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Valuing the absence of feral swine in the United States: A partial equilibrium approach

J.J. Holderieath[a,*], D.L. Pendell[b], J.C. Hadrich[c], A. Anderson[d], C. Slootmaker[d], E. Harper[d], S.A. Shwiff[d]

[a] Louisiana Tech University, Department of Agricultural Sciences and Forestry, P.O. Box 10198, Ruston, LA 71272, USA
[b] Kansas State University, Department of Agricultural Economics, 220 Waters Hall, Manhattan, KS 66506, USA
[c] University of Minnesota, Department of Applied Economics, 218J Ruttan Hall, 1994 Buford Avenue, St. Paul, MN 55108-6040, USA
[d] USDA/APHIS/WS National Wildlife Research Center, 4101 Laporte Avenue, Fort Collins, CO 80521, USA

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ABSTRACT

Feral swine (also called wild pigs; *Sus scrofa* Linnaeus) are known to cause damage to crops among other types of property damage. This research addresses the lack of economic welfare estimates of wild pig imposed crop damages in the literature by estimating the value of wild pig removal with respect to five crops in nine southern U.S. states. An equilibrium displacement model was used to assess the changes in price and quantity that would result from eliminating damage to corn, soybeans, wheat, rice, and peanuts in these nine states. Changes in price and quantity were used to calculate the changes in producer and consumer welfare in both the short- and long-run. The total producer and consumer surplus gains were found to be $142 million in the short-run and $89 million in the long-run.

1. Introduction

Conflicts between humans and wildlife arise due to diverging interests between species. Those conflicts can range from property damage to threatening and predatory behavior (USDA APHIS, 2015). The United States devotes considerable financial resources to managing human-wildlife conflicts. In 2014, the USDA allocated $106 million to the Wildlife Services division of the Animal and Plant Health Inspection Service (APHIS) for a portion of the federally-funded human-wildlife conflict mitigation efforts (USDA, 2015). Among policy makers and researchers interested in human-wildlife conflicts, one species of particular recent interest is feral swine (also called wild pigs; *Sus scrofa* Linnaeus). The USDA has allocated $20 million to support the goal to "eliminate feral swine from two States [sic] every three to five years and stabilize feral swine damage within 10 [sic] years" (Bannerman and Cole, 2014).

Spanish Conquistadors introduced wild pigs in the southeastern United States and California in the sixteenth century as well as by Polynesians to Hawaii in the fourth or fifth century (Kirch, 1982; Mayer and Brisbin, 2008; Mann, 2006). By 1982, wild pigs were present in 699 counties in 19 states, primarily in the southeastern United States (Mayer and Brisbin, 2008). Over the next 30 years, wild pigs spread at an accelerated rate, affecting 1323 counties in 39 states (Lutman, 2013; Bevins et al., 2014). The 624 counties into which wild pigs moved between 1982 and 2012 comprised a land area of approximately 1.9 million square kilometers, which is more than the combined land area of Texas, California, Montana, and New Mexico.

Feral swine are known to cause damage to crops and other types of property. A recent survey reported by Anderson et al. (2016) found a production loss of nearly $190 million in eleven states from just six of the crops grown in those states. This survey result is important, as it demonstrates the size of the crop that wild pigs have prevented reaching the market.

Production losses are only part of the overall impact caused by wild pigs. Preventing commodities from reaching the market restricts supply, resulting in higher equilibrium prices for consumers. In the absence of wild pig imposed damage, market supply would increase resulting in a downward push on prices. Unequivocally, consumers would be better off as they would enjoy more of these commodities at a lower price; however, the outcome for producers is less obvious. Producers experiencing the reduction in damage would be better off only if the increase in crop quantities made up for the lower prices. Producers who would not see an increase in production would be worse off. These changes in the wellbeing of consumers and producers are known as welfare changes. To date, the authors are unaware of any studies that assess the welfare implications of wild pig crop damage.

* Corresponding author.
E-mail addresses: jjhold@latech.edu (J.J. Holderieath), dpendell@k-state.edu (D.L. Pendell), jhadrich@umn.edu (J.C. Hadrich).

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To address this gap in the literature, this study estimated the economic impact of wild pig damage in nine Southeastern states on U.S. crop producers and consumers of corn, soybeans, wheat, rice, and peanuts. Specifically, this research estimated changes in producer and consumer welfare by calculating the changes in price and quantity implied by assuming the previously destroyed commodities now enter into the market. Changes in price and quantity were used to calculate the change in producer and consumer welfare.

A partial equilibrium model is presented in the next section based on historical U.S. production data from USDA National Agricultural Statistics Service (NASS) and wild pig presence data and damage estimates from Anderson et al. (2016) with more details in Holderieath (2017). The result of this model depicts a scenario free of wild pig associated crop damage to contrast with the current reality of wild pig imposed damage. This approach follows Elser et al. (2016) by placing an economic value of managing birds in U.S. sweet cherry production. It stands to reason that the difference in welfare measures between the model result and the current reality of damage is the value of removal with respect to these five crops in these nine states.

2. Materials and methods

Building on previous wild pig damage literature, this analysis examines the impacts through market linkages of an exogenous shock comprised of hypothetical removal of wild pig associated damage. Wild pig associated crop damage is primarily incurred at the farm level and the end use of the crop is indistinguishable at this level. These factors led to the producer selling output at the farm gate serving as the primary market of concern for this work. One commonly used framework for measuring the quantity and price effects due to shocks such as this is an equilibrium displacement model (EDM).

The EDM is a linear abstraction of supply and demand functions that describe the transition from one equilibrium to another (Wohlgenant, 1993, 2011). The EDM is a system of logged and totally differentiated supply and demand equations where the change in quantity supplied and change in quantity demanded are functions of own and cross prices, elasticities, and an exogenous shock. Provided a relatively small exogenous supply shock, current prices and quantities, and elasticities, the EDM can be used to calculate the new price and quantity equilibrium resulting from the change in supply due to an elimination of wild pig crop damage. Those price and quantity changes are then used to geometrically measure the changes in producer and consumer surplus (welfare changes).

First, supply and demand functions are derived for each commodity in the EDM. The EDM used in this study is fully documented in Holderieath (2017). A. Second, the exogenous production shocks were incorporated into the EDM, and changes in price and quantity were obtained. Third, producer and consumer welfare were calculated and used to evaluate the changes in welfare resulting from a reduction in wild pig damage.

This analysis considers five commodities: corn, soybeans, wheat, rice, and peanuts. Grain sorghum was not included, as it was only reported by Anderson et al. (2016) for one state, and Missouri and California were not included as they did not have sufficient responses in the five commodities of interest to report damages. Five sets of supply and demand equations make up the EDM used in this analysis. Change in quantity demanded for each commodity, k, is a function of its own change in price and its own price elasticity of demand. Similarly, changes in quantity exported and imported of commodity k are a function of their respective elasticities and the price change of commodity k.

Two regions (ω) supply the commodities to the market, the region with the reduction in wild pig damage (WPR) and all other states (AOS). Supply for all commodities in each region, except peanuts, are a function of each own price elasticity of supply for the same region, the change in price of commodity k as well as the respective cross price elasticities and price changes of commodity where $j \neq k$. Change in quantity supplied of peanuts for each region is a function only of the own price elasticity and the change in price of peanuts. Supply equations for the WPR region also include an additive change due to the exogenous production shock. In this research, we considered an exogenous shock as the increase in quantity present in the market due to the reduction of wild pig damage.

Elasticities can be obtained from past literature, "guestimated," or estimated (James and Alston, 2002). "Guestimated" elasticities often take the form of unit elasticities (Sumner, 2007; Harrington and Dubman, 2008). For this study, a mixed strategy is employed. Supply, import, and export elasticities come from previously published studies or are set to a value consistent with previous literature. Demand elasticities were estimated using the Almost Ideal Demand System (AIDS) developed by Deaton and Muellbauer (1980). These elasticities were estimated because a single source for all the demand elasticities in the system was not available. The set of elasticities used in this study is presented in Holderieath (2017) along with their sources.

Each commodity destination and source is linked together into a single equilibrium condition that considers weights of each destination and source. These weights function as limiting terms that prevent a very small portion of a market from disproportionately impacting the larger market and are discussed in Holderieath (2017). The efficency in price transmission exhibited in these five markets allowed a single price to be assumed for consumers, exports, imports and in both production regions. The five equilibrium conditions were solved simultaneously for change in price and then change in price was substituted into each demand, supply, import, and export equation to find quantity changes.

Exogenous production shocks ($EB_{k,\omega}$) were derived from estimates of damage for each of the nine U.S. states (*States*) as reported by Anderson et al. (2016). Anderson et al. (2016) (see Table 1) presents the amount of each crop that would be present in the absence of wild pigs ($Damage_k^{State}$). Pre-shock production ($Production_k^{State}$) was the total reported production in each state by USDA National Agricultural Statistics Service (USDA NASS, 2015). The exogenous production shock is calculated as follows:

$$EB_{k,\omega} = \frac{\sum_{States} (Damage_k^{State} * Production_k^{State})}{\sum_{States} Production_k^{State}} \times 100. \quad (1)$$

We assume that wild pigs are instantly and permanently removed from nine Southeastern U.S. states to demonstrate potential gains from elimination of wild pig related crop damage with respect to these five crops in these nine states. The wild pig removal states are Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Texas. California and Missouri were omitted from this study due to low survey coverage in Anderson et al. (2016). This scenario is used to find a value of removal in these nine states with respect to these five crops. The calculated production shocks represent an increase of 1.47%, 0.50%, 1.66%, 0.46%, and 1.80% in corn, soybeans, wheat, rice, and peanuts, respectively, in the WPR region.

Table 1
Percent of crop lost to wild pigs by state (%).
Source: Anderson et al. (2016).

State	Corn	Soybeans	Wheat	Rice	Peanuts
Alabama	0.93	1.38	0.62	NA	6.17
Arkansas	1.09	0.27	0.75	0.27	NA
Florida	4.41	3.43	NA	NA	1.84
Georgia	4.73	1.07	4.39	NA	NA
Louisiana	0.83	0.74	0.94	1.26	NA
Mississippi	1.34	0.4	0.7	0.12	NA
North Carolina	0.38	0.09	0.15	NA	0.49
South Carolina	1.59	1.52	1.71	NA	NA
Texas	1.65	1.1	3.05	2.46	9.28

NA is not applicable.