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Economic impacts of bird damage and management in U.S. sweet cherry production

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ABSTRACT

Bird damage is a common and costly problem for fruit producers, who try to limit damage by using management techniques. This analysis used survey data from producers in five U.S. states to estimate bird damage to sweet cherry (*Prunus avium*) crops with and without the use of bird management. A partial equilibrium model was applied to the data to estimate the change in the marginal cost of production resulting from disuse of bird management. The model incorporates both decreased yield and elimination of management costs. A welfare analysis was conducted with short and long run supply elasticities derived from time-series data using geometric distributed lags. With no bird management, total surplus in the United States decreases by about $185 to $238 million in the short run and $21 to $29 million in the long run, indicating that bird management has a large impact on cherry production and associated market outcomes, including price and consumption.

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1. Introduction

The United States is the world's second-largest cherry producer after Turkey, accounting for 15% of the world's total output (ERS, 2012a). Cherries are becoming an increasingly important fruit crop. They were ranked the eighth most valuable fruit and nut crop in 2010, generating $762 million in total cash receipts (ERS, 2012a). Production of sweet cherries (*Prunus avium*) has expanded in recent years, with bearing acreage increasing steadily over the last decade. Expansion of cherry production has been driven by increased consumer demand, due in part to the preventive health attributes of cherries including prevention of cancer, cardiovascular disease, diabetes, and Alzheimer's disease (McCune et al., 2010). Michigan, Oregon, California, and Washington account for about 98% of total U.S. sweet cherry production (ERS, 2012a). Sweet cherries are increasingly utilized fresh (about 75%), and the rest are processed, often as maraschino cherries.

Birds are a significant pest for fruit crops (Dolbeer et al., 1994; Lindell et al., 2012). U.S. apple and grape producers lose tens of millions of dollars each year due to direct bird damage and expenditures on management measures (NASS, 1999; Anderson et al., 2013). Birds reduce crop yields by consuming fruit, damaging fruit which leaves it susceptible to infection, and requiring fruit to be harvested before it is fully ripe, resulting in inferior products (Dellamano, 2006). Almost 60% of sweet cherry growers reported that bird damage is either one of several significant factors affecting their profits, or the most significant factor (Anderson et al., 2013). Since the majority of sweet cherries are sold fresh, even minimal damage can reduce a crop's marketability.

A variety of bird management techniques are available to fruit producers (Conover, 2001; Tracey et al., 2007). Bird-exclusion netting is widely considered one of the most effective methods for reducing bird damage (Dellamano, 2006; Simon, 2008; Anderson et al., 2013). However, installing netting is expensive and labor intensive so many producers avoid using it unless bird damage is severe (Pritts, 2001; Tracey and Saunders, 2003). Application of chemical repellents to crops is another nonlethal method for managing birds. However, development and registration of repellents is costly, so few products are available for agricultural use (Avery, 2003; Eisemann et al., 2011). Methyl anthranilate (MA) is a compound found in Concord grapes that birds perceive as an irritant. Effectiveness of MA as a bird deterrent

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in crops is unproven (e.g. Avery et al., 1996; Dieter et al., 2014). In addition, MA is a volatile compound that must be reapplied frequently, especially after rainfall, making application expensive and time-consuming (Pritts, 2001; Avery, 2003). Other bird deterrent techniques include auditory and visual deterrents and lethal shooting. Many bird management techniques may negatively impact non-target species (Tracey et al., 2007), and the efficacy of some deterrent measures is uncertain.

Limited research has been done on the economic impacts of bird damage to fruit crops, and much of this research has focused on wine grapes (e.g., Crase et al., 1976; Gadd, 1996; Boyce et al., 1999; Berge et al., 2007; and Anderson et al., 2014). A comprehensive study of pest damage on multiple crops was performed by Gebhardt et al. (2011) but the study region only included California, and was not limited to bird damage or cherries. A study focusing specifically on bird damage in cherry production in multiple regions will be useful to producers and policymakers when making decisions about management measures, as well as to researchers developing new technologies for bird management.

Modeling the absence of bird damage management reveals its benefits to growers and consumers. This study analyzes the economic impacts of hypothetical disuse of bird management on sweet cherry production and consumption, and estimates the market outcomes that result from decreased yield and eliminated management costs. It builds on work by Anderson et al. (2013) which used a survey of fruit producers to estimate the costs of bird damage to growers. The survey encompassed five specialty fruit crops across fives states. Direct assessment of bird damage is ideal, but impractical and costly on such a large scale. Under these conditions, producer surveys are the best option for obtaining estimates of crop damage (Conover, 2001). This analysis will elucidate the economic impacts of bird management for both producers and consumers, and may be useful for policymakers when considering future regulations and for producers when making implementation decisions.

2. Methods

2.1. Data collection

A mail survey was distributed to fruit growers in Michigan, New York, Oregon, Washington, and California in the spring of 2012, targeting producers of Honeycrisp apples, blueberries, wine grapes, and sweet and tart cherries (Anderson et al., 2013). The survey consisted of 21 questions soliciting information about acreage, yield, estimates of bird damage, and the bird management techniques used with their associated costs. A total of 7666 surveys were distributed and 2351 completed surveys were returned for a 30.7% response rate.[1] Of those returned 1590 grew one of the crops listed above, and of those, 644 grew sweet cherries.

Producers were asked to estimate their yield loss due to bird damage in 2011, their expected yield loss if they had not used any bird management methods, and their expected yield loss if they and their neighbors had not used any bird management methods. The two differences between yield loss with no management and yield loss with management provide low and high estimates of yield loss for calculating the economic benefits of bird management. Survey data were used in this study for two reasons. First, it is ideal to have data from as many regions as possible, so field studies would have been impractical and cost-prohibitive. Second, bird damage varies from year-to-year, and growers' perceptions are likely based on their experiences over a number of recent years. Their damage estimates are less subject to year-to-year variability than data from a field study. However, there is reasonable concern regarding the reliability of survey data due to possible grower bias or uncertainty. Unfortunately, few previous studies have addressed this topic. A notable exception is Tzilkowski et al. (2002), who compared survey and field study estimates of wildlife damage to corn, and could not conclude that the estimates were significantly different. Other wildlife experts have expressed confidence in growers' ability to assess damage (Conover, 2001). Conversely, growers' ability to assess the impact of their neighbors' bird management practices on their own crops is uncertain, which is why the two damage estimate questions were used as low and high estimates of bird damage to the individual grower's crop.

The price of cherries varies by state and year of production due in part to differences in quality and because different varieties of cherries are better suited for production in different regions. The average price of sweet cherries ranged from \$0.36 per pound in Michigan to \$1.44 per pound in New York from 2009 to 2011 for a nationwide average of \$1.05 per pound (ERS, 2012b).[2] A single price is used for the analysis as varietal differences are considered small enough that all sweet cherries are regarded as a single product.

2.2. Partial equilibrium model

A partial equilibrium model is an economic model in which only one factor is allowed to change while everything else that could potentially affect the market is held constant (Mas-Colell et al., 1995). Prices and quantities produced are allowed to adjust until they are in equilibrium through market interactions between suppliers and consumers. Consumer income and prices of substitutes and complements are assumed not to change. Additionally, changes in a given market are assumed to have no impact on other markets. This type of model makes analysis of the effects of single changes much simpler.

A partial equilibrium model developed by Anderson et al. (2014), in which producers explicitly choose to employ bird management, was applied using the survey data. The model is similar to the models developed by Lichtenberg et al. (1988) and Sunding (1996) in that all have the same data requirements and can be used to estimate welfare changes. Supply and demand elasticities, market price, production data, and cost-effectiveness of bird management are necessary to apply the model.[3] Farm-level demand for cherries has been reported as inelastic (Schotzko et al., 1989; Cembali et al., 2003), and an average of reported estimates was used for this analysis. Estimates of management costs and crop damage were obtained from the survey results, and supply elasticities are derived in the following section.

Each producer's profit maximization problem is described by.

$$\max\pi = Pq(X,Z) - xX - zZ, \tag{1}$$

where X is the number of acres harvested in a given year, Z is the number of acres to which bird management is applied, x is the per-acre production cost excluding the cost of bird management, z is the per-acre cost of bird management, and P and q are market price and quantity produced. First order conditions are $\frac{\partial\pi}{\partial X} = P\frac{\partial q}{\partial X} - x = 0$ and $\frac{\partial\pi}{\partial Z} = P\frac{\partial q}{\partial Z} - z = 0$, implying that producers will use bird management on an acre if the additional revenue gained from doing so is greater than the cost. Input demand functions are $X^* = X(P,x,z)$

[1] Response rate was calculated by dividing the number of returned surveys by the number of distributed surveys.

[2] Prices were adjusted to 2011 dollars.

[3] Perfect competition, identical producers, and product homogeneity are assumed for this model.