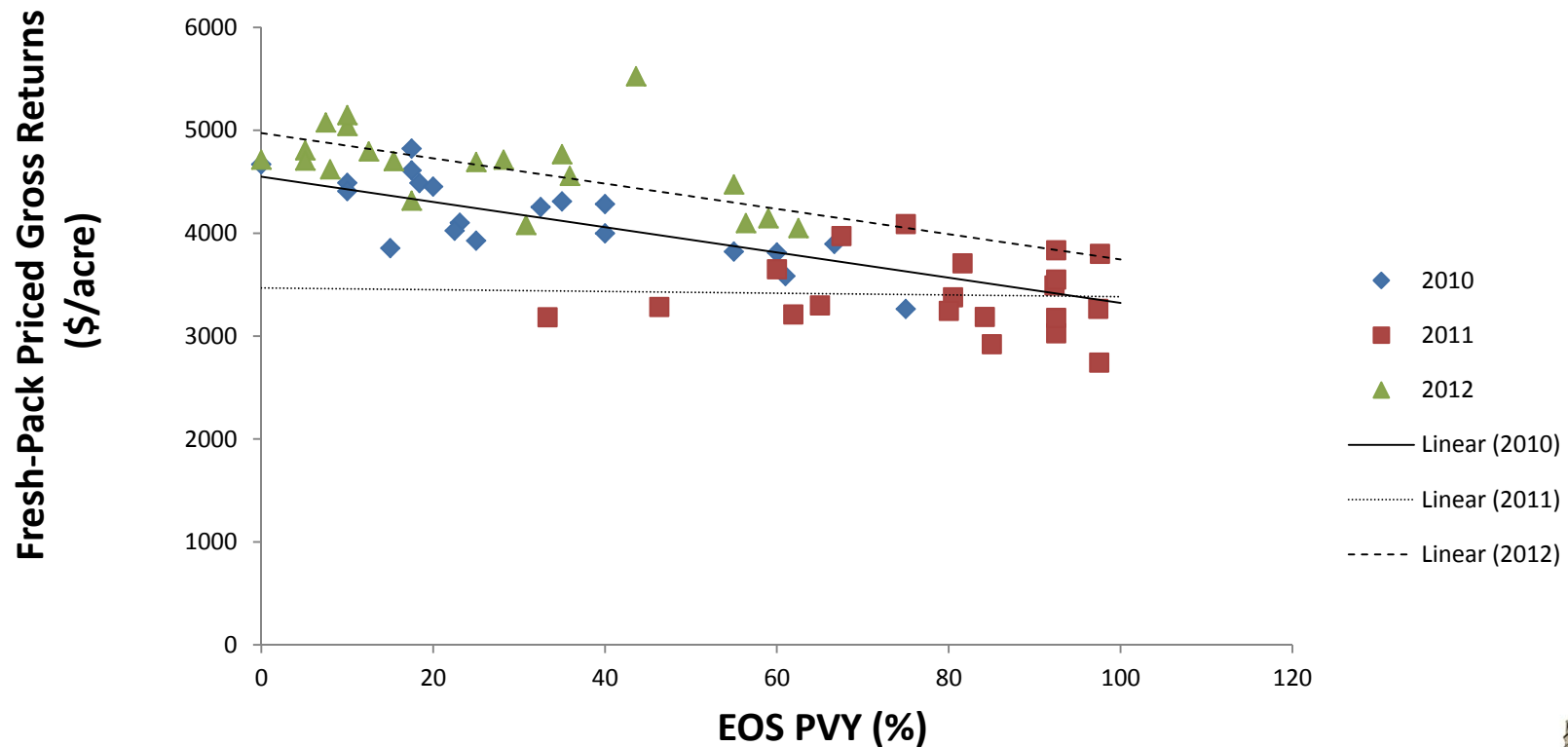
Dollar Impacts of PVY - RB



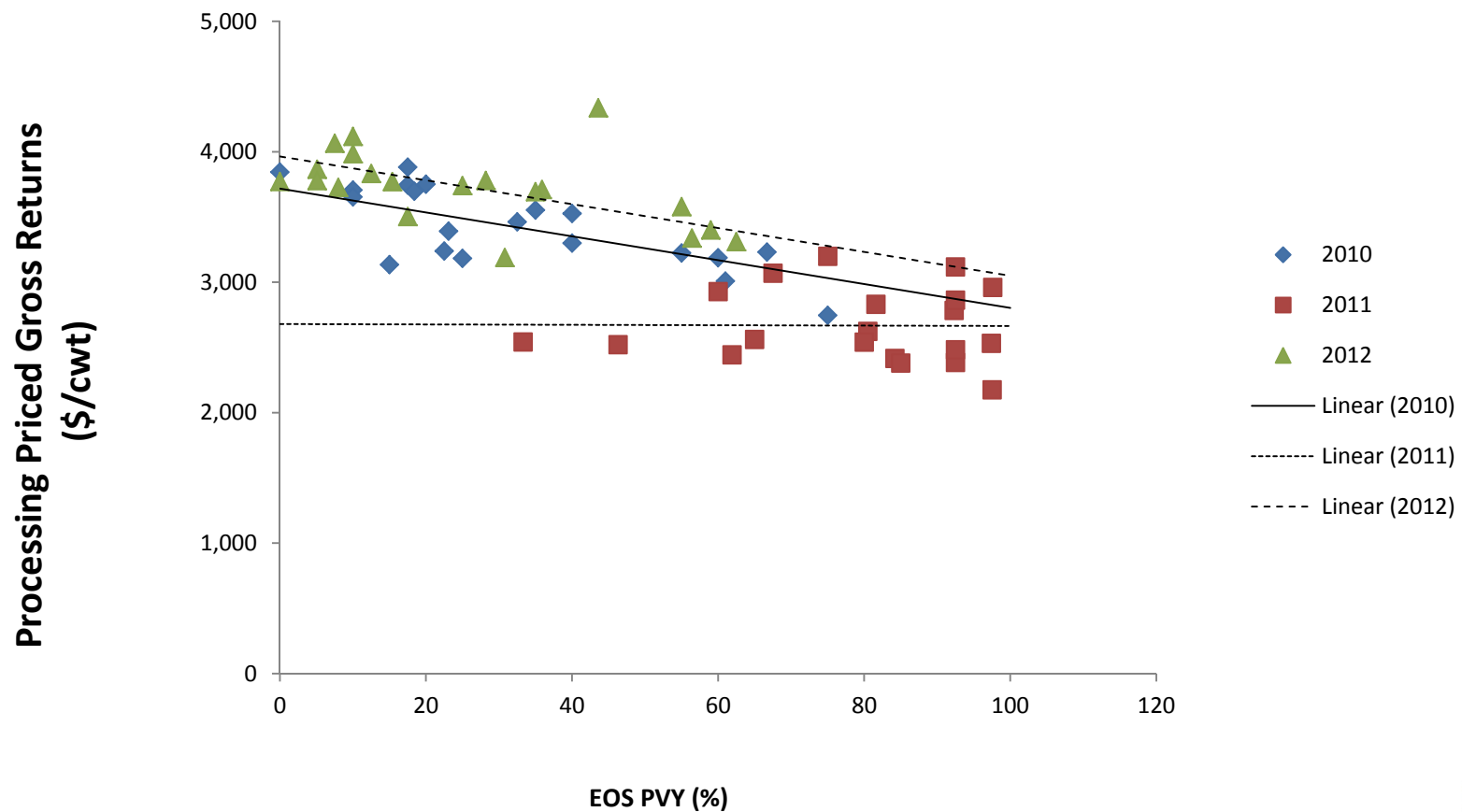
Dollar Impacts of PVY - RB



Dollar Impacts of PVY - RN



Dollar Impacts of PVY - RN



Conclusions

- Seed that is positive for PVY has a statistically significant impact on total yield and the size distributions of harvested tubers.
- With a 10% level of infection in your seed, you could see income reductions of approximately \$90 to \$120 per acre depending on the variety and market channel.



State-Wide Impacts of PVY - Idaho

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The Idaho Potato Industry

The Idaho potato industry is the largest producer of potatoes in the United States and provides an important contribution to the state economy.

- Over 340,000 acres
- Over 141,000,000 cwt produced
- Value of production over \$1 Billion

(USDA NASS, Potatoes Annual Summary, 9/19/2013)



Statewide Impacts of PVY - Idaho

As with most states, the Idaho economy is comprised of a large number of sectors. A shock in economic activity to one sector not only affects the directly impacted sector but also creates a wave of effects extending to all related sectors.

A reduction in output caused by PVY (or any other factor) is felt not only by producers, but also those businesses supplying transportation, utilities, insurance, business services and so on.



Statewide Impacts

Based on the average amount of PVY found by the Idaho Crop Improvement Association, and using the estimates of PVY spread and yield impacts discussed previously, we estimated that the shrinkage-adjusted total impact of PVY in a reduction in output of 2.32 Million cwt.

This reduction resulted in an estimated reduction in sales to the fresh-pack, frozen, and dehydrated processing sectors were reduced by \$5 million, \$6.7 million and \$2.7 million



An Important Assumption

The economic impact calculations that follow are based on the estimated reduction in output that could be attributable to PVY.

No price impacts are included

That is – the reduction in output is not reflected by price changes for these calculations.



Economic Impact of PVY

The impact that PVY has on the overall economy was estimated using a model based on the 2011 IMPLAN software.

We measure the impact of reduced potato yields using a Leontief Input-Output model.



Output Impacts

The *direct* output impact of a sector of potato industry to the economy is the reduction in the sector's own output due to PVY.

The *indirect* output impact to the economy due to reduction in output of the directly impacted sector is the sum of the reductions in outputs of all other remaining endogenous sectors which are linked with the potato production sector.



Output Impacts

	Total Impact	Direct Impact	Indirect Impact
Potato Production	\$16,149,795	\$ 8,707,468	\$7,442,327
Frozen Processing	\$10,050,032	\$5,629,073	\$4,420,959
Dehydrated Processing	\$3,934,293	\$2,364,561	\$1,569,732
Fresh-Packing	\$3,798,763	\$2,862,135	\$936,628
Industry Output Impact	\$33,932,883	\$19,563,237	\$14,369,646



Employment Impacts

Based on the output impacts we estimate the number of jobs lost due to reductions from PVY.

	Total Impact	Direct Impact	Indirect Impact
Potato production	91	19	72
Frozen potato processing	50	17	33
Dehydrated potato processing	16	5	11
Fresh-packing	27	19	8
Industry Employment Impact	184	60	124



Employment Impacts

Wages are also impacted by reduced outputs.

	Total Impact	Direct Impact	Indirect Impact
Potato Production	\$3,268,800	\$1,170,192	\$2,098,608
Frozen Potato Processing	\$1,963,692	\$846,489	\$1,117,203
Dehydrated Potato Processing	\$612,705	\$221,449	\$391,254
Fresh-Packing	\$633,457	\$372,251	\$261,206
Industry Wages Impact	\$6,478,654	\$2,610,382	\$3,868,272



Value-Added Impacts

Value-added impacts are the sum of employee compensation, proprietor income, other property-type income, and indirect business taxes (includes wages) .

	Total Impact	Direct Impact	Indirect Impact
Potato production	\$8,942,391	\$4,625,256	\$4,317,135
Frozen potato processing	\$3,405,169	\$1,181,300	\$2,223,868
Dehydrated potato processing	\$1,181,841	\$407,814	\$774,027
Fresh-packing	\$1,073,177	\$559,965	\$513,211
Industry Value-Added Impact	\$14,602,578	\$6,774,336	\$7,828,242



Conclusions

- PVY reduces marketable yields and changes the composition of the crop produced
- Grower returns are significantly reduced by PVY
- PVY is estimated to have impacts of:
 - **\$33.93** million on the Idaho economy (output impact)
 - **186** fewer jobs and **\$6.5** million in wages
 - **\$14.6** million in lost value-added (includes \$6.5 million wage impact)



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