The eradication of possums from Kapiti Island, New Zealand

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Abstract The Australian marsupial the brushtail possum *Trichosurus vulpecula* was introduced to Kapiti Island, a nature reserve off the south-west coast of New Zealand, in 1893. Various attempts were made to control possums on Kapiti because of their negative impacts on forest ecosystems. Possums can kill individual trees, potentially alter forest succession and regeneration processes, suppress flowering and fruiting, and prey upon native birds and other native animals. Possum control was initiated in 1980 and approximately 21,000 possums were removed by 1985. Eradication was achieved using traps, dogs and guns. Dogs located 32 of the 80 possums that were removed during 1985-1986. This programme has shown that dogs and intensive trapping are effective tools for eradicating possums from large areas of land where re-invasion is prevented. Eradication attempts are inherently risky and require a bold commitment from those bureaucracies with the responsibility to succeed. Thorough planning and highly skilled and motivated teams are essential ingredients to the success of eradication attempts.

Keywords Leg-hold traps; trained dogs.

INTRODUCTION

The Australian brushtail possum (*Trichosurus vulpecula*) was introduced to New Zealand in 1840 and subsequently released at many different sites throughout the country by Acclimatisation Societies and private individuals to establish a fur industry (Pracy 1974). The possum has been a very successful colonist, reaching high densities in favoured habitats (>30 possums/ha), and occupying a wide range of habitats throughout New Zealand (Clout and Ericksen 2000). Possums are pests that have had dramatic impacts on native plant and animal communities, and ecological processes, and they impact on agricultural production through the spread of bovine tuberculosis.

Possums were controlled on Kapiti Island by trapping between 1920 and 1968 to protect conservation values. The value of this control was disputed and a moratorium was placed on trapping in 1969, when research commenced to better quantify the importance and nature of possum impacts (Cowan 1992).

Atkinson (1992) studied possum impacts on native vegetation on Kapiti Island between 1969 and 1980. He observed "increasing defoliation, and sometimes mortality, of species vulnerable to possums" and he concluded, "had this continued, major changes in the structure and composition of the island's forests would have followed". Possums compete with birds and insects for food (foliage, flowers and fruit). They are also known to prey on eggs, chicks and adult birds (Brown *et al.* 1993), and have contributed to the local extinction of North Island kokako (Innes *et al.* 1999). However, at the time that research was carried out on Kapiti Island little was known of their impacts on birds. Phil Cowan was supported by a range of other scientists and Lands and Survey staff when he proposed eradication of possums following the success of possum control between 1980 and 1982 (Cowan 1982).

Four government departments with overlapping responsibilities were involved in the debate over the justification and feasibility of eradication. The eradication of cats from Little Barrier Island in 1980 (Veitch 2001) offered psychological weight in favour of eradication (B. Bell pers. comm.). The New Zealand Forest Service was the one department that favoured sustained control over eradication but still contributed significantly to the eradication programme, primarily due to political pressure. This debate was not fully resolved at the time but a commercial operation turned into intensive control that eventually evolved into an eradication programme (at least in the minds and hearts of those on the ground). Possums were eradicated from Kapiti Island in October 1986.

The eradication of possums from Kapiti Island has been described elsewhere by Cowan (1992) in a scientific paper and some of the methods by Sherley (1992) in a published report. This paper differs from Cowan (1992) by describing more fully the methods used and from Sherley (1992) by expanding on the lessons learned. We describe in detail the methods used and their relative importance, and outline the key ingredients for success that can be applied elsewhere to eradicate possums and other introduced pests.

KAPITI ISLAND

Kapiti is a rugged island lying 5 km off the south-west coast of the North Island of New Zealand. It has precipitous western cliffs that run along a fault line and numerous streams and gullies dissect its eastern slopes. Tall podocarp forest once covered Kapiti but it was largely deforested by Maori and European fires and farming in the 19th and

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early 20th century (Maclean 1999). The island's vegetation has regenerated (assisted by plantings and introductions by caretakers) in the 20th century and the island is now a mosaic of forest and shrubland with some grassland. Tawa (*Beilschmiedia tawa*) and kohekohe (*Dysoxylum spectabile*) are the dominant canopy species but shrublands dominated by kanuka (*Kunzea ericoides*) and fivefinger (*Pseudopanax arboreus*) are the most common vegetation type (Atkinson 1992). Kapiti was gazetted a nature reserve in 1897.

Kapiti is one of New Zealand's most exciting restoration stories. At 1965 ha, it is New Zealand's second largest offshore nature reserve and the largest single area of lowland coastal forest that is free from introduced mammalian herbivores and predators. It provides a home for various endangered bird species including little spotted kiwi (*Apteryx owenii*), saddleback (*Philesturnus carunculatus*), kokako (*Callaeas cinerea*), hihi (*Notiomystis cincta*) and takahe (*Porphyrio mantelli*). Cattle (*Bos taurus*), sheep (*Ovis aries*), goats (*Capra hircus*), pigs (*Sus scrofa*) and feral cats (*Felis catus*) were eradicated from Kapiti between 1916 and 1934 (Veitch and Bell 1990; Maclean 1999). Possums were introduced to Kapiti Island in 1893, just four years before Kapiti became a nature reserve, and were eradicated in 1986. Norway rats (*Rattus norvegicus*) and Pacific rats (*R. exulans*) were eradicated in 1996 (Empson & Miskelly 1999). With its prolific birdlife and healthy forest, Kapiti Island offers up to 18,000 visitors a year a window into how New Zealand used to be.

METHODS

Three phase operation

There were three distinct phases to the eradication of possums from Kapiti Island:

- Phase 1. Feb 1980-Oct 1982. Seven trappers commercially harvesting possum skins. Peter Daniel, the Kapiti Island ranger, supervised trappers to minimise the risk to birds and strongly discouraged normal harvesting practices such as release of small possums. Tracks were cut by the trappers along major ridges, spurs and valleys, mainly in the centre of the island.
- Phase 2. Feb 1983-Jan 1985. Four trappers worked for wages as opposed to selling skins and were assisted by Wildlife Service trainees. The complex network of tracks was completed during this phase and trapping intensified from 800 to 1500 traps set each night.
- Phase 3. Mar 1985-Mar 1987. Two trappers working up to 1800 traps, and three dog handlers with teams of up to three dogs intensively searched the island for the remaining possums.

Tracks, traps, sets and lures

An extensive network of tracks totalling more than 450 km covered Kapiti by the end of the intensive trapping phase. Tracks were cut 50-80 metres apart so that all possums had access to traps placed along tracks within their home ranges (Cowan 1992). Tracks on the western cliffs were the exception at up to 400 m apart because of the difficulty of the terrain. Tracks were cut so as to create minimal disturbance to the native vegetation but allow a trapper with sets protruding above their heads to have unimpeded access.

Lanes Ace leg-hold traps were set at approximately 50 m intervals along all tracks. Traps were checked daily and regularly maintained to minimise the risk of possums escaping and potentially becoming trap shy. Traps were sprung approximately once a week and the mechanism checked and CRC lubricant applied when required. Most importantly, traps were left in place for up to six months. It was believed that individual animals that were aware of the traps (potentially trap shy possums) would eventually make a mistake. Traps were not "fine set", instead they were set firm enough to minimise the risk of small birds (e.g. robins (*Petroica australis*)) being caught.

Traps were moved from the south to the north end of the island in a "rolling front" (i.e. the southern-most traps were placed in front of the northern-most traps). Trappers took approximately two years to traverse the island and did so twice between February 1983 and December 1986. Karaka (*Corynocarpus laevigatus*) groves were also trapped each February to target possums that would travel long distances to feed on ripe fruit.

Wooden sets (Fig. 1) were used to minimise the risk to flightless birds (little spotted kiwi and weka (*Gallirallus australis*)) by raising traps out of their reach. The sets were designed to be effective at catching possums and this set design evolved through time. The final design provided a cradle in which traps were inset flush with the lower part of the set and offset so that the paws of the possum used to cling to the sides of the set when climbing would be in line with the trap. Traps were firmly held to minimise the risk of being knocked off by possums but traps still jumped when sprung, which increased efficacy.

Traps were tied to staples in trees with a self-tightening knot (to prevent possums escaping with traps) and at a height that allowed possums to sit on the ground to minimise their distress and desire to escape. Sets were placed on palatable tree species with the base of the set on and in line with a possum run to increase the likelihood of use. Concentrated liquid cinnamon essence was the most commonly used lure because it was believed to be effective and attractive to possums but not to birds (Sherley 1992). Subsequent trials have confirmed that cinnamon is an effective and safe lure (Morgan *et al.* 1995). Cinnamon essence was placed on the tree above the top of the set (every five days and after heavy rain) so that a possum smelling it would place its paws on or near the trap.

Huts, helicopters and boats

Trappers and dog handlers used a combination of portable and permanent huts to facilitate quick access to all parts of the island. Multiple camps saved time and money and enabled the staff to achieve more. This was particularly important to dog handlers working at night. Helicopters and boats were essential tools for the movement of

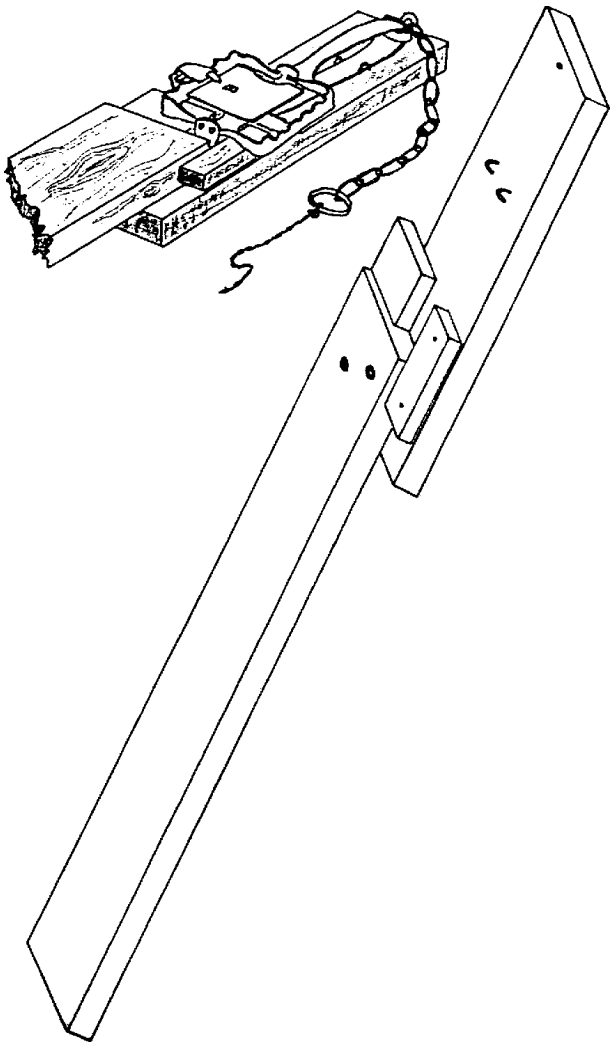

Fig. 1 Kapiti Island possum trap set, designed by Geoff Alexandra (from Sherley 1992).

huts, equipment and personnel. The extensive track system also greatly reduced travel time.

Dogs, handlers and guns

Dogs were used in the eradication phase only (Phase 3). The island was divided into blocks of approximately 40 ha and these blocks were worked for about 10 days and three fine nights. Initially all tracks were walked and then the ground between tracks was walked in an intensive grid pattern. Dogs and handlers worked closely, in constant contact, as a team. The dogs were trained to respond to possum scent, and to ignore the scent of non-target species such as birds and rats. This skill was achieved by teaching the dogs to associate positive behaviour with the word 'yes' (e.g. eating food and killing possums) and negative behaviour with the word 'no'. Kiwi, weka and rats were placed in front of the dogs and the word 'no' was repeated in harsh tones. Non-target training was reinforced regularly in the field when non-targets were encountered and by the exposure of dogs to non-targets captured for that purpose. Dogs and handlers left the island periodically to reinforce dog/handler possum hunting skills on the Kapiti coast and in the Wairarapa. This reinforcement regime was especially important when possum encounters on Kapiti Island were extremely low, as was the case in the late stages of the eradication phase.

The dogs walked quietly ahead of handlers but within view. Dog behaviour changed dramatically once possum scent was detected. As the dog actively followed the scent it was the dog handler's job to stay with it and call the dog back if required. Once the possum was located the dog and handler worked as a team to place the possum at maximum risk from gun or dog (e.g. the dog could be directed to where the possum was seen to break out of cover or move through vegetation above ground). Guns (mostly shotguns) were used to kill possums up trees and the dogs were trained to kill possums they caught on the ground.

Three dog handlers generally worked with teams of two dogs each in the field (though each handler had up to four dogs available). Dogs were of mixed breeds but small terriers were favoured because of their tenacity and ability to move quickly through tight scrub. Handlers swapped blocks on completion so that each handler checked each block and therefore the whole island. Dogs and handlers generally worked behind the rolling front of traps. They were allowed to search for possums ahead of their blocks when scent led from the block. The dogs caught most possums in areas that had not previously been systematically hunted with dogs while travelling north for dinner at the ranger's house or to leave the island. No possum was caught in a block that had previously been worked by another handler. Night hunting was by torchlight along tracks until scent was located and then it was a matter of the hunter keeping up with the dogs. Not all dogs 'trail barked' (barked as they ran following fresh possum scent) but trail barking dogs were an advantage. A spotlight was used to locate the possum once it was forced to hide in a tree by the pursuing dog(s).

Following the first complete sweep of the island by dog hunting teams, all three handlers walked all tracks on the island with their dogs and no possums were scented. One trained dog remained after the eradication and was used to repeatedly search the island while track markers and sets were removed.

Aerial and bait station application of 1080

Approximately 330 ha at the northern end of the western cliffs were sown by helicopter in August 1984 with 15 kg/ha of sieved carrot baits that were dyed green and impregnated with 0.15% 1080 (mono sodium fluoroacetate) poison. Because Global Positioning Systems were not available in 1984, visual markers were used to guide the application of baits. One pre-feed of non-lured carrot baits (dyed green) was spread on the cliffs by helicopter one week before the poison drop.

Originally it was planned to follow phase two of trapping with poisoning. Bird-proof poison bait stations containing 1080 paste were tested for approximately six months during phase two. However poisoning was abandoned because

so few baits were taken relative to the effort involved (Sherley 1992). With hindsight, the low bait take is not surprising given that possums were then at such low density (1 per 25 ha).

Result monitoring

Mark-recapture of possums was used during all phases of the control and eradication to estimate the success of various phases of the operation (Cowan 1992). Two cage trap lines were used that were previously established and run by DSIR during 1975-1980. Faecal pellet analysis and trap catch data were also used to estimate the numbers of possums remaining in the eradication phase. These methods were not highly sensitive (far more sampling effort would have been required to give more accurate measures of abundance) but gave approximate measures of possum abundance. Also, non-target kills were monitored throughout the control and eradication operation (Cowan 1992).

Dogs provided an excellent tool for detecting possums at low density and they had the added advantage of being able to determine when no possums remained.

RESULTS

Gin trapping was a very effective tool for possum removal when set at the density and for the duration of time used on Kapiti (Cowan 1992). Gin traps removed over 19,500 possums over the duration of this programme (Table 1). In addition, based on pellet counts, an estimated 1500 possums were killed in the aerial 1080 operation at the northern end of the western cliffs. A further 32 possums were caught by dogs. Many possums caught by the dogs were old and showed signs of having escaped from a trap and were probably trap shy (K. Brown pers. obs.).

Non-targets

A total of 181 birds were caught in traps (Cowan 1992). Not all birds were killed and many were released with minor injuries. The most common species caught were New Zealand pigeon (*Hemiphaga novaeseelandiae*) (70), morepork (*Ninox novaeseelandiae*) (47), weka (29) and kaka (*Nestor meridionalis*) (16). An unknown number of birds were killed in the aerial 1080 operation but searchers found only three.

Table 1 Possums caught and trapping effort on Kapiti Island between February 1980 and October 1986 (adapted from Cowan 1992).

Date and phase	Number traps set	Number possums caught	Percent trap success
1. Feb 1980-Oct 1982 (Commercial trappers)	65,866	15,631	23.7
2. Feb 1983-Jan 1985 (Intensive control)	589,336	3933	0.667
3. Mar 1985-Dec 1986 (Eradication)	743,538	48	0.007
Total	1,398,740	19,612	0.014

DISCUSSION

Three basic criteria have been identified that must be met if eradication is to be successful; the rate of removal exceeds the rate of increase, there is no immigration, and all animals must be at risk (Cowan 1992; Bomford and O'Brian 1995; Parkes 1996). However there are many other strategic and operational factors that will determine the feasibility and efficiency of any particular eradication attempt and whether the above criteria can be met. Strategic and operational factors that are important to the success of the Kapiti operation are relevant to other eradication attempts and are discussed below.

Is eradication a viable option?

Pest managers need to decide between eradication, control and doing nothing to effectively manage a pest species (Bomford & O'Brian 1995; Parkes 1996). The decision to eradicate a pest will be dependent on people's assessment of the feasibility and justification of eradication. Lands and Survey (which administered the island), Department of Industrial and Scientific Research – Ecology Division and Botany Divisions (which researched Kapiti possums and their impacts), and Internal Affairs – Wildlife Service (protected species management) were the key agencies involved that believed possum eradication was feasible and justifiable. Their arguments were that the island flora and fauna were of national significance; that possums competed for food with, and preyed on, native birds, and that forest structure and individual species of plants were under threat. They also believed that eradication was feasible and was far more cost-effective (in the long-term) than sustained control. Cats were eradicated from Little Barrier Island (2817 ha) in 1980 (Veitch 2001) and this provided psychological support for the attempted eradication of possums from Kapiti Island (B. Bell pers. comm.).

The New Zealand Forest Service (responsible for wild animal control) argued that local possum eradication had never been achieved on the mainland and therefore was not feasible on Kapiti Island. The western cliffs were considered to be too steep to allow hunters access to all individual possums. The Forest Service also did not believe that the scientific evidence on possum impacts on ecosystem health was sufficient to justify eradication and it therefore supported sustained control as the most viable option. They also argued that the opportunity cost was high (i.e. valuable resources would be taken from other wild animal control operations elsewhere). Both points of view were reasonable but the lack of consensus did impact on the Kapiti possum eradication operation by fuelling interdepartmental frictions and slowing logistical support.

Iwi (indigenous people) own 12 hectares at Waiorua Bay at the northern end of Kapiti Island. These owners allowed access to their land and provided support and encouragement for the eradication effort. Hence the first lesson from this project is that *"buy-in of all key stakeholders is very desirable if not essential"*.

Institutional involvement and logistic support

Despite the Forest Service resistance to eradication, the inter-departmental working party fought hard to ensure ongoing funding. Logistical support was provided by the Forest Service based in Masterton and Lands and Survey through Peter Daniel, the Ranger on Kapiti. Peter was tireless in his efforts to ensure resources were available when required. Peter and his wife Linda also provided much psychological support over evening meals, once a week. The DSIR provided scientific advice, evaluation processes through monitoring and moral support. The Wildlife Service provided trainees as labour early in the operation, and Lands and Survey provided one staff, and Forest Service a further four staff. Hence the second lesson from this project is that *"an ongoing commitment of staff and resources is essential"*.

No immigration and access to all animals

Possums are poor swimmers and Kapiti is five kilometres from the mainland so immigration was not feasible short of possums being carried to the island as a malicious act. Only permitted boats are allowed to land on Kapiti. Anticoagulant poison is laid on boats that carry visitors to the island and visitors' luggage is searched prior to departure from the mainland to Kapiti. These precautions are primarily designed to prevent rat invasion but also reduce the risk of the accidental transport of possums to Kapiti. Hence the third lesson from this project is to *"ensure further immigration does not occur through stringent quarantine procedures"*.

The extensive network of tracks and placement of traps every 50 – 80 metres meant that all animals had access to traps. Tracking of the western cliffs was initially thought to be impossible but was achieved and was supported by aerial poisoning. The spacing of tracks and traps was based on research of possum home range sizes (Cowan 1992). Trapping at seasonal food supplies (such as karaka fruiting) further increased the risk to possums. Intensive searching with dogs also ensured that all animals were accessible. The use of multiple camps was also important in allowing traps to be serviced and dogs to be worked at the intensity and frequency required. Regular discussions were held among trappers and progress was reviewed with possum experts. Hence the fourth lesson from this project is to *"know your target animal and place all individuals at risk"*.

The right tools to do the job

An initial "knockdown" followed by "mop-up" is a strategically sound approach to eradication. The aerial application of 1080 is a potentially useful knockdown tool but was unacceptable on Kapiti due to the perceived risk to rare and endangered bird species. Traps placed on sets off the ground were the chosen tools for knockdown and they proved to be very effective. The efficacy of trapping was placed at risk by experimentation with set designs (and trap types) that resulted in a high proportion of escapes in the early design stage. Some escaped possums became trap shy that increased the risk of eradication failure. A very effective set was eventually designed (Fig. 1) and traps were maintained to a very high standard. Hence the fifth lesson from this project is that *"eradication tools should be developed off-site to minimise the risk that target species will become shy and avoid the eradication tools"*.

Highly-trained dogs (to minimise non-target risks and maximise search and destroy capabilities) proved ideal for locating the few remaining possums that had avoided traps. The dogs killed many possums in areas of high possum density on the mainland while training but it is not known if dogs would have been more successful than traps at high possum density, early in the operation on Kapiti. Part of the dogs' success as "mop-up tools" lay in the fact that they were tracking individual possums. This enabled information to be gathered on an individual (over a two-week period in one case) that inevitably ended in it being located and killed. The dogs provided the ultimate monitoring tool because not only could they detect the presence of possums at low density, they could also confirm the absence of possums. Hence the sixth lesson from this project is that *"well tested tools should be used in the right sequence to achieve the knockdown and subsequent mop-up phases of the operation"*. The seventh lesson from this project is that *"the tools chosen should minimise non-target risks"*. The eighth lesson from this project is that *"monitoring allows progress to be tracked and provides valuable information to sustain support"*.

Team attitude

The core team on Kapiti was small, highly motivated, highly committed, physically and mentally fit, skilled, compatible and hard working. The work was physically and mentally demanding and involved carrying heavy loads (100 gin traps equals approximately 50 kg) up and down steep slippery terrain, long periods of repetitive work with few returns (especially when possums were scarce) and living and working in close confinement. Key skills included the design and building of sets, building of huts, dog training to a high standard, meticulous care of equipment, organisation of logistics and keeping accurate records. The team often worked 12-14 hour days and dog handlers regularly worked during the day and after dark. Every team member believed that eradication was inevitable. This was particularly clear to the dog handlers who

understood the effectiveness of their dogs. Hence the ninth lesson from this project is that *"team skills (personal and technical) and attitude are essential ingredients in effective eradication"*.

Eradication of possums from other islands and areas of mainland New Zealand

Possums have been eradicated from Codfish Island (1336 ha), Rangitoto (2333 ha) and Motutapu Islands (1510 ha), and Allports Island (16 ha) and a number of other small islands since the eradication of possums from Kapiti Island (Clout and Ericksen 2000).

Traps, cyanide poison and dogs were used to eradicate possums from Codfish Island and a Kapiti Island dog handler removed the last possum. The eradication of possums on Codfish Island was thought to be complete in early 1987. A dog handler from Kapiti Island went to Codfish to confirm that eradication had been achieved in May 1987 for two weeks soon after possums were eradicated from Kapiti. He systematically worked the island, saving the tall forest habitat in the centre of the island for last. He detected and killed a female possum on day one of entering her territory and no other possums have been detected on Codfish Island since (R. Cairns pers. comm.).

Possums were eradicated from Rangitoto and Motutapu Islands in 1997 and 1996 respectively, using traps, dogs and guns and following the advice from Kapiti Island eradication staff (Mowbray 2002). Possums were also eradicated from Allports Island in conjunction with a mouse eradication programme (Brown 1993). Brodifacoum in Talon 50WB baits was the sole method used. Brown (1993) stated that the use of dogs would probably have been more cost-effective if possums were the only target animals (K. P. Brown had provided an estimated cost for the use of a dog to eradicate possums from Allports Island). A combination of traps and poisons was used to remove possums from most islands identified by Clout and Ericksen (2000).

It is our opinion that eradication of possums inside predator-proof fences on very large areas of the New Zealand mainland is feasible. Possums have been eradicated within a predator-proof fence protecting 250 ha of regenerating forest at Karori Reservoir using a combination of poison and trained dogs (R. Empson pers. comm.). Traps or poisons could be used as the initial knockdown tool and dogs could then be used to locate and kill the remaining individual possums and/or as monitoring tools to ensure that no possums remain. Hence the tenth lesson from this project is that *"tools and knowledge can be transferred to other eradication operations but new techniques can also prove successful"*.

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