

Hurricanes and Invasive Species: The Economics and Spatial Dynamics of Eradication Policies

2005 PREISM Workshop
ERS, Washington, DC
October 20th 2005

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Introduction

- Large economic effects that involve externalities justify public policy to control or eradicate invasive species.
- Externalities
 - Spread of disease.
 - Loss of markets.
- The optimal choice of policy depends on various pest characteristics:
 - costs, how it spreads, how easy it is to detect and eradicate, as well as the extent of the current infestation.
 - more likely to eradicate an invasive species when the infestation is isolated or easy to isolate and the risks of spread are high.
 - If the infestation is already spread over a wide geographic region it may be less economic to eradicate.



Introduction

- Random events such as rain, winds, and human activities that may help spread the disease increase the cost of eradication.
 - Increased infestation level of disease.
 - Wider geographic coverage of the disease.
 - Increased monitoring costs.

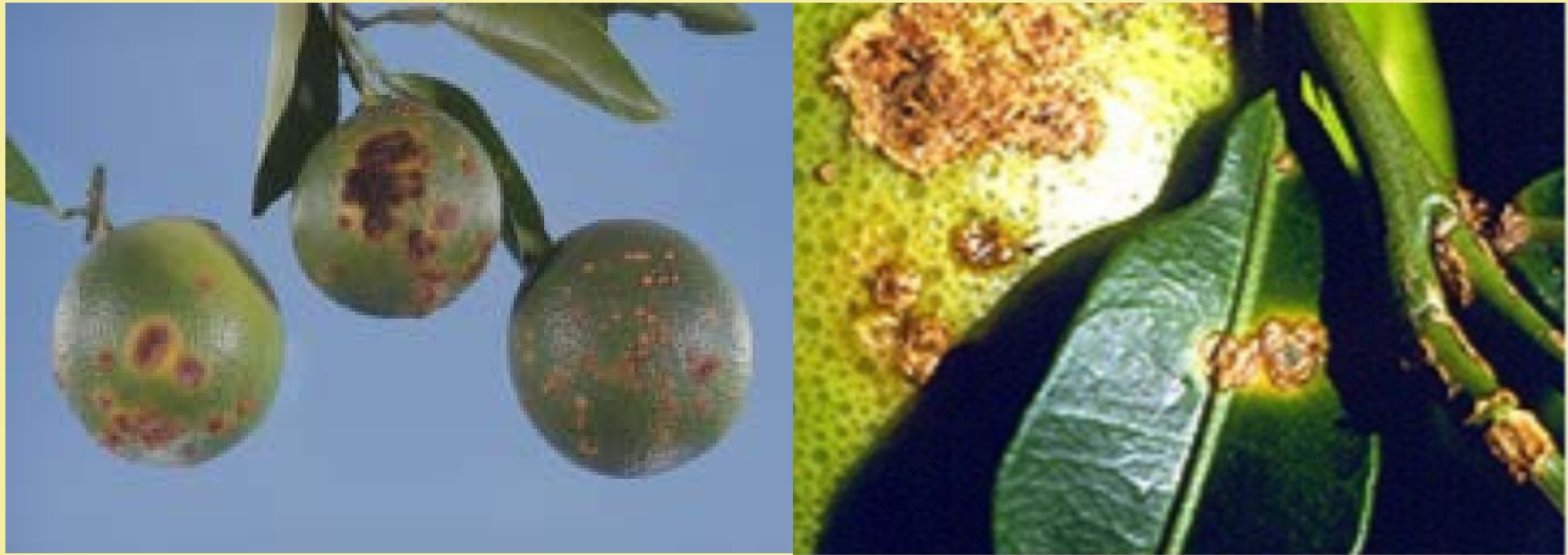


Introduction

- As an infestation spreads eradication may not be economically feasible, since cost of eradication may exceed the total costs of the infestation.
 - As a result of recent hurricanes in Florida, an additional 509 thousand commercial citrus trees were destroyed (20% of the total number since the 1995).
 - At the end of September 2005, the USDA approved \$53.75 million in new money to continue the eradication program and recently it announced another \$200 million to compensate growers who have their trees and groves destroyed to stop the spread of the bacterial infection.
 - To date, USDA has paid out more than \$378 million for eradication work and \$336 million in grower compensation.



Effects of Citrus Canker



Fruit symptoms of Citrus Canker on sweet orange

Lesions on orange leaves and twigs

Effects of Citrus Canker

- Effects of an outbreak include:
 - Lesions on fruits.
 - Increased use of chemicals to treat groves for prevention of attack and treatment of compromised trees.
 - Use of chemicals to clean fruits before they get to the market.
 - Quality of FCOJ is not affected.
 - 5 percent to 10 percent increase in fruit drop, results in reduction in orange production.
 - Trade restrictions are placed on U.S. exports of fruits, peels, and leaves (but not FCOJ).



Effects of Citrus Canker

- Commodity policies for Florida oranges:
 - Federal crop insurance for oranges.
- ❖ In 2002, 69% of eligible Florida orange acreage was under CAT insurance.
 - ❖ About 88% of eligible Florida acreage was covered under federal crop insurance.
- Import tariffs on FCOJ.
 - ❖ Tariff of \$0.2972/gallon for 2004 (about 40%).
 - ❖ Imports accounted for about 12% (\$227 million) of domestic FCOJ consumption in 2003.



Characteristics of the Pest – Citrus Canker

- Cost of prevention, eradication, and control.
 - Border control, pesticides, destruction of trees and quarantines.
 - If established, continuing yield loss and loss of markets.
- Ease of spread.
 - Heavy rain and wind, human activity.
- Ease of detection.
 - Fruits, twigs, and leaves.



Characteristics of the Host - Oranges

- Perennial crop.
 - Current acreage, plantings, and removals determine future production.
 - Trees may be considered investments.
 - Benefits from current plantings realized over a period of time.
- Consumption.
 - In Florida, mainly grown for processing.
 - Import tariff on FCOJ.
- Simple static model not appropriate for supply response and market for oranges.



Production and Utilization of Florida Oranges (1997 – 2002 Average)

	Florida Production	Share of Florida Total	Florida Share of U.S. Total
	<i>(million boxes)</i>	<i>(percentage)</i>	
Fresh			
Domestic	10.01	4.5	24.04
Net Export	0.70	0.3	6.55
Processing	209.87	95.1	95.90
Total	220.59	100.00	81.33



U.S. Production and Consumption of Orange Juice (1997 – 2002 Average)

	Production	Share
	<i>(million gallons)</i>	<i>(percentage)</i>
Net Imports	143.47	9.5
Florida Production	1,340.67	88.3
Other U.S. Production	56.52	3.7
Change in Stocks	-22.61	-1.5
Total	1,518.04	100.00



Supply Response for Oranges

$$\text{Plantings: } PL_t = f\left(E_t \sum_{k=t}^{t+K} \pi_k\right)$$

$$\text{Bearing Acreage: } A_t = A_{t-1}(1 - R_t) + PL_{t-4}$$

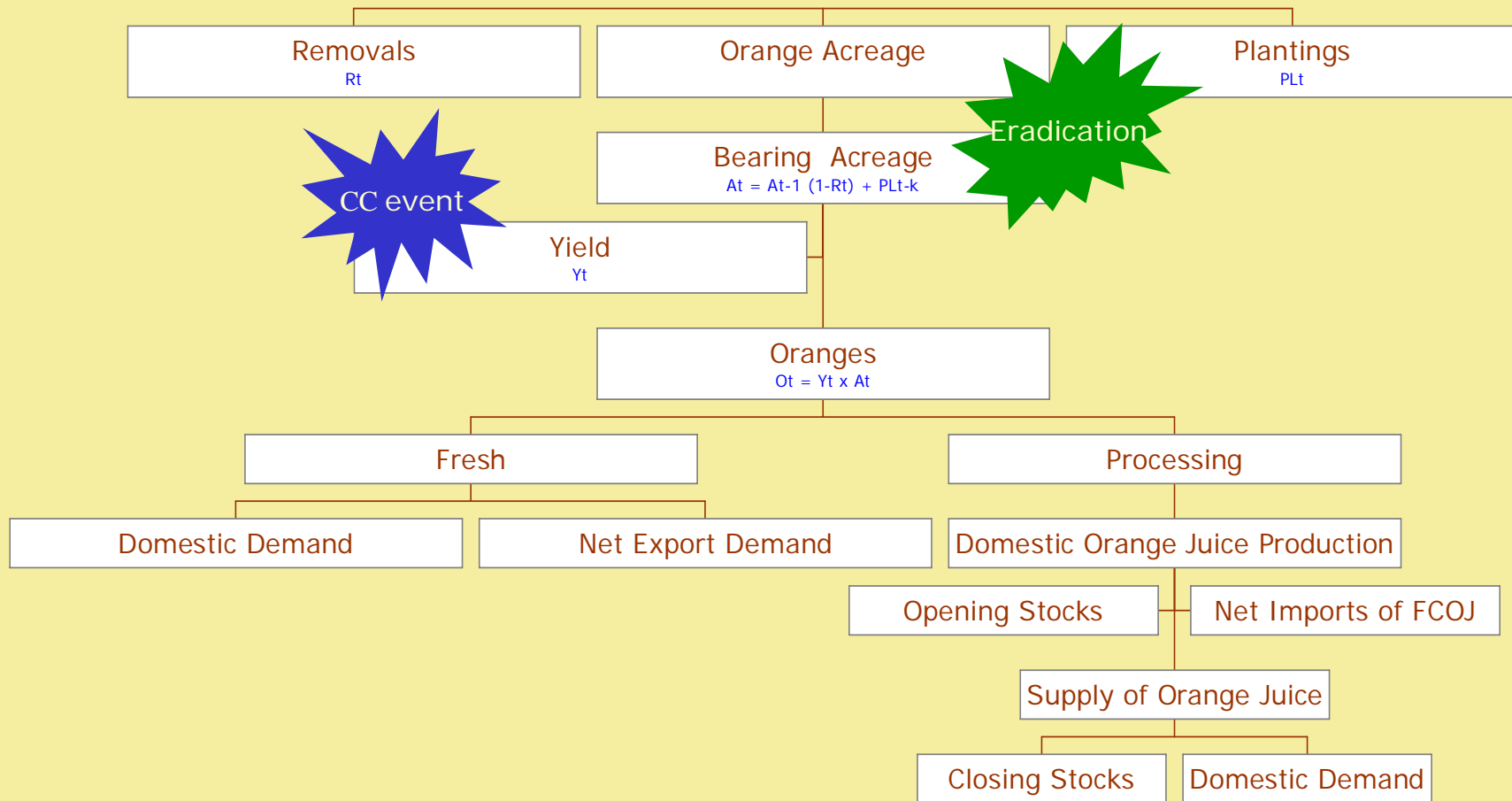
$$\text{Yield: } YM_{t+n} = (1 + y)^n YM_t (1 + \mu_{t+n})(1 - cc_{t+n})$$

-An age-specific yield profile of trees (which is a fraction between 0 and 1) transforms mature yields to age-specific yields.

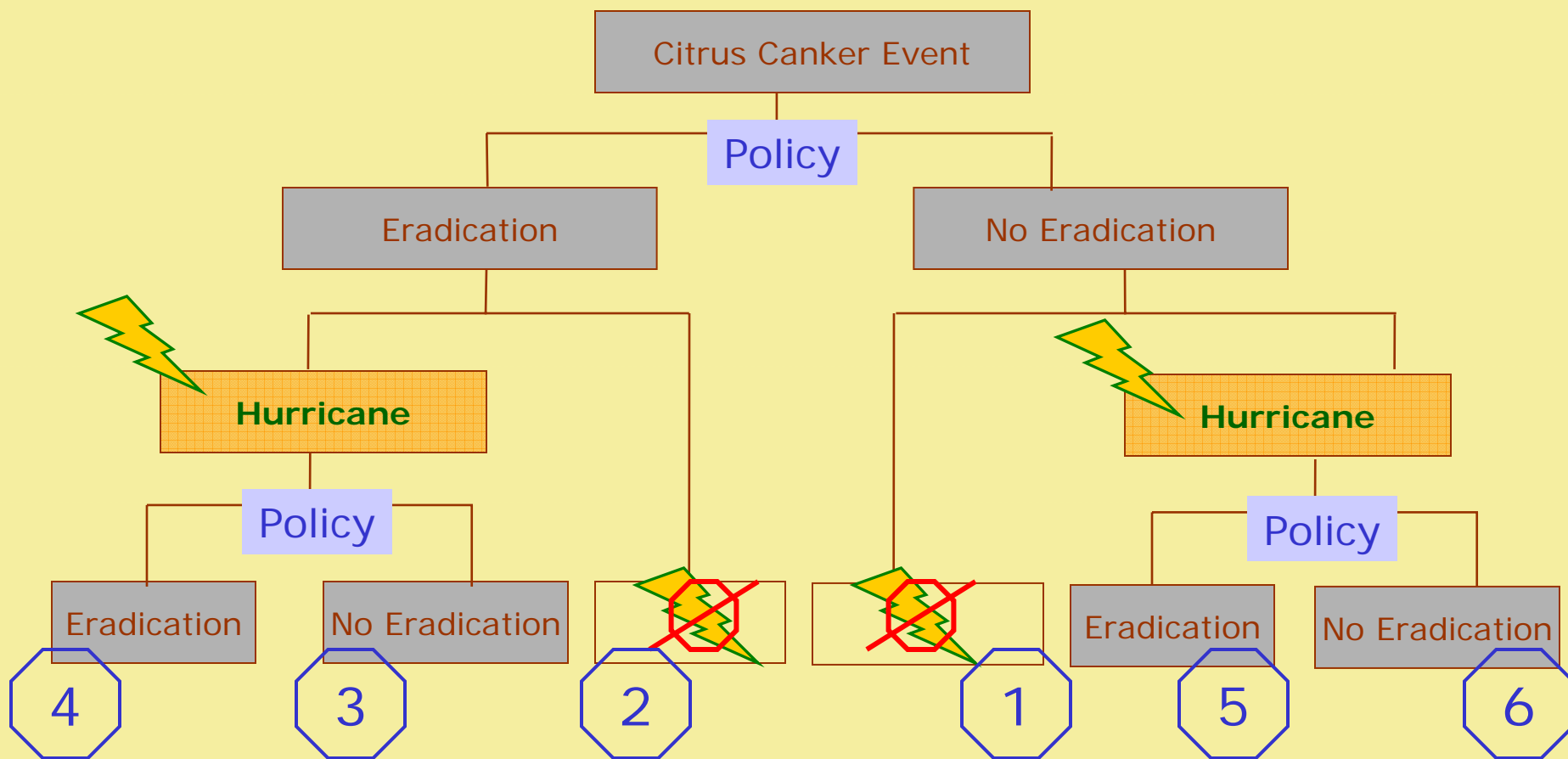
$$\text{Production: } O_t = \sum_i Y_{it} \times A_{it}$$



A Model of the Orange Market



Events and Actions After a Citrus Canker Infestation



Elasticities of Supply and Demand and Growth Rates

Elasticities

Elasticity of demand for fresh Florida oranges	-1.00
Elasticity of demand for Florida exports of fresh oranges	-4.00
Elasticity of demand for orange juice in the U.S.	-0.50
Elasticity of demand for orange juice stocks	-0.50
Elasticity of supply of orange juice imports	5.00

<i>Annual growth rates in supply and demand</i>	<i>(percent)</i>
U.S. demand for fresh Florida oranges (<i>d</i>)	1.25
Export demand for fresh Florida oranges (<i>e</i>)	-4.68
U.S. demand for orange juice (<i>c</i>)	1.90
U.S. demand for orange juice stocks (<i>s</i>)	1.99
Yield of Florida oranges (<i>y</i>)	1.56
Import supply of orange juice (<i>i</i>)	-11.00

Source: Elasticities are authors' assumptions and annual growth rates are past average growth rates over the period 1991 through 2002 computed by the authors using data obtained from Florida Agricultural Statistics Service.



Dates and Effects of Citrus Canker and Hurricane

- Simulation starts in 2004
- Citrus canker event in 2011.
- Affects 10% of acreage in Central region of Florida.
- Yield of affected acreage down by 10%.
 - ❖ If no eradication policy introduced, export demand for Florida fresh oranges down 50%.
- Under eradication, trees on 15% of acreage in the affected region pulled out, and no replanting for two years.
 - ❖ No loss of export demand.



Dates and Effects of Citrus Canker and Hurricane

- Hurricane occurs in 2016 and spreads Citrus Canker.
- Affects 10% of acreage in Central, Western, and Northern regions with eradication policy introduced in 2011.
 - ❖ Eradication policy following hurricane involves pulling out trees on 15% of acreage in 3 regions.
- Affects 15% of acreage in Florida state if no eradication policy introduced in 2011.
 - ❖ Eradication policy following hurricane involves pulling out trees on 20% orange acreage.
 - ❖ Under eradication policy, full recovery of export demand by 2021.



Obvious hurricane damage

But the spread of disease may be more costly



Welfare Change From a Citrus Canker Event and Eradication Policy

Changes in	Benefits from a Minor Event With no Eradication	Benefits from a Severe Event		
		No Eradication	Eradication	Benefits from Eradication
	<i>(annual values in millions of 2003 dollars over 50 years)</i>			
Producer surplus	-1.45	5.50	162.80	157.31
Consumer surplus	0.94	-8.21	-176.00	-167.80
Fresh oranges	0.05	-0.29	-6.69	-6.39
Processed oranges	0.89	-7.91	-169.32	-161.40
Taxpayer surplus	-0.01	0.03	-12.17	-12.20
Tariff	-0.01	0.03	1.99	1.96
Compensation	0.00	0.00	-14.16	-14.16
Total domestic surplus	-0.51	-2.68	-25.37	-22.69
Foreign surplus	-0.25	-0.25	-0.25	0.00
World surplus	-0.76	-2.93	-25.62	-22.69



Effects of a Hurricane on the Benefits from Eradication

	Benefits from Eradication in 2011 Given			Benefits from Eradication in 2016 Given	
	No Hurricane in 2016	Hurricane in 2016		Hurricane in 2016	
			No Eradication in 2016	Eradication in 2016	No Eradication in 2011
	(1)	(2)	(3)	(4)	(5)
Changes in	<i>(annual values in millions of 2003 dollars over 50 years)</i>				
Producer surplus	157.31	139.27	-57.64	441.51	244.60
Consumer surplus	-167.80	-145.17	79.82	-533.78	-308.80
Fresh oranges	-6.39	-5.57	1.52	-16.84	-9.75
Processed oranges	-161.40	-139.59	78.29	-516.94	-299.05
Taxpayer surplus	-12.20	-11.90	16.35	-52.65	-24.39
Tariff	1.96	1.95	-0.23	5.32	3.14
Compensation	-14.16	-13.85	16.58	-57.96	-27.53
Total domestic surplus	-22.69	-17.80	38.53	-144.92	-88.59
Foreign surplus	0.00	-0.06	-0.03	-0.08	-0.05
World surplus	-22.69	-17.86	38.50	-145.00	-88.64



Conclusion

- Simulations indicate that
 - Florida orange producers benefit from the eradication of the pest in Florida.
 - U.S. consumers, taxpayers, the nation, and the world as a whole lose.
 - The benefits and costs from the subsequent eradication following the hurricane are substantially higher, because the infection following the hurricane extends to several regions whereas the initial infection was confined to a smaller area.



Conclusion

- Interests of Florida orange growers are directly opposite those of the nation as a whole.
 - From the nation's view point, the optimal strategy in 2011 is also not to eradicate. If there is no eradication in 2011, then non-eradication after spread is still the optimal strategy.
 - If we will eradicate the disease after spread in 2016, then it is better to eradicate after initial outbreak in 2011.
 - From the producer's view point, if spread of the disease is expected, the optimal policy is to wait until the spread of the disease then eradicate. If no spread is expected, then eradicate in 2011.



Ongoing Work

- Currently extending the model to allow for the spread of the disease within counties and among counties.
- Examining the effects of varying probability of a hurricane occurring on Canker management decisions.
- Alternative funding schemes for paying for canker eradication (check-offs etc.).
- Extending the cases to other industries and other pests.

