Economically Optimal Management of *Huanglongbing* in Florida Citrus

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HLB Background

- Bacterial disease that affects all varieties of citrus.
- First discovered in Florida in 2005 and now found in all counties where commercial citrus is produced.
- Spread by a small leaf-feeding insect, the Asian citrus psyllid (ACP).
- Florida has lost 6,600 jobs, direct revenue of $1.3 billion and indirect revenue of $3.6 billion due to HLB (Hodges and Spreen, 2012).
- There are three distinct strategies being employed to deal with greening.

1. Strategy 1, referred to as "do nothing", allows the disease to spread and takes no measures to slow its spread or mitigate its impact. This strategy represents a baseline from which to estimate the net benefits of Strategies 2 and 3
2. Under Strategy 2, an aggressive inspection program is initiated to identify and eradicate symptomatic trees (Brlansky et al. 2008). By eradicating symptomatic trees, the level of inoculum in a particular citrus grove gradually will be reduced.
3. Strategy 3 proposes to treat the symptoms of HLB through foliar application of micro and macro nutrients (Spann et al. 2010).

- The question to be addressed in this study is: what are the economic consequences of the three strategies?
- Currently, the long term net present value of the control strategies is unknown because of uncertainty in the efficacy of the strategies.

Objectives

1. Identify control efficacies for Strategies 2 and 3 at which citrus groves remain economically viable in the long run.
2. Determine efficacy thresholds at which a given control method is economically preferred over other available methods for a planting of a given age and rate of infection.

Materials and Methods

- A citrus grove is an asset. We estimate the economic impact of HLB through its effect on the value of a particular citrus grove, using the income method.

- Given data on estimated boxes of fruit per tree by age group for both Valencia and non-valencia oranges from the Florida agricultural statistics service (Florida citrus statistics 2008-2009), the logistic curves are interacted with the investment or NPV model as specified above to estimate HLB impact on grower earnings based on tree age.

Biological Model:

$$\frac{\partial Y}{\partial t} = \dot{Y} = \beta Y(1 - Y)$$

$$\dot{Y} = y_t^G - y_{t-1}^G, \qquad Y = y_t^G$$

$$Y_t^G = e^{In(y0)e^{\beta t}}$$

$$Y_t = Y_{t-1} + \hat{\beta} Y_{t-1}(1 - Y_{t-1})$$

Yield Impact Model:

$$r_t^1 = R_t(e^{-bX_t})$$

$$X_t = \sum_{i=1}^{t} (\hat{y}_i^L - \hat{y}_{i-1}^L) x_{t-i},$$

$$i = 1,2,\ldots t, \qquad \hat{y}_t = \frac{s_t}{Q}$$

$$x = 1 \Big/ (1 + (1/x_0) - 1)e^{(-\theta t)}$$

$$r_t^3 = \alpha r_t^1 + (1 - \alpha), \alpha = 0.1, 0.2, ..$$

Bioeconomic Model:

$$NPV = \sum_{t=1}^{T} \frac{(P_t r_t^1 Q_t - C_t(r_t^1 Q_t))}{(1+i)^{t-1}}$$

- where Y is the proportion of diseased trees at time t, $\dot{Y}$ is the change in the proportion of diseased trees, β is the annual rate of spread of the disease, y_0 is the disease incidence at first detection, and y_t^G is the Gompertz disease spread function, R_t equals 1, representing the full yield of a healthy grove (average boxes/tree), r_t^1 is the percent of healthy yield obtained for a given level of disease severity, X_t is total grove severity at time t, $\hat{y}_t^L$ is the proportion of symptomatic trees in the grove, x is the fraction of HLB symptomatic tree canopy area at time t, x_0 is the fraction of HLB symptomatic tree canopy area at first detection, θ is the annual rate of disease severity progress in an affected tree, Q is total number of trees in the grove, and *s* is the number of symptomatic trees in the grove.

Figure 1: NPV at Average Age of 0

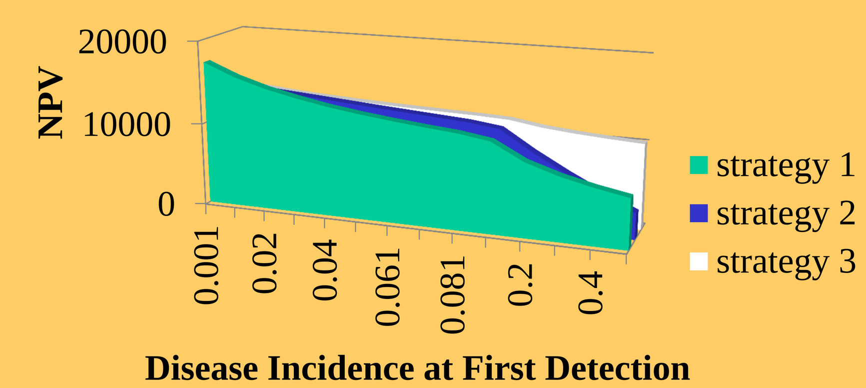


Figure 2: NPV at Average Age of 3

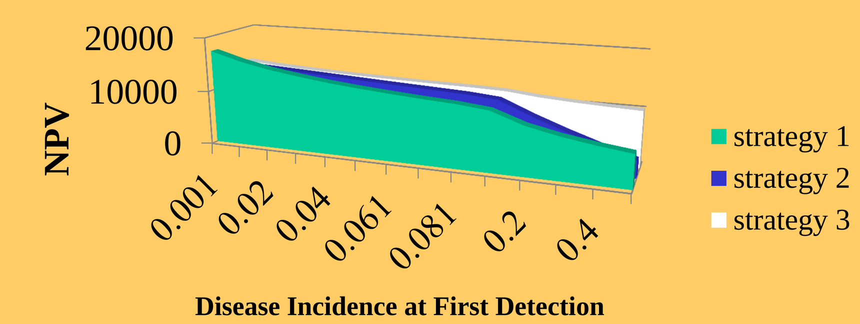


Figure 3: NPV at Average Age of 6

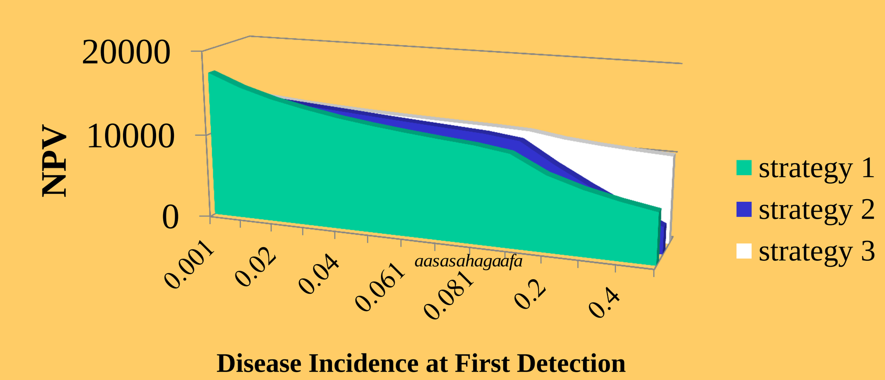


Figure 4: NPV at Average Age of 10

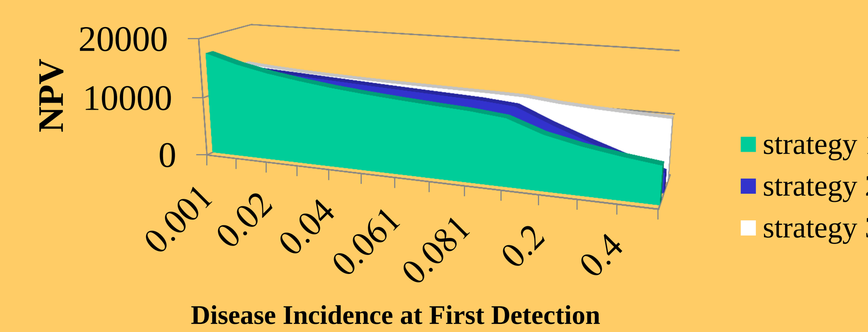


Figure 5: NPV at Average Age of 14

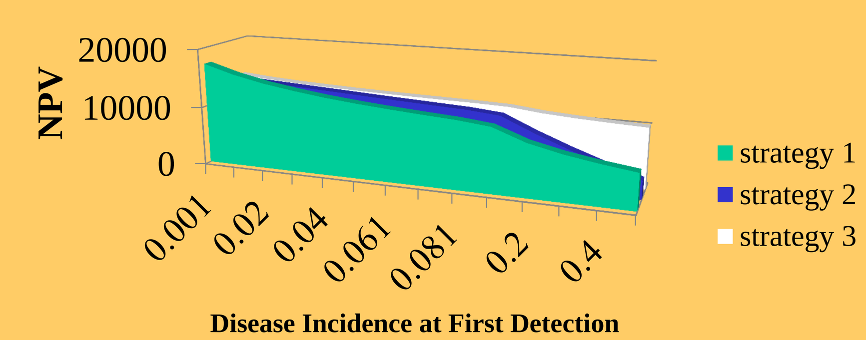
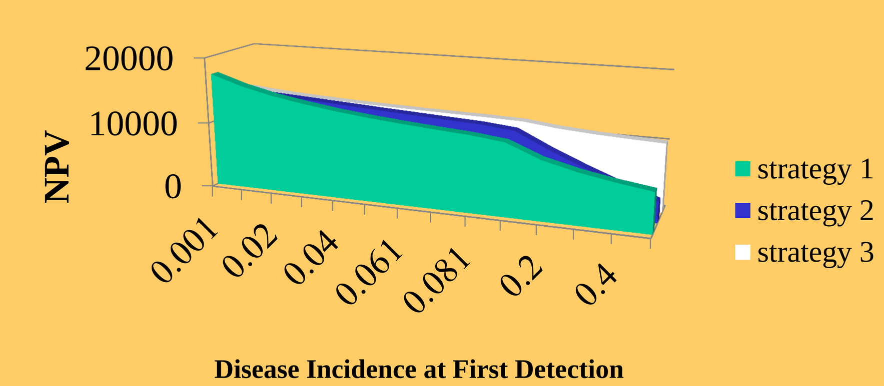
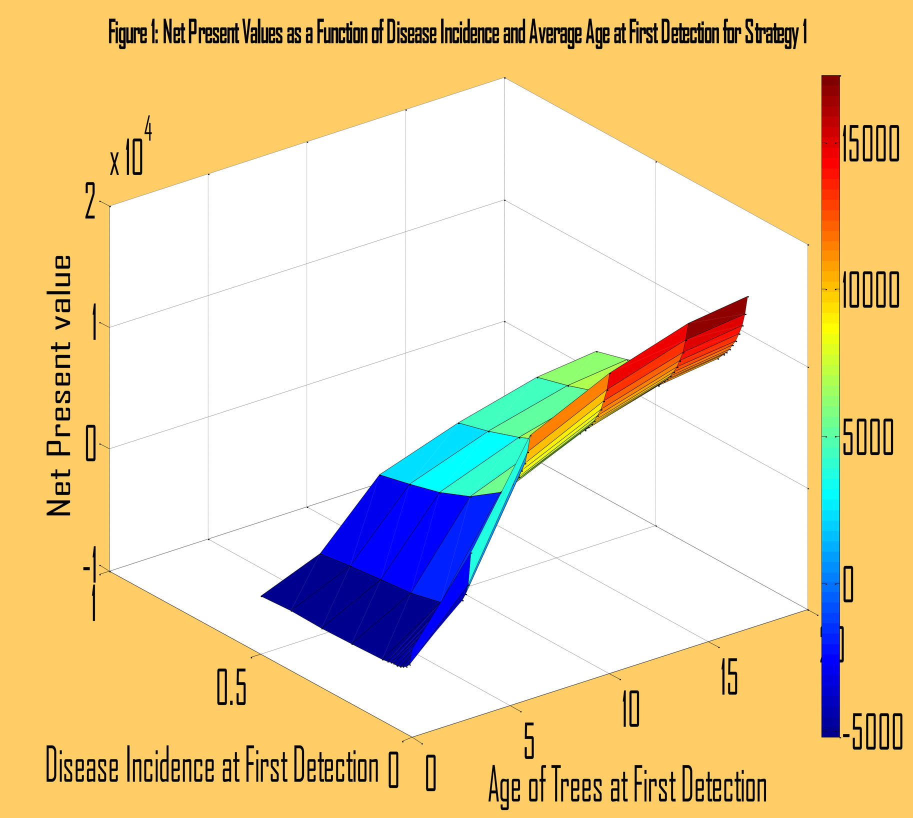
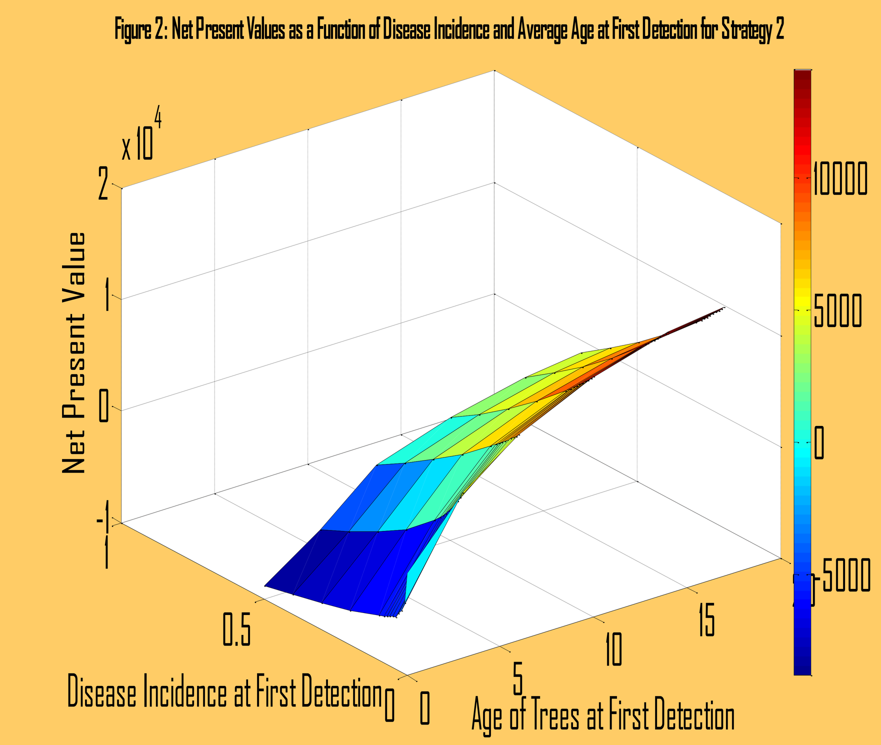
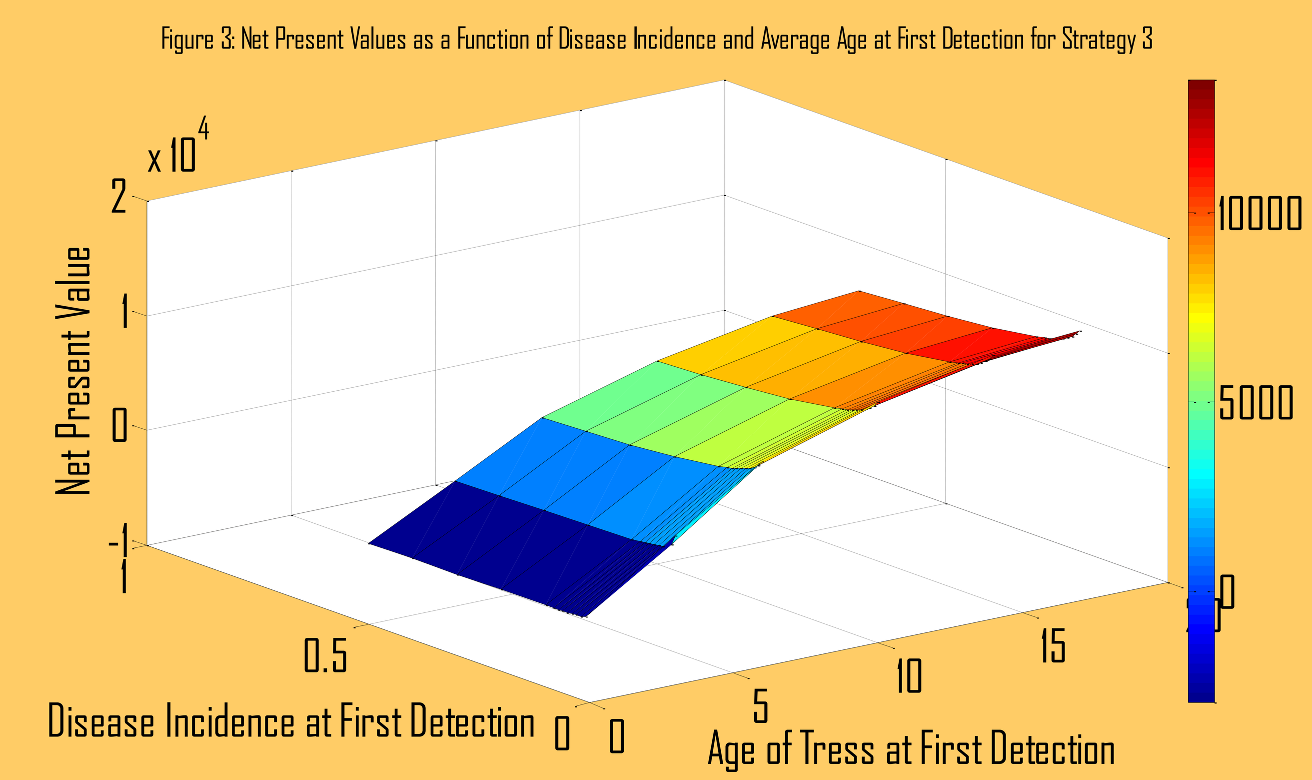


Figure 6: NPV at Average Age of 17









Results

- For ease of comparison, figures 1 through 6 juxtapose the net present value for the three strategies for each age class.
- Figures 7 through 9 plots the net present values as a function of disease incidence and average age at first detection for each of the respective strategies.
- In figures 7 and 9, the contour lines with the light blue areas mark the ages and disease rates at which the net present value is $0.00. In figure 8, it is the somewhat green areas at which the NPV is $0.00.

Conclusion

- Which strategy is superior to the other(s) depends on the age of trees at first detection and the initial rate of disease incidence at first detection.
- For almost new solid sets, strategy 3 dominates, whereas strategy 2 dominates for trees with average age of 3 years.
- For more matured trees (over 6 years), strategy 1 dominates at low initial disease incidence that were considered in the analysis, followed by strategy two which dominates when initial disease incidence is in the middle ranges, and at the highest initial disease incidence rates considered, strategy 3 dominates.

Reference

- Brlansky, R. H., M. M. Dewdney, and M. E. Rogers. 2011. 2011 Florida Citrus Pest Management Guide: Publication #PP-225.
- Alan W. Hodges and Thomas H. Spreen. (2012). Economic Impacts of Citrus Greening (HLB) in Florida, 2006/07–2010/11. EDIS document FE903.