The Benefits and Costs of Alternative Policies for the Management of Pierce's Disease:
A Case Study of the Blue-Green Sharpshooter in the Napa Valley

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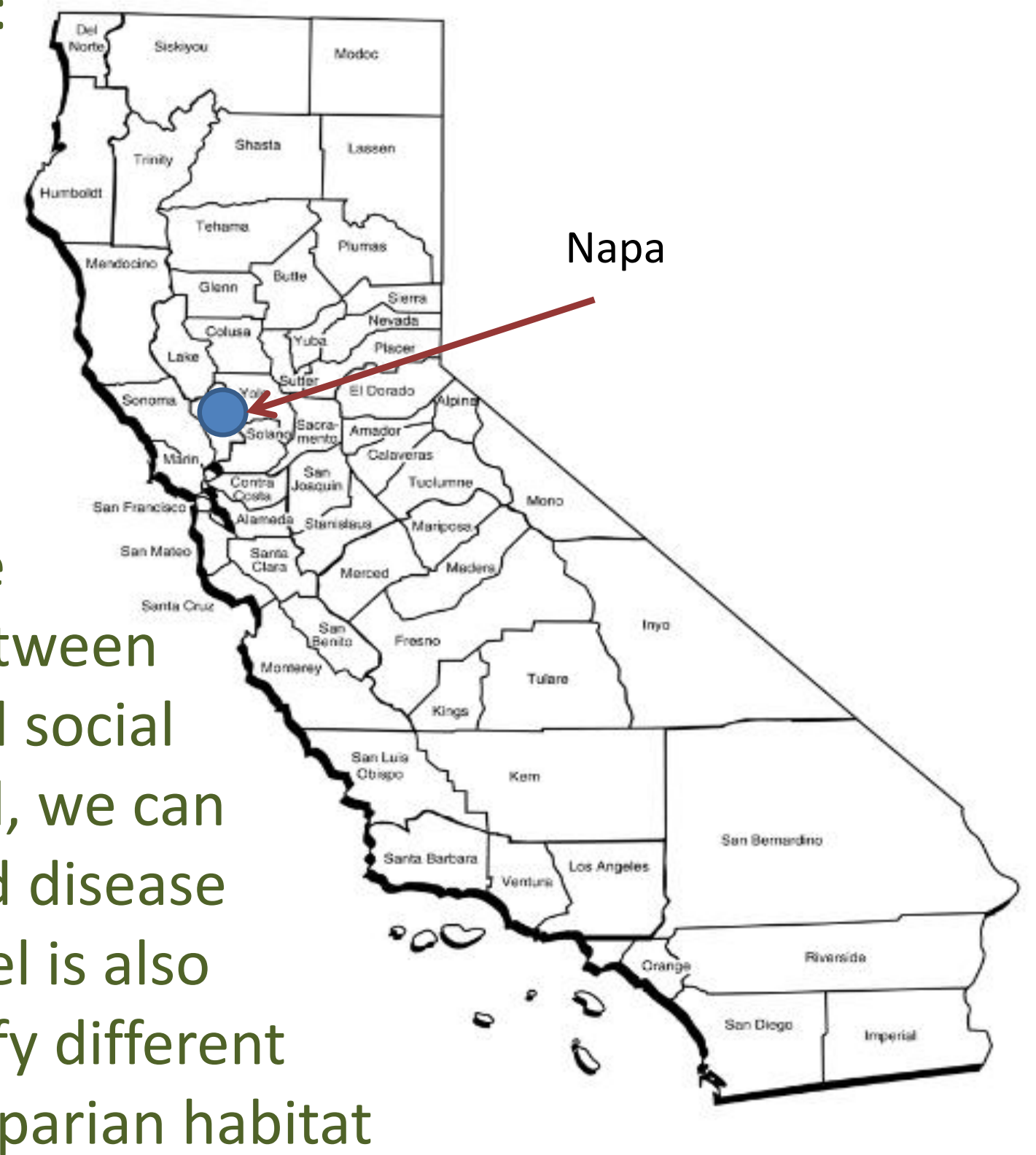
Kate Fuller **Julian Alston** **Jim Sanchirico**

Abstract: Pierce's Disease poses a deadly threat to California wine grapes. It is spread by xylem-feeding insects called sharpshooters. In addition to direct interest in the specific case, we aim to gain more general insight into the economics of Pierces Disease in California as a whole by studying PD as vectored by the Blue-Green Sharpshooter (BGSS, *Graphocephala atropunctata*) in the Napa Valley, where it has been endemic for many years.

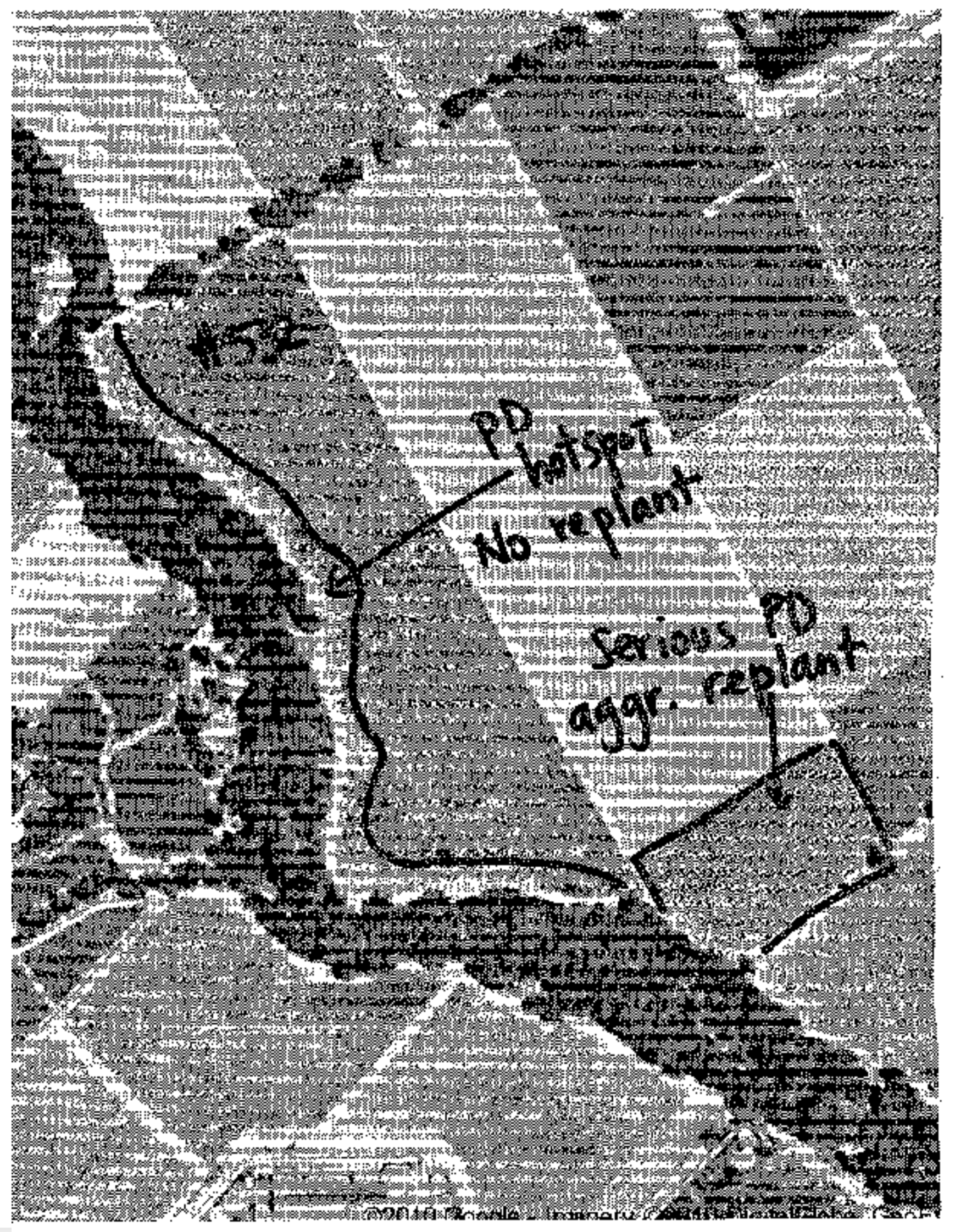
In the Napa Valley, methods of control include riparian revegetation, green fencing, and pesticide application. Some studies suggest that benefits from both revegetation and green fencing exceed the costs. However not all vineyards opt to use these controls, suggesting that previous studies may have failed to capture some aspects of the problem, including:

- Differences between properties
- Interaction between neighbors
- Large up-front costs
- Perennial crop, revegetation and green fence plants



We have developed a model of pest and disease management to study the role of interaction between neighboring growers as it affects the private and social optimal management strategy. Using the model, we can simulate grower responses to prices of pest and disease control, vine replacement, and crush. The model is also developed in such a way such that we can specify different types of controls: (1) change in the amount of riparian habitat BGSS can occupy (the carrying capacity for the insects) due to riparian re-vegetation or (2) a pesticide application that kills the insects directly.

We calibrate the model using information from interviews with vineyard managers. Seven vineyard managers were interviewed using a process called "participatory mapping" to gain insight into how they make decisions regarding management of PD in different areas of their vineyard.



Focusing on two vineyard blocks, one with high PD incidence and one with relatively little, respondents were asked to sketch onto aerial images of those blocks where and how they manage PD and the associated costs over the space of the block. These interviews have allowed us to parameterize, test, and extend the bio-economic model, which will be used to understand and predict grower behavior under different scenarios, such as the introduction of a better-performing control technique, a dramatic increase in PD, or PD spread by other vectors with different characteristics.


Image: Anthony Gould

Model: We examine how neighboring vineyard owners affect each other through their control choices. Each vineyard owner seeks to maximize profit, subject to PD damage that depends on given control choices of nearby vineyards. Each grower faces the following maximization problem, where p represents the price of grapes, A^B is bearing vines, Y is yield per vine, *w(s)* is the cost function for PD control, *w(I)* is the cost function for vine replacement, and ρ is the discount rate.

$$\max_{I_i, S_i, N_i} \int_0^\infty \left[pA^B Y - w(S) - w(I) \right] e^{-\rho t} dt$$

This maximization is subject to the following state equations for nonbearing and bearing vine stocks, respectively. A^{NB} is the number of nonbearing vines, μ is the percentage of vines that move from nonbearing to bearing each year, *N* measures the BGSS stock, and $d_{i\,j}$ the damage those insects inflict on nonbearing and bearing stocks, respectively. η is the death rate for vines that die of old age.

$$\dot{A}^{NB} = I - \mu A^{NB} - d_1 N$$

$$\dot{A}^{B} = \mu A^{NB} - d_1 N - \eta A^{B}$$

Total land is fixed, which constrains the total number of vines a grower has. In the following equation, *a* converts vine count to acreage.

$$\bar{A} = a(A_{NB} + A_B)$$

Additionally, the following equation of motion describes the insect population. Control (S) changes the population carrying capacity:

$$\dot{N} = \alpha N - \frac{\varepsilon}{2} N^2$$

$$\varepsilon = 0.01 + \beta S; \; 0 \leq \beta \leq 1$$


Image: Allen Lew

Results: We utilize quadratic cost functions for vine replacement and revegetation. Parameters were derived from the field interviews. We solve for steady-state optimal control, insect population, and vine replacement in cooperative and non-cooperative scenarios. Note that these two growers receive different prices for their grapes; Grower 2's are higher-valued than Grower 1's.

Parameter	Explanation	Given value
w^S	Unit cost of control ($/vine)	6
w^I	Unit cost of investment ($/vine)	11
p_1	Crush price of grapes for Grower 1 ($/ton)	4000
p_2	Crush price of grapes for Grower 2 ($/ton)	8000
d^{NB}	Damage per insect for non-bearing vines (transmission rate)	0.05
d^B	Damage per insect for bearing vines (transmission rate)	0.05
α	Number of live offspring produced in one year by an adult female sharpshooter	25
β	Measure of control effectiveness	0.03
Y	Yield/vine (tons)	0.00382
a	Acres/vine (acres)	1/1555
$\bar{A}$	Scale unit at which the problem is solved (acres)	15
ρ	Discount rate	0.04
μ	Annual rate of vine maturity from non-bearing to bearing	0.2
η	Annual non-PD death rate	0.02

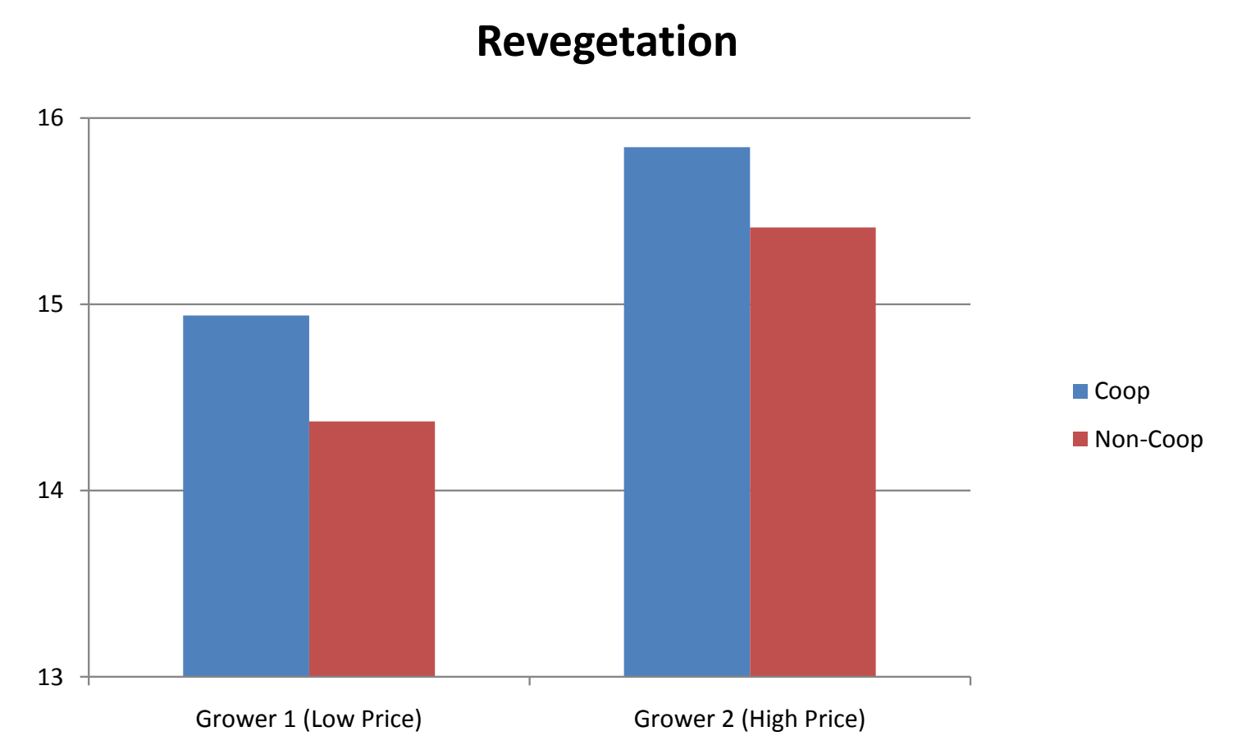
Under these assumptions, we find that:

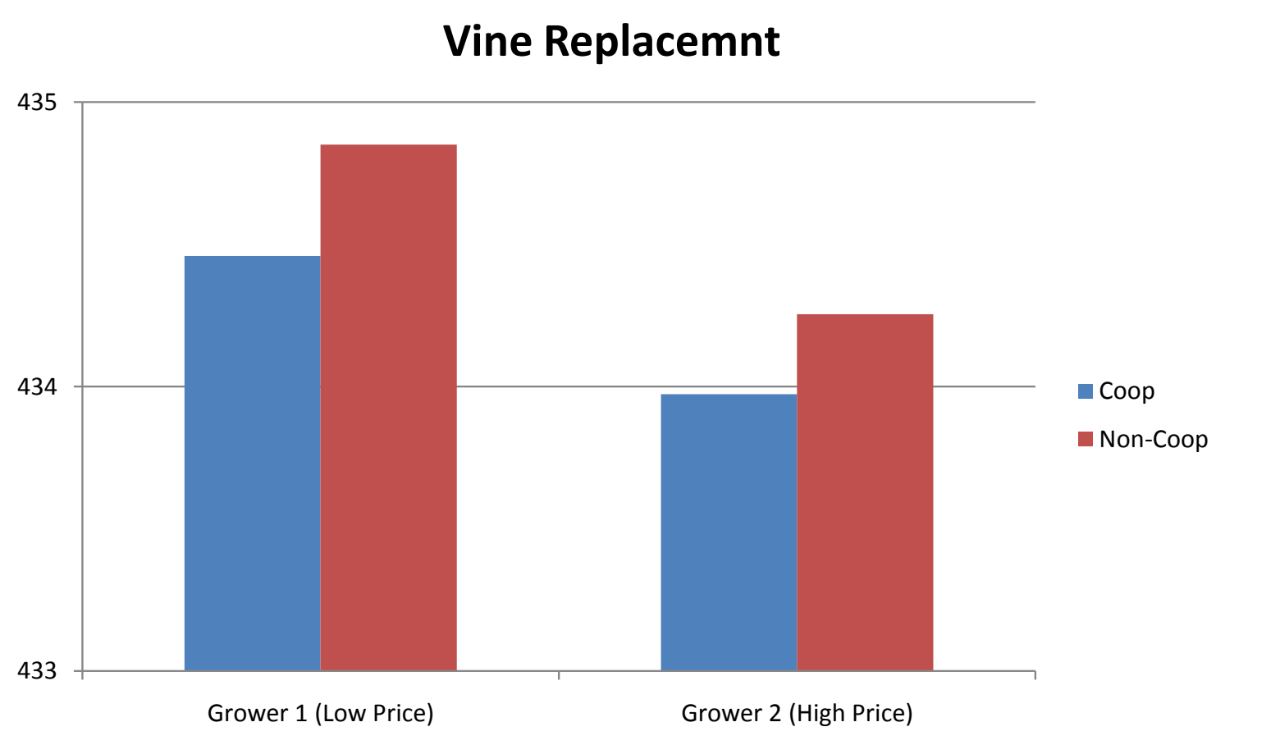
- Revegetation will be used to a greater extent under the cooperative regime than a non-cooperative one. Growers 1 and 2 will revegetate four and three percent more than they would in the non-cooperative case, respectively.

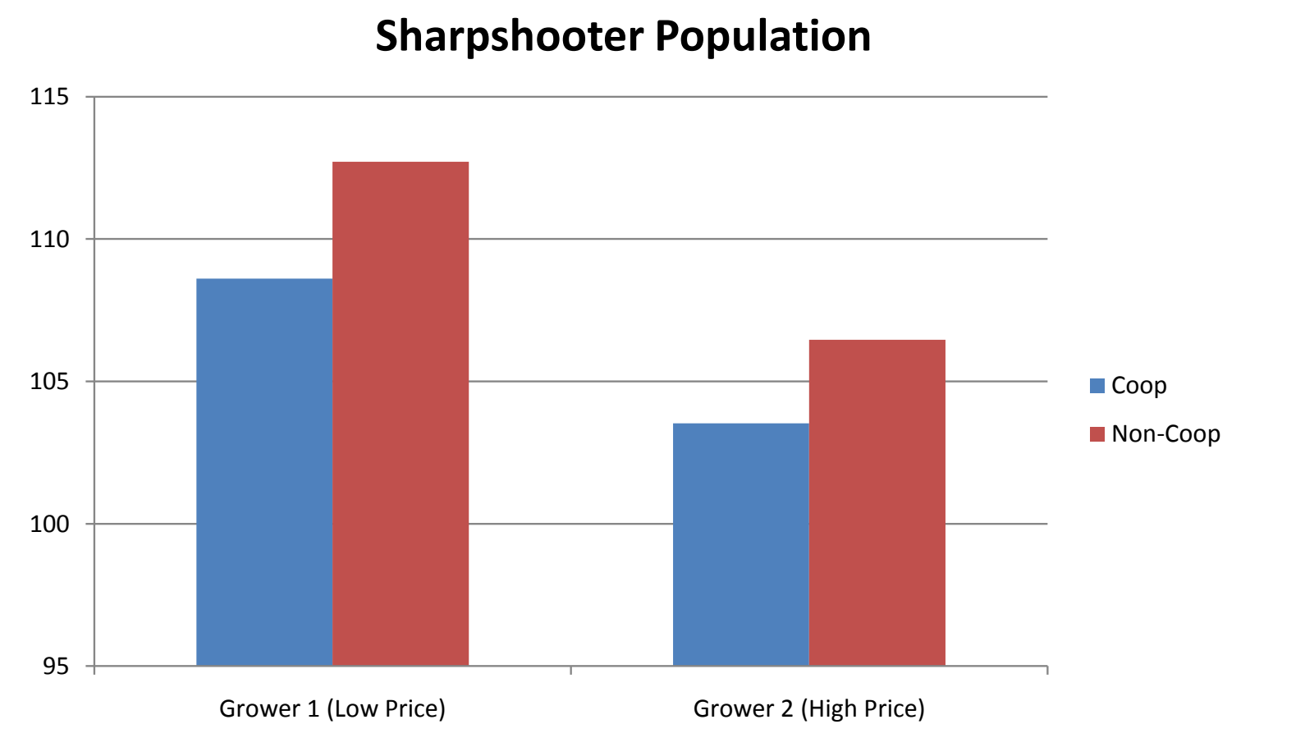
- Sharpshooter counts will be lower in the cooperative regime than in the non-cooperative one. Growers 1 and 2 will have four and three percent fewer sharpshooter than they would in the non-cooperative case, respectively.

- Replacement due to vine death will be less under the cooperative regime than this non-cooperative one. This effect is relatively small; Growers 1 and 2 will replace fewer than one percent less vines than they would in the non-cooperative case.

We have graphed the difference in cooperative versus noncooperative outcomes for two growers, one who receives a relatively high crush price, and one who receives a relatively low crush price.







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