CHAPTER 56

Eradication: Is it Ecologically, Financially, Environmentally, and Realistically Possible?

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INTRODUCTION

Eradication is the removal of every potentially reproducing individual of a species from an area that will not be reinvaded by other members of the species. The undertaking of an eradication program implies that the program organizers have the right, jurisdiction, and technological ability to eliminate the species, and that cost-benefit analyses support the decision. Exotic species are the most frequent targets of eradication programs, and their potential removal from the ecosystem is likely to be acceptable to most people, particularly those who are not directly involved. However, the financial, environmental, and potential health costs resulting from exposure to poisons or insecticides that accompany large-scale eradication programs are usually unacceptable to a portion of society. In addition, individuals often are required to give up certain rights for the sake of the area-wide program, consequently obtaining the necessary cooperation for eradication programs is sometimes difficult (Collins et al., 1999; Kazmierczac and Smith, 1996).

Complete eradication, which is really the only kind, is likely to be successful only under certain circumstances. Six requirements for successful eradication outlined by Myers et al. (2001) are (1) sufficient funds, (2) clear authority of a lead agency, (3) a target species that is biologically susceptible to eradication procedures, (4) feasible prevention of reinvasion, (5) methods for continued surveillance, and (6) restoration if necessary. Eradication is most likely to succeed when the target population is very small and restricted. For introduced species, by the time the presence of the species is discovered, the number of individuals can be quite large and possibly past the threshold for feasible eradication. Populations in well-defined island habitats to which dispersal does not occur, are the most vulnerable to eradication. For example it may be possible to eradicate wasps from a building, or plants or animals from small islands or lakes, or a disease organism from a human body. But on a larger scale, eradication is unlikely to succeed except in cases of homogeneous habitats, and in programs in which financial support is plentiful and environmental side effects are of no consideration.

An eradication program may be undertaken when an exotic species is first identified in a new geographic area or it may involve a pest species that is well established. Almost always programs are initiated by a government agency that has the necessary jurisdiction, but may require further regulations that compromise private property rights. To engender support for an eradication program, the agency involved must inform and convince the public that the program should be

1-56670-612-2/03/$0.00+$1.50

undertaken. Public relations are particularly difficult because initially there could be little interest in the project. Furthermore, the agency may already have decided to proceed with the project, and a skeptical public may interpret the agency's promise of success as unrealistic, or doubt the potential damage that the target species can cause. A danger is that the program proponents assume the attitude of the experts: "Just trust us, because we know best." Critical review of proposals may be avoided to reduce controversy, but in the long run doing so is probably not wise.

Justification of eradication programs usually begins with a cost-benefit analysis. The biases involved in cost-benefit analyses have been reviewed in Myers et al. (1998). Estimation of the benefits of eradication is influenced by the length of time over which the costs will be amortized. If a pest species is eliminated, its destructive actions will be removed forever. Therefore, the estimated benefits can be enormous. However, projecting the benefits into the future can be misleading. If, for example, successful eradication increases the supply of a commodity, this could reduce its value and the profit made by the grower. Accurately predicting the influences of a newly established exotic organism can be difficult, thereby biasing the cost effectiveness estimates. Will it become established? Will it create economic damage? A strong commitment by the lead agency may cause the estimates of benefits to be inflated and those of costs to be conservative. Estimated costs do not always cover all of the contingencies. Unanticipated costs are almost always going to occur. Some factors that may not be adequately estimated include; costs for long-term monitoring of:

- Success or failure
- Public relations
- Preventing reintroductions,
- Lawsuits
- Human health problems
- Human error
- Compensation for lost crops
- Initial population reduction that may require removal of host trees and extensive spray programs
- Continuing the project until the last individual is eliminated.

Three eradication programs that have been undertaken in British Columbia, Canada and serve to illustrate prospects for success in estimating cost effectiveness and in eradicating the target species.

GYPSY MOTH

The gypsy moth (*Lymantria dispar*) is native to Europe and Asia. The European form of gypsy moth was first introduced to North America in Massachusetts in 1869 (Elkinton and Liebhold, 1990). The preferred hosts of the gypsy moth are deciduous trees, particularly oaks, although larvae will feed on conifer foliage. The species has now spread north through Quebec, Ontario, New Brunswick, and Nova Scotia, in eastern Canada, south into Virginia and North Carolina, and west into Michigan. After an efficient pheromone trapping system was developed in the mid-1970s, monitoring for new introductions of the moths was undertaken in western states and provinces. The first captures of male gypsy moths in British Columbia occurred in 1978 (Pacific Forest Centre Web Site, August 1999). Since that time captures have been made at approximately 120 sites (Figure 56.1). Eradication programs have been carried out at 20 of these sites to –prevent" establishment. A microbial spray with the active ingredient *Bacillus thuringiensis kurstaki* (Btk) has been used in these programs. The advantage of this spray is that it is specific to Lepidopterans, but the belief of some people that spraying of bacteria threatens human health is disadvantageous. Therefore, proposed aerial spray programs in British Columbia all have been associated with a public out cry.

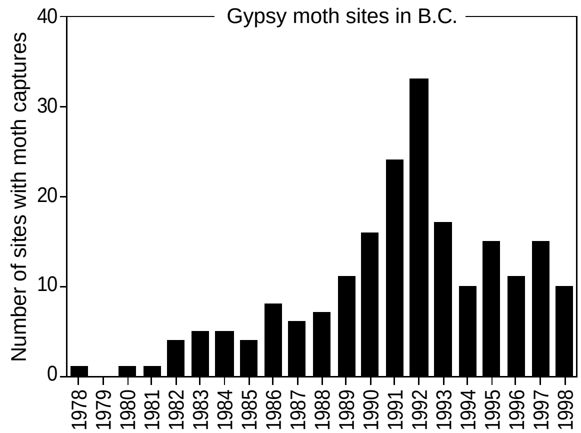

Figure 56.1 Number of sites with captures of male gypsy moths in the pheromone trap monitoring program in British Columbia. Data from the Canadian Forest Service, Pacific Forestry Centre web site.

The largest gypsy moth eradication program in British Columbia was undertaken in 1992. The city of Vancouver (20,000 ha) was sprayed from the air three times at the cost of approximately $6 million. This followed the capture of 23 males of the Asian form of gypsy moth in a relatively restricted area near the grain port in Vancouver 1991. The Asian gypsy moths are more likely to feed on conifers, particularly larches, and unlike the European gypsy moth, female Asian gypsy moths fly and are attracted to lights. During population outbreaks in the early 1980s and 1990s in eastern Russia, female moths were attracted to the well-lit grain terminals, and many hatching egg masses were found aboard Russian grain ships arriving in Vancouver during spring of those years. Small caterpillars are assumed to have been carried from the ships to trees near the port by the wind.

The proposed eradication program initially aroused very little public interest, but as awareness grew, discussion eventually became heated. Of particular controversy was the use of the microbial spray, its possible effects to human health, and the patent protection that prevented disclosure of all of the ingredients in the spray, Foray B. Experts were imported from the United States to describe the potentially devastating result they anticipated if this species should become established. Local officials declared that once the spray program was undertaken, the Asian gypsy moth would be eradicated. That claim was optimistic, and in 1993, 1994, and 1995 several male Asian gypsy moths were captured in the vicinity of Vancouver, although no further spraying was undertaken and no moths have been captured subsequently. The Asian gypsy moth seems to have not become established.

Since 1987, various numbers of male European gypsy moths have been captured at sites in southern Vancouver Island almost yearly. Eradication programs were begun in 1988. Between 1995 and 1998, the number of males collected in traps that were placed to delimit the distribution of the gypsy moth in this vicinity rose from 5 to 280, and egg masses were found (Pacific Forest Centre web site, 1999). In 1999, Southern Vancouver Island was declared to be a regulated area requiring inspection of Christmas trees, nursery stock, and outdoor household articles before they may be transported from that area into unregulated areas (those without established gypsy moth populations) of the United States. In 1998, a spray program was proposed, but permits were denied following court action involving health concerns of some citizens. However, in the summer of 1999, a $3 million aerial spray program was undertaken.

Is the gypsy moth a threat to British Columbia? The gypsy moth primarily defoliates deciduous trees and therefore its potential influence is largely as a nuisance in recreational and urban areas. However, Canada regulates gypsy moths to protect export trade with the United States. Regulated areas are established based on survey results, and certification programs ensure that material shipped from infested areas are inspected for freedom from gypsy moths (, Stubbings, personal communication). Although expensive, the cost of aerial spray programs is less than that for certification of materials, including lumber, which would result if the whole province were to become a regulated area. Jurisdiction in this case falls to the United States that requires eradication of the gypsy moth in British Columbia to prevent trade restrictions.

Gypsy moth introductions to British Columbia from eastern North America will continue, and each aerial spray program is likely to be met with an outcry from concerned citizens. While eradication programs with Btk have reduced gypsy moth populations, moths frequently are caught in these locations at a later date (Myers and Rothman, 1995). Even if not successful as eradication, population outbreaks and further spread of gypsy moths are reduced by spray programs. Slowing the spread is an alternative to eradication for introduced species (Myers et al., 2000). Attempted eradication of the gypsy moth is more about trade and trade barriers than biology.

CODLING MOTH

Codling moth (*Cydia pomonella*) is the most serious pest afflicting apples worldwide. It is native to western Asia and eastern Europe but occurs now in all apple-growing areas. The amount of damage caused by codling moths is partly influenced by the number of generations that occur each year, a figure that can vary from one to three. Soon after hatching from the egg, codling moth larvae enter the fruit where they feed on the seeds. When fully developed they burrow out through the fruit. In British Columbia the crop may be down graded at the packing house if more than 0.5% of the fruit is damaged by worms. Codling moth is particularly troublesome for organic fruit growers.

In the 1970s, a pilot project was undertaken by the Canadian Department of Agriculture in the Similkameen Valley in the southern Okanagan region of British Columbia to investigate the feasibility of eradicating codling moth through the use of sterile male release (Proverbs et al., 1975, 1982). This project was carried out in a 500 ha apple-growing area over three years. By the end of the program most orchards in the area had no codling moths, but 7 of the 476 orchards had apple damage above the acceptable level. The cost of the program was $225/ha/year compared to normal investment of $95/ha/year for insecticide control. The conclusion at the end of the project was that eradication would not be feasible, even considering that insecticide use was reduced for several years. Further expansion of the program was not recommended.

Rather surprisingly, in the late 1980s, renewed interest was expressed by Agriculture Canada in initiating a codling moth eradication program for the whole Okanagan Valley, from Kelowna in the north to Keremeos in the south (Myers et al., 1998, 2000; Winston, 1998). Agriculture Canada and the B.C. Fruit Growers Association became partners in the program that was funded by the federal and provincial governments and by special taxation on both orchardists (approximately $195/ha) and urban and rural land owners ($45/ha). To sell a special tax to the taxpayers required a very positive spin to be put on the project, and the cost-benefit analysis was very optimistic as a result. The aim was to initially eradicate codling moths first from the southern end of the valley and eventually to expand the program to the north. The economic analysis amortized costs over a long period of time and this enhanced the financial benefits side of the equation. The proponents underestimated some costs in the analysis, such as the enormous cost required to initially reduce the moth population with spray programs, fruit culling, and removal of abandoned and urban fruit trees. The costs of monitoring and evaluation were minimized, and other technologies, such as mating disruption and the possible development of viral sprays, were initially ignored. Critical comment on the program was ignored or suppressed. People were easily convinced because everyone wanted the program to succeed. Everyone wanted to reduce insecticide use, and the sterile insect release (SIR) causes no negative environmental side effects.

A state-of-the-art moth rearing facility was built and the program began. Five years into the program the feasibility of eradicating gypsy moth was evaluated. One of the major problems influencing the success of the SIR was the failure of the first generation of sterile males to fly actively and to compete for mates with wild males. The initial reduction of wild populations was slow and expensive. Growers began turning to other controls such as mating disruption or even chemical sprays. Between 1995 and 1998, the percentage of orchards with no codling moth damage increased from 42 to 84%, and the percentage of traps with wild moths declined from 98 to 60% (Anonymous, 1999). But clearly eradication remained allusive. In the winter of 1998–1999 the program goal was changed from eradication to area-wide suppression with the long-term goal of eventual eradication (Fisher-Fleming et al., 1998). By the summer of 2001, codling moth densities were very low in the southern Okanagan Valley (Edwards, personal communication).

Eradication of the codling moth in the Okanagan Valley is an unrealistic goal for several reasons. For one, land use in the area is heterogeneous. In addition to commercial orchards the region contains urban lots with backyard apple trees, and abandoned orchards. Part of the area is in native land reserves under a separate jurisdiction. Reintroduction of moths to treated areas is difficult to stop unless the movement of fruit bins is very carefully controlled. The value of apples has been declining because worldwide production is high and therefore prices are low. Maintaining a program that is more than twice as expensive to the growers as chemical control must show rapid results or support declines. On the other hand, the high capital cost for the rearing facility and the optimistic promises of the program team make the eradication program difficult to stop.

The advantage of the sterile insect release approach to eradication is that it is species specific and environmentally friendly, although high levels of insecticides are initially required to reduce moth populations. The greatest long-term costs of the failure of this program are the growers' increased mistrust of scientists' advice and the poor value for taxpayers’ dollars. Whether it is economically feasible to use SIR as part of an integrated pest management strategy remains to be seen.

THE NORWAY RAT ON LANGARA ISLAND

Langara Island (3,100 ha) on the northwest tip of the Queen Charlotte Islands was formerly one of British Columbia’s largest sea bird colonies with six species of burrow-nesting birds. Between 1971 and 1980, four of these bird species became extinct and populations of the ancient murrelet were greatly reduced. The Norway rat (*Rattus norvegicus*) is known to have a large impact on colonial seabirds and even displaced black rats from Langara Island during the seabird decline (Bertram, 1994; Bertram and Nagorsen, 1995). Diet analysis indicated that Norway rats did attack ancient murrelets (Drever and Harestad, 1998). By 1992, experimentation had shown the effectiveness of a new anticoagulant rat poison, brodifacoum, for eradicating rats from small islands in New Zealand (Taylor and Thomas, 1989). The advantage of this poison is that it kills the rat after one dose, but it is slow acting, which has implications to the social system of rats. In 1993, $2.5 million became available for seabird enhancement as mitigation for the Nestucca oil spill. In hopes of restoring Langara Island as a successful breeding colony, a rat eradication project was undertaken. In 1994, a pilot project was carried out on Lucy Island, a small, nearby island. The use of fixed stations baited with poison pellets was successful in removing rats from Lucy Island, and the next year a large-scale program was launched on Langara Island. In July 1995, the eradication of rats from Langara Island began. Bait stations were placed at 100 m intervals with the aim of having one in each rat home range. In total, 3905 bait stations were used. By August 1995 most rats were gone and none were captured between 1996 and 2001 (Kaiser et al., 1997; Taylor et al., 2000; Kaiser, personal communication).

The poisoning program had some impact on other animals on Langara Island (Howald, 1997). Ravens learned how to extract the poison pellets, and approximately 50% of the raven population was killed. Eagles would not feed on dead rats but did eat poisoned ravens and also suffered some mortality. Raven populations have since recovered through immigration from other islands. Ancient murrelets do not breed until the age of three or four years, so recovery will be slow. The continued success of this program depends on preventing a reintroduction of rats. Because Langara Island is isolated and the sites visited by humans are localized, that may be possible.

The factors that contributed to the success of the program included the effective poison, territorial behavior of the rats, the isolated nature of the island, and the fact that the rats were not thriving because food was limited. Seasonal laborers and volunteers enabled this program to be carried out on such a large scale. This successful program is also well documented.

CONCLUSIONS

Eradication programs are difficult to evaluate because little information is available in the published literature. Monitoring is often not carried out in a rigorous manner, and the desire for success is strong. Therefore, undesirable or compromised results are not welcome. In eradication programs of insects, such as those for the gypsy moths, numbers of male moths trapped may be recorded, but the number of traps used are not. Such limited documentation undermines the ability to compare the numbers caught in different areas and in different years. Evaluation of the growth or decline of populations is difficult. Eradication programs are always very expensive, and the large scale of projects sometimes influences the impetus to maintain the project.

Programs can be classified into three categories: those called eradication for the purpose of preventing trade barriers (gypsy moth eradication), those called eradication of well- and widely established native or exotic organisms (usually insects) that should truly be called area-wide management (codling moth eradication), and those that target the removal of a species from a defined area for which eradication is possible (Norway rat eradication). I believe that eradication should be attempted only in very restrictive situations in which it can be complete and permanent. That will occur in situations in which the distribution of the organism is limited, either because it is newly introduced and concentrated in a particular area, or because it is on an island with limited access. Vertebrates are likely to be more susceptible to eradication because they are more readily detected than invertebrates, they may have limited breeding seasons, and baited poisons have been developed that have been shown to be effective.

Programs should be undertaken only following realistic economic evaluation and should be carried out only when the benefits are sufficiently great to warrant what may have to be an extended and expensive program. Having an emergency response plan in place for dealing with introduced species that may become pests is important. A model that could be emulated by other countries is that of Hosking (2001). This document outlines six response phases: (1) detection, (2) evaluation, (3) the response decision, (4) the operation phase, (5) the monitoring stage, and (6) the review stage. In the early stages of a program, communicating honestly with members of the public who will pay the cost of the program is most important. Program directors should realize that in the long run the truth will emerge. If an eradication program is not successful, the credibility of the scientist usually suffers if unrealistic promises have been made. It is best to call area-wide management by its name rather than proposing that a widespread or frequently introduced organism can be successfully eradicated. Slowing the spread might be an alternative to an eradication program (Sharov and Liebhold, 1998) with more achievable goals. And finally, the monitoring and review stages are most important in evaluation of eradication success or reasons for failure. These should not be forgotten.

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