Assignment #1

Impact of Historical Case Examples on Today's Agricultural Program

Introduction

The presence of exotic and invasive species of flora and fauna, as well as introduced pathogens, can threaten the delicate ecological balance present in a geographical area, affecting not only the ecosystems themselves but also the agriculture and economy that rely on their survival. Further, these species can affect human food production and health if left unchecked (Sumner 2003). Though most invasive species are introduced accidentally, intentional introductions of plants and insects (i.e. proposed biological controls) may also run awry and negatively affect agriculture or the functioning of ecological systems, despite their projected and calculated usefulness. The modern agricultural program, including governmental controls, rests on both current threats and a historical analysis of the success and failure of these previous cases. The North American Free Trade Agreement (NAFTA), the World Trade Organzation (WTO), and the Sanitary and Phytosanitary (SPS) Agreement found in the 1994 General Agreements on Tariff and Trade are just a few of the policies that indicate the importance of global cooperation and regulation to prevent the spread of pests (Sumner 2003). Governmental reactions to invasive pests have ranged from the establishment of quarantines to the creation of regulatory agencies (Lehman 1995). The presence of pests throughout most of history sets a clear precedent for instances of invasive species to continue into much of the future. The impact of historical cases on the establishment of the modern agricultural programs will be assessed by briefly examining the following three examples: cottony cushion scale (once a threat to the citrus industry), the screwworm (once a threat to livestock), the boll weevil (a threat to the cotton industry) and the red imported fire ant (currently a threat to wildlife and agriculture). Cottony Cushion Scale

The cottony cushion scale, Icerya purchasi Maskel, is known as an agricultural pest, especially to the citrus industry, because it feeds on the host phloem sap and can cause heavy damage to plants. Though the scale is rarely found on the fruit itself, early immatures settle and feed on leaves, older nymphs typically drift to twigs, and adults inhabit the branches and trunks of the trees (Fasulo & Brooks 2001). Heavy infestations of the scale can lead to losses of branches, leaves, and foliage in plants, decreasing the agricultural yield of citrus trees; the scale also causes mold growth and infestations of ants that consume the honeydew secreted by the feeding scales (Grafton-Cardwell 2003). Believed to have been introduced to California in the late 1860s from Australian acacia shipments, the insect quickly began to threaten the entire California citrus industry (Harmon & Fasulo 2008). The serious threat prompted an entomologist, Koeble, to seek a natural predator to counteract the exploding population; he brought the Vedalia beetle to California in 1889, where it rapidly reproduced and brought the scale populations under control. The pest eventually established populations in Florida in 1897, and the state has had to utilize similar controls to stop its impact on the citrus industry (Gossard 1901). Attempts to control the scale population led to a restructuring of both research and insect control in California and eventually throughout the entire United States, as biological controls were coupled with governmental quarantines to prevent the spread of the insect. Successful biological controls of this scale, including a parasitic fly Cryptochetum iceryae

(Will) and the vedalia beetle, Rodolia cardinalis (Mulsant), have reduced the agricultural damage it causes. The parasitic fly oviposits in both the mature larvae and pupae of the scale; the vedalia beetle, which matures quickly, both feeds on scales (those not infested by the parasitic fly) and lays its eggs inside the scale sac, keeping the cottony cushion scale population under control, but does not eliminate it entirely. Chemical controls are used less often than biological ones, except in cases of high infestations in young groves or plant nurseries (Fasulo & Brooks 2001).

The successful control of the cottony cushion scale set a historical precedent for immediate government action in response to infestations, and the response highlights an early case of the success of natural biological controls to manage invasive species; researchers still continue to search the native home of invasive pests to find natural predators and import them to the U.S. to control infestations. Screwworm

The screwworm, Cochliomyia hominivorax, is a parasitic fly that enters animal wounds and causes myiasis in the living tissue. Infection of the screwworm in cattle causes hide damage, and large infestations can lead to livestock death and have been known to infect and kill humans as well as other animals (Krasfur et al.1987). The adult flies oviposit on warmblooded animals, and the larvae enter open wounds, where they feed on living tissue until they fall to the ground to pupate and emerge as adults (USDA/APHIS 2001).

A pest established in the United States as early as the 1820s, the screwworm has caused hundreds of millions of dollars of annual damages to the livestock industry, originating in the Western states but spreading to the Southeast by the 1930s (USDA/APHIS 2001). Because chemical controls of the insect were ineffective against the vast populations, the USDA sought a new method to eradicate the pest in the early 1950s, now called the sterile insect release technique (SIT; Krasfur et al. 1987). Researchers exposed screwworm pupae to gamma radiation, creating generations of sterile male flies. When released into infested areas, these sterile males attempted to breed with females but no longer could successfully produce offspring. Each successive generation of the population became smaller until no new offspring were produced. The technique was effectively used in Florida in 1957, leading to the complete eradication of the pest from the southeastern United States by 1959 (USDA/APHIS 2001). SIT was eventually applied to the southwestern United States in 1962, and the self-sustaining colonies of screwworms were considered officially eradicated from the U.S. by 1966. Governmental regulations of "sterile fly barriers" have prevented the reinfestation of the screwworm in the United States.

Because of the successful use of this biological control to eradicate the pest from the United States, SIT has been used in neighboring countries, such as Mexico (which was declared free of the screwworm by 1991), and utilized in Central and South American nations to stop the establishment of self-sustaining fly colonies (Krasfur et al. 1987). This historical case exemplifies the use of a new scientific technique (SIT) that is still commonly used to control pests today, and set a model for international cooperation to control and eradicate a major pest from neighboring countries.

Though the United States successfully eradicated the screwworm in 1966, the USDA predicts that a reintroduction of this pest could cause almost $750 million in damages to the cattle industry. Recent discoveries of screwworm larvae in a dog in 1997 and a horse in 2000 have prompted urgent action (and immediate treatment), as the agricultural community continues to fear the accidental reintroduction of the pest by infested travelers or animals. Veterinary warnings about the screwworm, coupled with governmental barriers and programs, are still utilized to prevent the threat of the damaging pest (USDA/APHIS 2001). Boll Weevil

The boll weevil, Anthonomus grandis, is a major pest to the cotton industry throughout the United States. Introduced into Texas in 1892, the boll weevil has cost cotton producers more than $200 million each year, in addition to over $75 million in attempts to control the population and millions of dollars spent on pesticides (Cross 1973). The adult boll weevils feed on immature cotton bolls (buds) as the females lay their eggs; after hatching, the larvae burrow into the cotton bolls and feed for days before pupating. The adults emerge from the cotton squares and continue to cause damage unless in their temporary state of diapause.

Because of the overwhelming cost the boll weevil causes to farmers, the USDA has sought methods to work cloesly with state governments to eradicate the pest. After the successful eradication of the pest from North Carolina and Virginia in 1978-1980, the USDA established the Boll Weevil Eradication Program to control the pest throughout all cotton farms in the rest of the United States. The program utilizes three individual techniques over a three- to five-year period: “pheromone traps for detection, cultural practices to reduce the weevil’s food supply, and chemical treatments for control” (USDA/APHIS 2006). Traps are used to capture and assess the boll weevil problem and maintain awareness of the levels of the pest, and pesticides such as malathion (usually requiring multiple applications) has been successfully sprayed over cotton fields to kill populations of the insect.

Eradication of the pest is predicted to increase the cotton yield of a field by ten percent or more, successfully reducing the costs of production and increasing the stability and acreage of the cotton industry (and, therefore, increasing profits by millions of dollars). The use of other pesticides on the crops is reduced from 40 to 100 percent. In 2006, the USDA even predicted that nationwide eradication of the boll weevil would occur by 2009, marking this program as an incredibly successful use of integrated pest management (IPM) in the United States (USDA/APHIS 2006); the success of this program has prompted and encouraged the use of IPM to control many other invasive species. Red Imported Fire Ant

The Red Imported Fire Ant (RIFA), Solenopsis invicta (Buren), is a both an urban and an agricultural pest to many areas of the United States. Believed to have been originally introduced to the U.S. through soil brought into Mobile, Alabama around 1930 (USDA/APHIS 2009), the RIFA is now commonly found throughout the country from the Central Valley of California to the state of Florida. Because of its antagonistic nature, the invasive insect has been extensively studied to understand its biology and control of its spread (as more often threatens agriculture and other beneficial organisms); the RIFA can also act as a biological predator and control for some other pests, including the aforementioned boll weevil (Fillman & Sterling 1983). The extremely aggressive ants, which can nest in mounds 35 centimeters high or larger, readily attack animal or human intruders with their venomous stings, and often infiltrate sprinklers, mechanical equipment, and even traffic signals when searching for new areas to colonize (Klotz et al. 2003).

Especially in California, where the pest continues to be brought into the state through commercial trade with infested states, affecting wildlife, homeowners, growers, and even their crops, researchers are seeking to find ways to (1) prevent entry, (2) eradicate outbreaks, and (3) contain established populations of the insect (Klotz et al. 2003). If the insect spreads throughout the state of California, researchers predict that direct damage to crops will be coupled with the costs of repairs from intrusion, insecticide treatments, and medical treatment of humans and animals and reach losses between $387 and $989 million, excluding the effect of the pest on the biodiversity of the state's ecology; birds, reptiles, tortoises, rodents, and many endangered species in the state are threatened by the presence of the ant (Klotz et al. 2003). The RIFA affects the agriculture of soybeans (in Georgia and North Carolina), citrus plants, potatoes, cucumbers, and many others, as the voracious insects feed on the plants themselves, affect machinery used to harvest the plants, and even interfere with the plant roots systems (Stimac & Alves 1994).

The aggressive and volatile nature of the RIFA causes a majority of the problems with this invasive pest. Because of its current impact and potential for severe future damage, many researchers are searching for both chemical (i.e. mound control) and biological controls (i.e. pathogens, parasitic flies, and parasitic ants) to eliminate the threat. The RIFA, unlike the cottony cushion scale, screwworm, and boll weevil, represents a pest that has not yet been successfully controlled or eradicated and continues to present a growing threat to agriculture and biology in the United States. Quarantines and extensive research programs have been implemented and are still in use to combat this pest. Furthermore, cost- benefit analyses and economic models are being used to determine the most effective and efficient methods of control; these programs reflect the continuation of research and government legislation/control in the modern context to find innovative ways to combat invasive species. Overview and Conclusion

As seen in multiple case examples, the investigation of agricultural pests requires interaction and cooperation between the agricultural industry, researchers, and the government. Some pests of historical importance have forced the establishment of protocols and programs still used today to combat these species. The accidental introduction of the cottony cushion scale to the United States quickly led to a population that threatened the entire citrus industry of California but was rapidly counteracted by legislative sanctions and a successful biological control (the predatory Vedalia beetle from Australia). The presence of the screwworm threatened the livestock industry of the Southwestern and Southeastern U.S., only controlled when the sterile insect technique (SIT) decreased the population size and eradicated the pest from the United States (and eventually Mexico). The boll weevil, once a great threat to the cotton industry in the United States, has been controlled through an integrated pest management program of chemical, cultural, and cooperative methods. Unlike the cottony cushion scale, the screwworm, and the boll weevil, however, the aggressive red imported fire ant has not been successfully eradicated and continues to pose a threat to wildlife and agriculture from California to Florida. These case examples show a variety of governmental and agricultural response to known pests, allowing for an understanding of the history of the modern agricultural program to better predict its future directions. With the continuation of cooperation between research and government (as well as international cooperation), the agricultural industry will continue to fight off the damaging pests that threatened its existence.

References

Cross, W. H. 1973. Biology, Control, and Eradication of the Boll Weevil.
Annu. Rev. Entomol. Entomology 18: 17-46. Fasulo, T. R. and R. F. Brooks. 2001. Scale pests of Florida citrus. Series
of the University of Florida, Entomology and Nematology Department ENY- 814. Available from http://edis.ifas.ufl.edu/CH059. (Accessed September 12, 2009).

Fillman, D.A. and W.L. Sterling. 1983. Killing power of the red imported
fire ant [Hym.: Formicidae]: a key predator of the boll weevil [Col.: Curculionidae]. Biocontrol 28: 339-344.

Gossard, H. A. 1901. The cottony cushion scale. Florida Agric. Exp. Station
Bulletin 56: 309-356. Grafton-Cardwell, E. E. 2003. Cottony Cushion Scale. IPM Education and
Publications, UC Statewide IPM Program, University of California, Davis, CA. Available from http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7410.html. (Accessed September 12, 2009).

Hamon, A. B. and T. R. Fasulo. 2008. Cottony Cushion Scale, Icerya purchasi
Maskell. Series of the University of Florida, Entomology and Nematology Department EENY-034. Available from http://edis.ifas.ufl.edu/pdffiles/IN/IN16100.pdf. (Accessed September 12, 2009).

Klotz, J.H., K.M. Jetter, L. Greenberg, J. Hamilton, J. Kabashima, and D.F.
Williams. 2003. An Insect Pest of Agricultural, Urban, and Wildlife Areas: The Red Imported Fire Ant, pp. 151-166 In D.A. Sumner (ed.) Exotic pests and diseases: Biology and Economics of Biosecurity. Iowa State Press, Ames, Iowa. 276 pp.

Krasfur, E.S., C.J. Whitten, and J.E. Novy. 1987. Screwworm Eradication in
North and Central America. Parasitology Today 3: 131-137. Lehman, P.S. 1995. Nematodes and Other Introduced Pests that Provided
Impetus for the Establishment of Regulatory Agencies in the United States. Nematology Circular No. 212. Florida Dept. Agric. and Consumer Serv., Div. Plant Industry, Gainesville, FL. Available from
http://www.doacs.state.fl.us/pi/enpp/nema/nemacirc/nem212.pdf. (Accessed September 13, 2009).

Sumner, D. A. 2003. Exotic Pests and Public Policy for Biosecurity: An
Introduction and Overview, pp. 3-6 In D.A. Sumner (ed.) Exotic pests and diseases: Biology and Economics of Biosecurity. Iowa State Press, Ames, Iowa. 276 pp.

Stimac, J.L. and S.B. Alves. 1994. Ecology and biological control of fire
ants, pp. 353-380 In D. Rosen, F.D. Bennett and J.L. Capinera (eds.) Pest Management in the Subtropics: Biological Control - A Florida Perspective. Intercept Publ. Co., Andover, U. K. 737 pp.

USDA/APHIS. 2006. Plant Protection and Quarantine Factsheet: Boll Weevil
Eradication. Available from

http://www.aphis.usda.gov/publications/plant_health/content/printable_version/fsbollweevil.pdf. (Accessed September 12, 2009).
USDA/APHIS. 2009. Red Imported Fire Ant, Solenopsis invicta Buren. Available from http://www.aphis.usda.gov/lpa/pubs/invasive/4fireant.html. (Accessed September 12, 2009).
USDA/APHIS Veterinary Services. 2001. Screwworm. Available from http://www.aphis.usda.gov/lpa/pubs/fsscworm.html. (Accessed September 12, 2009).