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VALUING CATASTROPHIC LOSSES FOR PERENNIAL AGRICULTURAL CROPS: CITRUS AS A MODEL

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Abstract. **Courts are often required to estimate changes in welfare to agricultural operations from catastrophic events. For example, courts must assign damages in lawsuits, such as with pesticide drift cases, or determine "just compensation" when the government takes private land for public use, as with the removal of dairy farms from environmentally sensitive land or destruction of canker-contaminated citrus trees. In economics, the traditional method of quantifying producer losses is estimating changes in producer welfare, but courts rarely use this method. Instead, they turn to substitute valuation methods that may not fully capture welfare change, such as changes in land value, tree replacement value, and total revenue. This study examines various measures for valuing the back-to-back catastrophic freezes that occurred in the Florida citrus industry in the 1980s. We first use the traditional method to determine the welfare change due to a freeze (1) for a citrus grove that loses one crop and is able to return to full production the next year, and (2) the lower measure of welfare loss due to a citrus grove that loses all of its trees and is abandoned or is replanted. The lower measure is used to simulate the legal doctrine of avoidable consequences. These measures are then compared to substitute valuation measures that have been used by courts to determine welfare changes. For case 1, total revenue overestimates losses by 35.6%. For case 2, total revenue overestimates losses by 55.3%, tree replacement value underestimates losses by 93.6%, and changes in land value underestimates losses by 13.2%.**

One cornerstone of applied economic analysis is the valuation of dramatic events for policy analysis. For example, economists may estimate the effect of a disease outbreak on the beef industry as in the case of "Mad Cow Disease" or E. coli contamination of packing facilities, or estimate the effect of changes in agricultural or trade policy as in the case of Federal Agriculture Improvement and Reform Act or North American Free Trade Act. Courts, too, are often required to estimate changes in welfare to agricultural operations from catastrophic events. For example, courts must assign damages in lawsuits, such as with pesticide drift cases, or determine "just compensation" when government takes private land for public use, as with the removal of dairy farms from environ-

mentally sensitive land or destruction of healthy citrus trees within range of canker-contaminated trees.

In economics, the traditional method of estimating the effects of a catastrophic event is the computation of the change in producer welfare as developed in Just et al. (1982), but courts rarely use this method because sufficient data may be lacking and because the method may seem complicated. Instead, they turn to substitute valuation methods that may not fully capture producer losses, such as changes in land value, replacement value, and total revenue.

This study examines various approaches for valuing losses to producers of perennial agricultural crops following a catastrophic event. One such catastrophic event was the back-to-back freezes that occurred in the Florida citrus industry in the 1980s. Following this event, citrus in Florida retreated further to the south.Using this catastrophic event as an example, we first compute producer losses using the traditional economic approach to valuing catastrophic losses—change in producer welfare. We then compare these measures to other valuation approaches often used by courts and by the marketplace to estimate producer losses, including tree replacement value, the change in land values, and total revenue value. Although "Acts of God" are not a basis for compensation by a court, this catastrophic freeze example nonetheless provides a means for comparing the various valuation approaches.

Methods

Change in Producer Welfare. We first calculate change in producer welfare (ΔW) due to the freeze event. A change in welfare is measured as "the amount of money, which when taken away from an individual after an economic change, leaves the person just as well off as before. For a welfare gain, it is the maximum amount that the person would be willing to pay for the change; for a welfare loss, it is the negative of the minimum amount that the person would require as compensation for the change" (Just et al., 1982). ΔW due to the catastrophic freeze is a function of the age of the original grove.

Assuming a 30-year planning horizon, price expectations based on market information available prior to the 1983-84 marketing period, and using an age distribution assuming that the average tree age structure for Lake County holds for the individual grower, the value of the loss with and without tree replacement is computed using

$$(1)\Delta W = -\sum_{t=o}^{30} \delta^t \{(TR_t^{wo} - TVC_t^{wo} - I_t^{wo}) - (TR_t^{W} - TVC_t^{w} - I_t^{w})\}$$

where ΔW is the value of the freeze loss in dollars; $\delta^t = (1/(1 + .0465))^t$ is the factor used to discount future dollars back to

[2]The citrus industry essentially shut down in the traditional northern groves around Orlando and moved to the flatwood areas to the south.

current dollars at an interest rate of 4.65 percent as suggested by Moss et al. (1991); TRt denotes total revenue in time t; TVCt is the total variable cost in time t; It is costs associated with tree replacement and care in time t; and superscripts w and wo indicate, respectively, with and without the freeze event, which is assumed to occur in time $t = 0$.

For a typical 100-acre grove, a tree-age profile for Lake County is constructed from the Florida Agricultural Statistics Service Commercial Citrus Inventories (1982-1986) that implies a loss of 90.1% of trees and a lost yield of 24,927 boxes of oranges in the freeze year. We estimate a second order autoregressive function to project expected future orange prices before the 1983-84 freezes[3]. Averaging over a projected 30-year planning horizon yields an average orange price of $7.54 per box with an expected price in the 1983-84 marketing period of $7.99 per box. A TVC_t of $2.10 per box[4] is assumed. ΔW is calculated for the freeze year and over a 30-year planning horizon both without and with tree replacement for a typical 100-acre grove (Table 1).

ΔW for annual crops can be simulated by computing losses to the citrus producers in the freeze year only (and thus assuming that the grove will produce a crop next year because the bloom was not frozen). Investment is assumed to be unaffected. In this case, $\Delta W = \$-141,240$ in year 2002 dollars for the freeze year only.

When trees are lost, but not replaced, the ΔW must similarly be calculated over the expected life of the grove and must consider differences in tree yields for trees of different ages. We use tree age yield information from Zanzig et al. (1997). When calculating yield differences over time, one must also consider grove age distribution and attrition rates. Maintaining a citrus grove includes replacing under-producing trees—those that produce less than 50% of their expected yield. Muraro and Fairchild (1985) have stated that citrus trees have an age-dependent probability of permanently under-producing, which for Lake County is 2.3% of citrus trees aged 0 to 3, 1.3% of those aged 4 to 10, and 3% of those aged 11 or more. Given a grove age distribution at the time of a freeze, one can predict what that grove's age distribution and number of trees would be both with and without the freeze, and with and without replacement. Future grove yield is found by multiplying the grove tree age distribution by the average yield per tree for a tree of each age. $\Delta W = \$-961,608$ million without replacement. $\Delta W = \$-773,522$ with tree replacement. The legal doctrine of avoidable consequences would require a producer to take steps to minimize losses following a tortious act or state land taking. In this case, to simulate this doctrine, the accepted change in producer welfare would be the lower of the two welfare measures.

We will now compare the change in producer welfare with the measures used in the market place and by courts. These include tree replacement value, the change in land values, and total revenue.

Tree Replacement. Tree replacement includes buying new citrus trees, preparing the land for trees, and planting new trees. For the Lake County tree age distribution, in year 2002 dollars, tree replacement cost is $499 per acre for trees and land work (Muraro, 1983), or $49,900 for a 100-acre grove

(Table 1). This is significantly less than the $961,608 welfare loss without tree replacement and the $773,522 loss with tree replacement (Table 1).

Change in Land Values. Another approach to valuing the cost of the catastrophic event is the change in land values. Under traditional asset valuation concepts, the land value of a grove reflects the normal profit from citrus production. Accordingly, after the freeze, rational investors would incorporate the effect of the lost land use alternative (i.e. loss of economically-viable orange production) into their bids for farmland in the area. The post-freeze value of the citrus land should be equal to the land's pre-freeze next best use value. For example, if the pre-freeze next best use were as a cattle ranch, then the change in land values approach would measure damages as the difference between the net present value of the land as a citrus operation and the net present value of the land as a cattle operation. We assume that Lake County citrus land had no economically viable next best use. Under these assumptions, the change in the land value between pre-freeze years and the post freeze years provides an estimate of the economic loss of the shutdown.

According to the Lake County property register[5], before the 1983 freeze event, orange grove land in Lake County sold for about $10,721 per acre in year 2002 dollars. After the freeze, land in the same area sold for almost $4,010 per acre. Thus, about $6,711 per acre was lost due to the freeze. Multiplying this by 100 acres yields an estimated economic loss of $671,100 in year 2002 dollars (Table 1). Figure 1 shows the changes in average per acre land values for Lake County between 1981 and 1986.

Total Revenue Approach. A related methodology that is sometimes used to quantify the economic loss is the total revenue approach. The total revenue approach overstates ΔW because total variable costs and total investment costs are not included in the valuation. Following this procedure, the total revenue loss in year 2002 dollars on the 100-acre grove using Lake County is $1,201,604 with tree replacement, and $3,823,062 without replacement (Table 1).

Results and Discussion

A summary of the alternative measures of economic loss due to the freezes of the 1980s for the typical 100-acre orange producer in Lake County, Florida using the estimated Lake County tree replacement distribution are presented in Table 1.

Table 1. Alternative measures of freeze loss for a 100-acre citrus grove in Lake County, Florida.

Method	Loss[a]
ΔW without tree replacement	$-961,608
ΔW with tree replacement	-773,522
Tree replacement cost only	-49,900
Lost land value	-671,100
Total revenue w/out tree replacement	-3,823,062
Total revenue with tree replacement	-1,201,604

[a]Loss over life of grove (30 Years), in year 2002 dollars.

[3]Typical assumptions of welfare analysis as discussed in Just et al. (1982) are based on *ex ante* expectations.

[4]Based on Muraro (1983). This paper assumes that pick and haul costs remain nominally fixed over the 30-year planning horizon.

[5]Lake County land values were accessed using the Florida Deed Transfers and Tax Assessor Records database from www.lexis.com/research.
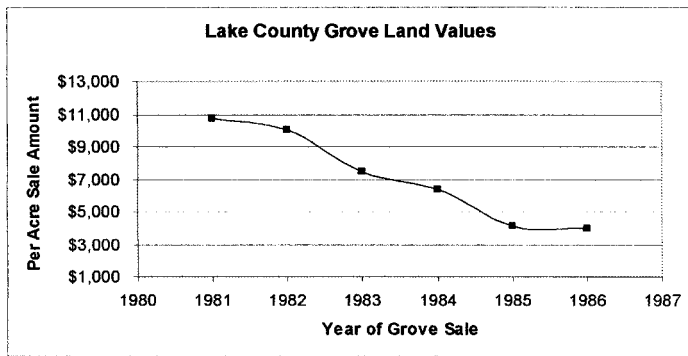
Fig. 1. Average per acre land values for Lake County orange groves before and after the 1983 freeze event.

Catastrophic events that permanently damage perennial crops pose a more difficult valuation problem than annual crops. Much more data is needed to calculate ΔW using traditional economic measures and courts must also consider contingencies. In the case of the freezes of the early 1980s, ΔW must be calculated with and without tree replacement. It is the lower of the two loss calculations that should be used to simulate courts' use of the doctrine of avoidable consequences, which provides that a damaged party must try to limit losses as much as possible. In our case, ΔW with tree replacement is the lower measure by $188,085 (Table 1).

If a court needs to use alternative measures, it is important to know which method performs best. For the typical 100-acre orange grove in Lake County, the ΔW is most closely approximated by the change in land values, with total revenue and cost of tree replacement providing much worse estimations.

The total revenue measure overestimates economic loss as compared to the ΔW measures both with and without tree replacement. This is expected because the total revenue concept pays the grove owner for variable costs that the grove owner did not experience (e.g., pick and haul costs). Total revenue is an imprecise measure of economic loss. For the typical 100-acre grove in Lake County, the total revenue measure with tree replacement overestimates economic losses by $428,082 in year 2002 dollars, or 55.3% when compared to ΔW with tree replacement (computed from Table 1).

The cost of tree replacement measure also does not perform well. It does not consider the lost revenue from current or future income that will result from the increasing tree yield as the tree gets older, so it severely understates the economic loss experienced by the grove owner. Cost of tree replace-

ment is a very imprecise measure of economic loss. In this case, when compared to ΔW with tree replacement, it underestimates producer losses by almost $723,647, or over 93.6% (computed from Table 1).

Finally, change in land value performs the best when compared with ΔW with tree replacement, but it underestimates producer loss. Here, the change in land value when compared to ΔW with tree replacement, underestimates producer loss by $102,420 or 13.2% (computed from Table 1). Although this method performs best among the alternative methods, change in land values may not be a good estimate of producer losses, especially when urban development pressures are strong.

In theory, successful lawsuits are meant to make the complaining party "whole" or as well off with the court-awarded compensation as they were before the catastrophic event. This is equally true for personal injury awards as it is for government takings awards. In economics, the traditional method for determining the amount needed to make the party "whole" is a ΔW estimation. While the most accurate, this method requires complicated calculations and an understanding of economics and statistics to make appropriate estimations. As such, courts often turn to alternative measures, like change in total revenue, change in land value, or cost of tree replacement. These measures may not fully capture producer losses due to a catastrophic event. Our estimates suggest that this is the case for the back-to-back freezes of the early 1980's (1) for a citrus grove that loses one crop and is able to return to full production the next year and (2) for a citrus grove that loses all of its trees and is abandoned or is replanted. For case 1, total revenue overestimates losses by 35.6%. For case 2, total revenue overestimates losses by 55.3%, tree replacement value underestimates losses by 93.6%, and changes in land value underestimates losses by 13.2%.

Literature Cited

Florida Agricultural Statistics Service. 1982-1986. Commercial citrus inventory. Fl. Agr. Stat. Serv.

Just, R. E., D. L. Hueth, and A. Schmitz. 1982. Applied Welfare Economics and Public Policy. Englewood Cliffs: Prentice-Hall.

Moss, C. B., R. N. Weldon, and R. P. Muraro. 1991. The Impact of Risk on the Discount Rate for Different Citrus Varieties. Agribusiness: An International Journal 7:327-38. (Abstr.)

Muraro, R. P. 1983. Budgeting Costs and Returns: Central Florida Citrus Production, 1982-3. Univ. Fla., Inst. Food Agr. Sci., Econ. Info. Rpt. 185.

Muraro, R. P. and G. Fairchild. 1985. Economic Factors Affecting Postfreeze Production Decisions in the Florida Citrus Industry. Proc. Fla. State Hort. Soc. 98:91-96.

Zanzig, B., C. B. Moss, and A. Schmitz. 1997. Natural Disasters and the Yield Curve of Florida Valencias. J. Agr. Resource Econ. 22:402.