A Bioeconomic Model of Invasive Species Control: The Case of Spotted Wing Drosophila in the United States

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Introduction

Background

Spotted Wing Drosophila (SWD) (Figure 1), native to eastern Asia, is an insect pest presently having a devastating effect on high value, high nutrient berry and stone fruit such as blueberries, blackberries, raspberries, strawberries, and cherries in much of the United States.

Damasges

SWD is causing significant damage, more than any other vinegar (fruit) fly; it attacks healthy ripening fruit while other flies only lay eggs on past ripe or rotting fruit.

• The female penetrates the fruit skin with her ovipositor and lays eggs just under the skin, creating a small puncture, or “sting,” on the fruit surface (Figure 2)

• Most damage occurs at the next stage, when eggs hatch and maggots develop and feed inside the fruit, causing the fruit skin to wrinkle, the flesh to turn brown and soft, making the fruit susceptible to decay and rots (Figure 3)

Economic Costs

U.S. crop losses due to SWD are estimated at $718 million annually, and increases in labor and input costs associated with SWD management are estimated to range from $129 to 172 million annually. High crop losses are due to:

• Zero tolerance for SWD infested fruit for either fresh market or whole frozen products

• Detection of even a single larva in a shipment can result in complete rejection

Management

• To meet the zero tolerance threshold, the main to treat for SWD is calendar-based broad-spectrum insecticide sprays.

• To better control SWD, it is very important to monitor for SWD activity. A common way to do this is using traps (Figure 4).

Figure 1 Male SWD (2-3 mm)

Figure 2 Small “stings” on this cherry are SWD oviposition scars

Figure 3 SWD damage to cherry showing soft spot

Figure 4 Example of a trap to monitor SWD

Literature

Spotted Wing Drosophila

Since the detection of SWD in the U.S., significant research and efforts have been undertaken to study the pathogens (Cini et al. 2012; Pfeiffer et al. 2012; Burkett et al. 2013).

Less emphasis on economic impact and optimal control of SWD (Boldea et al. 2010; Goodhue et al. 2011; Farnsworth 2013).

POMDP

Researchers have used the POMDP framework to address partial observability in invasive species control problem (Regan et al. 2006, 2011; Moore 2008; Haight and Polasky 2010; Williams 2011; Fackler and Haight 2014). The manager’s problem is solved using MDPSolve in MATLAB (Fackler and Haight 2014).

The optimal solution is shown in Figure 6, which displays the optimal action as a function of the current manager’s belief vector. Figure 7 displays the optimized total cost (the value of the objective function) under different belief states.

Results and Discussion

In this paper, we develop a bioeconomic model for decision-makers to optimally treating and monitoring invasive species such as SWD, taking into account the imperfect monitoring problem. The application of these bioeconomic techniques to SWD control will provide a useful framework for addressing the economics underlying other invasive species affecting U.S.