

## **Management Issues Introduced Species**

Mainly based on and adapted from reports and studies Goat Eradication project Galapagos Islands.

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# 1 GENERAL INTRODUCTION

## 1.1 Foreword

This document is compiled after receiving valuable documents from Karl Campbell of the Charles Darwin Research Institute on the Galapagos Islands, Ecuador. This document is meant as a summary to be a practical help in starting an eradication project on Bonaire in the first place and to anyone else to whom this may be of use.

Obviously all errors and omissions are the responsibility of the compiler (Section Environment and Nature Conservation). Comments are welcome and can be sent to: DROB, Section Environment and Nature Conservation, Kaya Amsterdam 23, Bonaire, Netherlands Antilles, email: drob.mnb@bonairelive.com

The document below is useful for the management of exotic animal species in general and goats in particular. For weed introductions other sources are available, e.g. the model of Panetta and Timmins [2002].

## 1.2 Effects of Introduced Species (IS)

Introduced Species	Competition for food with native and endemic herbivores	Destruction of vegetation layer and erosion	Elimination of woodlands, reduction of shadow and alteration of microclimate	Trampling of bottom vegetation and breeding areas	Predation of native and endemic animals	Competition with endemic carnivores	Competition with native and endemic invertebrates	Disease, parasitism, debility and mortality of native and endemic plants and animals	Competition for space, light, soils and nutrients with native and endemic plant	Impacts on nesting and access to nesting areas for native and endemic animals	Predation of introduced animal species	Dispersal of introduced plants	Pollination of introduced plant species
Mammals													
Goats	X	X	X	X								X	
Pigs	X	X	X	X	X								
Cattle	X	X	X	X								X	
Donkeys	X	X	X	X								X	
Horses	X	X	X	X								?	
Dogs					X	X				X	X		
Cats					X	X				X	X		
Rats	X				X	X				X		X	
Mice	X				X					?			
Birds	X				X	X				X	?	?	?
Reptiles	X				X								
Invertebrates													
Insects													X
Wasps							X					X	X
Ants	X				X		X	?		X		?	

Nematodes								X					
Micro-org's Fungus etc.								X					
Plants								X	X	X			

(From: CDF et al., 2001)

### 1.3 Prioritization issues

To determine the need to manage introduced species (IS), some kind of decision-support tool is needed. In general, it should be based on conservation values of the area (botanical and wildlife values, biodiversity issues etc) and the threat that the IS pose to those areas and values (Campbell, 1998b).

The first step is a list of IS that are threatening an area, followed by an estimate of the damage they inflict, their approximate numbers/density and if the population is growing (i.e. the potential damage). Damage can be based on the table above, but a way to weigh the impacts/quantify the damage must be developed.

For weeds, the model proposed by Panetta and Timmins [2002] for evaluating the feasibility is useful. For the assessment of the invasiveness of plant species, Pheloung et al. (1999) provide a valuable tool.

## 2. MANAGEMENT OF INTRODUCED SPECIES

### 2.1 Options for management

There are 4 management options when dealing with (the effects of) introduced species:

No action: do nothing on introduced species (IS) due to a variety of reasons, for instance no priority, lack of funding, political support, not seen as a problem, lack of social support.

Mitigation: actions taken to mitigate the damage by IS, without controlling the number of IS. For instance, putting goat-exlosures around fragile habitat. Interesting question is whether mitigation is more successful via reducing the population of invasive species or increasing the reproductive success of indigenous species.

Control: killing annually or killing occasionally a number of the IS to control their impact on the environment. The timing of control can be a response to an intolerable amount of damage by IS. To determine the amount of damage, a monitoring system should be in place. A problem with this option is that control will continue in perpetuity, and damage will continue too. This is especially so if the monitoring program and control program are not organized well enough. This option may be desirable when goats are an important resource themselves and where a sustained harvest is required.

Eradication: the killing or removal of all individuals of a certain introduced species in a finite project. For environmental reasons this option is the preferred way to protect a resource, because damage by IS stops when eradication is completed. Eradication is time-limited and thus it is cost-limited. This option may be cost-effective compared to control measures.

When dealing with invasive species eradication is ecologically most advantageous. This is a normally one-time intervention when the risk of re-introduction is low. It is however not always feasible due to lack of scientific knowledge, appropriate methods and institutional capacities and other factors.

Control is the second best option to maintain populations to levels that do not threaten ecosystem integrity. If that is not possible, then mitigation measures must be taken to temporarily reduce pressure of species at risk or the ecosystem in general. These measures are always short-term, while permanent solutions are being developed (CDF et al., 2001).

The complexity of ecological processes rarely permits the adoption of any single option in a given scenario, but rather the simultaneous or sequential application of combinations of one or more of these options. The selection of the best combination of options requires a solid body of information to base selection on and strong technical, operational and planning capacities (CDF et al., 2001).

## **2.2 Factors influencing decision-making**

To make decisions concerning the management of IS, (detailed) information is needed about factors like:

- ✓ Biological and ecological characteristics of the IS, for instance
  - habitat use
  - densities
  - migration patterns/trails
  - gestation and birth period
- ✓ Damage to value of natural resource by IS
- ✓ Topography/area characteristics
- ✓ Climate
- ✓ Management options proven to be successful for the particular IS in other parts of the world and translatable to local situation
- ✓ Predicted success of management options
- ✓ Costs related to management options (translated to local situation)
- ✓ Funding available, also contingency funding
- ✓ Public awareness
- ✓ Stakeholder participation
- ✓ Values of IS
- ✓ Institutional set up/capacities
- ✓ Local legislation
- ✓ Political climate and political commitment
- ✓ Risks and assumptions of the proposed management option
- ✓ Commitment and motivation of personnel and staff
- ✓ etc.

## **3 ERADICATION PROGRAM FOCUSING ON GOATS**

### **3.0 Goat reproductive cycle**

At the age of about 175 days, female goats reach puberty, depending on breed, nutrition and individual variation. Their oestrus cycle lasts about 20 days, in which period they will actively search for mates. 90-95 percent of the females will become pregnant when males are present. Gestation lasts for 150 days. Thus twice a year female goats will become pregnant and produce offspring.

### **3.1 Issues regarding the desirability and feasibility of eradication**

A checklist of points to consider before deciding to eradicate an area (Campbell, 1998b):

1. What other non-native species are present and is removal of goats likely to make them flourish harder or harder to remove? On some island, rabbits, goats and exotic weeds have taken advantage of the removal of goats. In another case study it proved to be advantageous to first remove feral pigs and after that remove feral goats. The goats kept the vegetation open, facilitating the removal of pigs.
2. Are there any positive effects of the goats that have been overlooked? These can be ecological effects of goats, scientific values, value to animal breeding, and value to local people as resource. Positive values of feral goats should be taken into account: intrinsic values of goats like sources of meat, milk and fiber, genetic resource, scientific interest and use in habitat management. These should however not compromise conservation values.
3. What native species/habitats are most vulnerable? Are there alternative ways of protecting them, for example, erection of exclosures or relocation?
4. Are the goats the main factor causing observed environmental impact? For example in cases of severe soil erosion are there human management decisions that could be taken to improve the situation without necessitating the eradication of goats?
5. Concerning secondary succession. Are there any foreseeable problems with secondary succession? Is the local flora able to recover after eradication (CDF et al., 2001) Will the habitat that has been modified by goats return to its natural state? It has been argued that modified habitat will not return to its original state. Ecosystem damage is not always reversible and another climax-stage will be reached. Goat exclosures can help answering this question and at the same time acting as a seed bank till future decisions are made. On some islands, weeds (also introduced flora) have spread rapidly after goat eradication, smothering other native vegetation. In cases of noxious weed growth, it is better to wait with eradication until resources are available to cope with that.
6. Is eradication a realistic proposition given the local conditions, like existing population size (of the goats), island area and topography?
7. Can the eradication/removal techniques be carried out humanely? It is important to eradicate with a fast speed to prevent reproduction and thus to prevent killing more animals than needed.

Criteria to select invasive species target and population locality:

- potential ecological degradation
- ecological importance of locality
- possibility of natural recovery after eradication
- proven eradication methods
- population size of invasive species
- institutional jurisdiction (CDF et al., 2001)

### 3.2 Requirements for successful eradication

Set of 6 criteria to determine if eradication is possible (1-3) and preferred (4-6) to control measures (Bomford and O'Brien, 1995 and others in: Campbell, 1998b):

1. **Immigration is zero:** there should be no re-introduction of the eradicated species possible. This means that the eradicated area should be 100% protected against re-introduction using e.g. fences and control systems. Barriers to immigration must be created to make eradication possible. If re-introduction is likely (by humans: social element to success), eradication should not be selected (Campbell, 1998a). This means that evaluation of risk of future human-assisted introductions should occur and development of a strategy to reduce that risk, including strategic surveillance and involvement of the local community (Galapagos Workshop, 1997).
2. **All (reproductive) animals are at risk.** All reproducing individuals of the species to be eradicated must be removed. No animals may be able to hide from eradication activities, like the ones that adapt to ground hunters and hunting dogs, the most wary ones. All reproducing animals must be removed to prevent population growth. Populations can, by natural selection, adapt to the eradication method, e.g. the black rats responding to predation by mongoose by changing to arboreal life (Husson, 1960). It is important to take these issues into consideration. A combination of methods may be the solution, e.g. helicopter and ground shooting in the case of goats (Campbell, 1998a).
3. **Rate of removal exceeds rate of increase at all population densities.** This is especially important at low densities, when it is very hard but very important to remove the extra animals. The removal of the low-density remnant population is often the most expensive/effort-consuming phase. E.g. in a case study (Raoul Island) the first 80% of a population was removed by 40% of the effort (Campbell, 1998a). In many cases the reproduction rate of the species increases when density of the species is reduced (compared to 'carrying capacity' or the start of the eradication process). For instance, when a goat population is reduced with 80%, the remainder can multiply to 90% of the original population size in only 4 years (Campbell, 1998b).
4. **Population can be monitored at all densities.** Especially when the population density is low, it is very important to be able to monitor accurately to prevent that animals are left unnoticed. An intensive monitoring program must be established following eradication to ensure that no small pockets of survivors remain.
5. **Discounted cost-benefit analysis favors eradication over control.**
6. **Socio-political environment is suitable.** It is important that the importance of the eradication is without doubt among the politicians, decision makers and public and that their attitude favors eradication. Also this must be guaranteed over the period until eradication is successful and afterwards, also to prevent reintroductions of IS. A campaign will also be very difficult when local people subsist on goats. This should be given special attention.

Key factor to achieve successful eradication is the use of **appropriate effort**. This is the use of an appropriate method, for sufficient duration, with sufficient force at an appropriate time (refs. in Campbell, 1998a):

- Method: for instance combination of methods to target all individuals, also the extremely wary animals. In the case of goats, methods like the use of aerial shooting, ground hunters, Judas goats, hunting dogs.
- Duration: campaign must be sustained until all animals are removed.
- Force: if not enough force is used the program results in control instead of eradication.
- Timing: for instance good knowledge of the biology of the IS needed. There is a case study where an eradication campaign including shooting and castration failed because fertile offspring of animals kept the population alive (Holy Island).

5 factors to determine appropriate effort (Refs. in Campbell, 1998a):

1. Sufficient resources available: the quantity and quality of finance, equipment, personnel and information are very important aspects of successful eradication. For instance high quality of hunters minimizes the risk of animals escaping, which would become extremely wary. Sufficient level of resources must be guaranteed for the whole project. The value of training staff in advance in planned eradication methodologies and in the use of advanced technologies such as radio-telemetry and global positioning systems. The importance of securing funding for the entire eradication campaign ex ante. The value of acquiring all equipment prior to start up (CDF et al, 2001).
2. Detection of low densities (see nr. 4 mentioned above)
3. Commitment of personnel, staff and management. They need to be convinced of the goal of the eradication, before a project can be successful. During the project, motivation of personnel can decline, for instance during the monitoring phase when no target animals are sighted for months. Keeping them motivated is essential. Use of social and moral boost events and financial incentives, like a reward after accomplishing the monitoring period, are very important.
4. Suitable social-political environment: positive political climate is essential. An eradication project is more difficult when the local people depend on/are used to goat husbandry on common lands. Court cases can stop eradication programs. Political and institutional support must be guaranteed from the beginning and sustained throughout the eradication campaign (CDF et al., 2001).
5. Basic biological knowledge: this determines the method, the combination of methods, the timing of eradication etc. (see also 3.0)

In the past eradication campaigns have been unsuccessful due to insufficient resources (funds), insufficient effort, lack of ability to monitor population at low densities, political interference, lack of commitment and lack of basic biological knowledge/incorrect timing of eradication (Campbell, 1998b).

### **3.3 Methods used for eradication**

In eradication projects it is a standard operating procedure to leave dead goats where they fall. This is based on 2 arguments:

- Extracting carcasses is logistically difficult and takes effort away from the goal of eradication. It also would typically involve commercial interest as middlemen start to make money. Goats then become a resource and people don't want to get rid of them, going contra the eradication goal.

- Goat carcasses are major nutrient sinks. If these are taken out of the ecosystem or burnt, then the nutrients are lost from the ecosystem. By letting them degrade, the nutrients are returned to the soil.

*Helicopter hunting (Galapagos workshop, 1997)*

This is most effective over open areas and steep slopes and ineffective over dense vegetation. Helicopter hunting quickly reduces the numbers of goats, much more than even can be obtained with large numbers of ground-based hunters. It can virtually remove all goats (and donkeys) from unforested areas.

Helicopters are mostly used for control or eradication of large management units. They were also used to remove the last goats from ground hunter-inaccessible areas or to muster/herd feral goats.

Some figures from past use of helicopter:

- 70 goats killed per hunting hour for U\$ 0.05 per ha (total 175.000 km<sup>2</sup>, 70% population reduction)
- 100 goats killed per hunting hour for U\$ 0.09 per ha (total 1000 km<sup>2</sup>, 45% population reduction)
- 100 goats respectively 14, <10 and 150 goats killed per hunting hour, (total 600 km<sup>2</sup>)
- 45 goats killed per hunting hour for U\$ 1.80 per ha (total 130 km<sup>2</sup>, >99% population reduction)

*Ground hunting with hunting dogs (Galapagos workshop, 1997)*

Dogs (finder bailers) can locate their quarry and corner them until the hunter arrives.

Combination/simultaneous ground hunting and helicopter hunting can be beneficial: hunters can drive goats out of the forested areas, while they can target goats that take refuge in caves etc. On Galápagos, 0.223 rifles will be used, which have more power than the usual rifles.

They will be equipped with power scopes and will have the possibility to add noise-suppression equipment. These rifles are preferred because killing instantly is more likely, thus minimizing animal suffering. The use of highly skilled and trained hunters improves success by improving kill rate of the target animals. This is extra important as escaped animals learn to avoid hunters.

Dogs will be fitted with radio collars. Also they will be trained not to attack native species.

Some figures from past experiences

- 17, <6 goats and 4 killed per hunter day and >22 per hunter day when helicopter assisted (total 600 km<sup>2</sup>).

In a project on Santiago Island, Galapagos, goats were mustered into funnel shaped traps (with over 5 km of netting) and then shooting the animals in holding pens. This is a possible strategy when no money for helicopters is available.

*Judas Goats (Galapagos workshop, 1997)*

Radio-collared goats locate the widely distributed remnant herds of feral goats, due to the goat's gregarious behavior. The Judas goats are fitted with a radio transmitter (GPS). When they have found a group of feral goats, these feral goats except the Judas goat, are shot. The Judas goat is left to track another group. This process continues until this goat only finds other Judas goats. On Galapagos, the strategy is to change method towards use of Judas goats when

the hunter harvest drops below 1 goat killed per hunter day. Also, Judas goats will be used until one year after the last feral goat is shot. After this period the eradication will be declared completed.

Still a lot is to be learnt about the use of goats as Judas. For instance when will a goat be a superior Judas goat (searches strongly for other goats, is strongly searched for by goats, is sterile, doesn't become wary). Castrated males were useless. Female goats tend to be most effective Judas goats, due to their higher sociability. It may be possible to enhance their effectiveness by maintaining them in season with a contraceptive.

It is important to use Judas goats only as "mob-up"-tool, after as many feral goats as possible have been removed. It is not efficient to use them when large numbers of feral goats are present. Also, it is very important to plan a Judas goat operation perfectly, including type and number of Judas goats, placement in operational area and strategy when and how to target them (Thomas, 2002).

Radio-collars with mortality component are highly recommended. These collars normally give a signal to show the presence of the collar. When there is no movement for 24 hours, the signal doubles its pulses, thus showing that your Judas goat died.

More information on Judas goat methodology:

Gregory, J., B. Kyle and M. Simmons (eds.). 2002. *Judas workshop 2002, Dunedin, November 2002*. New Zealand Department of Conservation. Otago Conservancy. To be downloaded from: <http://www.doc.govt.nz/>

### *3.3.1 Example eradication project Isla Isabela, Galápagos*

In very short, the eradication project on Northern Isabela Island has the following stages of eradication (CDF et al., 2001):

First a rapid knock down of the goat population with high precision aerial hunting using helicopters. This will reduce the goat population with 90%

Then ground hunting using hunting dogs and radio-collared Judas goats will kill 5-8% and the remaining 2-5% respectively.

Finally the success of the eradication will be evaluated, including validating goat absence using Judas goats.

### *3.3.2 Other methods used in control or eradication projects*

In the case of pigs on Santiago Island, Galapagos, a combination of ground hunting and poisoning were used to eradicate feral pigs (Cruz et al, in press). For ground hunting, hunting dogs were used. A few important lessons were learnt:

- Use dogs trained on bailing/finding pigs only. In the case of non-trained dogs the dogs would pursue a pig and abandon it when a goat appeared. This increases pigs becoming wary.
- The access of hunters to pigs resulted to be critical. Feral goats were left alone to keep the vegetation open, and additional trails were cut to allow access to all areas.
- It was a challenge to continually motivate hunters, especially when pigs were at low densities. For instance by social and moral boosting events and financial incentives (US\$ 12.000 to be divided after 18 months of monitoring after the last pig was killed).

The pig's trait of being omnivore is used to poison them. Carcasses of goats injected with poisons like 1080 or warfarin were used (using LD<sub>99</sub> or LD<sub>90</sub>). These were hidden under

vegetation to reduce risk to birds of prey. An anti-emetic was used to increase the uptake of poisoned meat by pigs. Poisoning proved very effective to target animals at low density. However, some pigs appeared to learn to avoid poisoned meat, probably because they could smell the anti-emetic. This problem was solved by using another poison (warfarin) which did not need anti-emetic.

Goat carcasses were also used in monitoring the presence of pigs. The baits were hung at equidistant points and monitored for disturbance by pigs. Monitoring of pig presence was continued for 18 months after the last pig was killed.

Important issues concerning use of poison

- Effectiveness of poison
- Risk of non-target poisoning, like native fauna and hunting dogs (when used)
- Risk of poison to personnel, and the availability of an antidote
- Environmental effects of poison

## **3.4 Project Planning**

### *3.4.1 Strategy and Timing*

Considerations:

- ✓ What method of eradication to be applied in what order. Adaptation of methods (Judas goat technique and helicopter assisted hunting) to local environmental conditions and scales. Consider topography, climate, ecosystem characteristics, costs etc.
- ✓ Biological characteristics of the IS e.g. reproduction season of IS.
- ✓ Re-growth of the vegetation when the IS (goat) density is decreased. If this occurs rapidly, it may make an eradication campaign more difficult, because goats can hide in this newly formed dense vegetation. Therefore it is important to have the eradication campaign be short compared to the speed of vegetation re-growth (Galapagos workshop, 1997).
- ✓ The order to remove different species of IS. When islands have more than one introduced species, it is important to remove these species in the right order. It is important to prevent the bloom of other introduced species after eradication of one species (for instance deer after goat eradication). Also, removal of a species can be made more difficult when eradicating another first (goat keep vegetation open, thus facilitating pig eradication first). Summarizing for managers: strategic planning, prioritization and biological knowledge of species/habitat interactions can help facilitating eradication in some situations (Campbell, 1998b).
- ✓ Climatic conditions (e.g. El Niño, hurricane season). To maximize effectiveness and probability of success it may be best to start a campaign during drought conditions (Galapagos workshop, 1997).
- ✓ Extensive training of staff and personnel
- ✓ Use of advanced technologies, like telemetry, GPS and GIS
- ✓ Establishment of professional hunting dog-training program
- ✓ Campaign to impart awareness of the need to perform the eradication targeted at communities, decision makers in government and civil society and animal rights groups (CDF et al., 2001)

Factors to consider when deciding what area to start the eradication (especially relating to large management areas) (Galapagos workshop, 1997):

- Severity of ecosystem damage
- Ungulate population and growth rate
- Ease and cost of eradication
- Weather/climate:
- Natural barrier availability
- Suitability for training
- Projected time for success in the area
- Sustainability of success in the area
- Efficient use of resources
- Public perception

### *3.4.2 Budgeting*

A sizeable contingency fund is required in the event of unforeseen problems (Galapagos workshop, 1997).

### *3.4.3 Stakeholder participation and public awareness*

The use of a matrix about stakeholder participation (CDF et al., 2001) can give clarity. In such a matrix stakeholders and their role in the project are listed.

Public participation and information/education is very important for the success of any project. In the case of eradication good attention to these issues will also help to prevent future accidental or intentional releases of goats in restored areas (Galapagos workshop, 1997).

Strategies must be developed for all groups of people involved: like local communities, government, tourists, animal right groups, conservation groups, staff/personnel, etc. The public awareness/stakeholder participation part of the eradication campaign must be given proper and careful attention to prevent counteractions/backfire (Galapagos workshop, 1997). It should be continued during and after the campaign too.

### *3.4.4 Impacts of eradication campaign*

An eradication campaign may have impacts on ecology/environment, animal welfare and socio-economic impacts. It is wise to make an assessment of potential impacts (CDF et al., 2001).

#### **Ecological/environmental impacts**

Fire damage, disturbance of native fauna by gunfire, helicopter movements, accidental pollution, fuel spill by helicopters, environmental pollution by shell casings and lead shot.

Using skilled hunters, proper training and intensive focus on target animals and surroundings will reduce the accidental killing of native fauna due to shooting operations. Accidental kill is less likely when using aerial shooting, than by ground hunting. Hunting dogs must be properly trained and selected (Galapagos workshop, 1997).

Bird species are most likely to be affected by the noise production of the eradication campaign. Critical periods for species likely to be affected need to be determined, critical areas need to be avoided as much as possible (Galapagos workshop, 1997).

### **Animal welfare**

Powerful rifles are used to kill goats as instantly as possible (0.223 rifles). An eradication campaign should be performed and completed as quickly as possible. If a campaign takes too long, the introduced species will produce offspring that need to be killed/removed too. Thus more animals will to be killed than was absolutely needed.

### **Socioeconomic impacts**

Impacts can be positive and negative. Local hunters can be contracted, increase in jobs and training. If foreigners are contracted, this will make locals feel marginalized and increase feeling of no confidence in local personnel (Galapagos workshop, 1997).

Impacts on tourism: positive when the eradication results in a more valuable product (nature reserve), temporarily negative when the area need to be closed for the eradication campaign, negative when the goal of the campaign is not well and carefully described: restoration of threatened nature by exotic species. Then, opposition to the killing of animals will rise. Need of a well-organized PR plan, taking into account concerns of animal rights groups, local people, etc.!

High standards of human safety should be assured to minimize risk to personnel. Guidelines need to be implemented.

## *3.4.5 Research and Documentation*

### **Before a campaign**

Monitoring and assessment of goat distribution and densities should be performed before eradication (Galapagos workshop, 1997). Important are

- ✓ Data on distribution, density and seasonality of goat movements
- ✓ Information on water sources, migration routes, habitat patch boundaries
- ✓ Vegetation types used by ungulates
- ✓ Presence and distribution of other IS (plants and animals), which can be removed in the same eradication campaign.

Release radio-collared goats (with mortality component) prior to eradication campaign to enable crude estimates of population size and hunting success based on mark-recapture techniques. Also, this will involve determining percent survivor ship of collared goats after intensive hunting campaigns in order to estimate total population size and number of survivors. Additionally, tracking these animals will also give details about movement patterns, distribution, location and general habits of feral goats in the area (Thomas, 2002).

### **During a campaign**

Documentation is critical for decision-making during the field campaign. Data to be gathered must include (Galapagos workshop, 1997):

- ✓ Hunting effort (flying hours, hunting days/hours)
- ✓ Area covered
- ✓ Habitat type

- ✓ Number of animals killed
- ✓ Location of animals killed (GPS-coordinates)
- ✓ Unit effort per animal killed
- ✓ Estimated number of known survivors
- ✓ Approximate location of known survivors (GPS)
- ✓ Number and location of collars retrieved and placed on other goats (GPS)

### **After a campaign**

It is important to document each eradication attempt thoroughly, also for other managers and the scientific community. Aspects to consider in documentation are (Campbell, 1998a):

- The amount of effort
- All factors that lead to failure

Also, it is interesting to monitor ecological changes resulting from the lack of ungulates (Galapagos workshop, 1997):

- Recuperation of forested areas
- Changes in species composition in various habitats
- Population dynamics of introduced vertebrate, invertebrate and plant species
- Increase in predator population (e.g. caracara, hawk)
- Changes in avifauna, herpetofauna and invertebrate fauna

After the campaign it is very important to monitor regularly the high-risk introduction sites, and buffer zones. Also, preferred goat habitat should be monitored. It would be best to also monitor the whole area (in some cases using fixed wing airplane). This way re-introductions will be noted quickly. The buffer zones should be regularly monitored/patrolled to enforce no re-introduction (Galapagos workshop, 1997).

## **3.5 Recommended reading – sources of information**

Daly, K. and P. Goriup. 1987. *Eradication of feral goats from small islands*. Study Report. International council for bird preservation. Cambridge. No. 17. 46p

Parkes, J., R. Henzell and G. Pickles. 1996. *Managing vertebrate pests: feral goats*. Australian Government Publishing Service. Canberra. 129p.

IUCN – Invasive Species Specialist Group;

<http://www.iucn.org/>

<http://www.iucn.org/themes/ssc/pubs/policy/invasivesEng.htm>

<http://www.issg.org/>, with among others:

- Invasive Species on Islands Database (ISID)
- ALIENS listserver

Website Pacific Island Ecosystems at Risk: <http://www.hear.org/pier/>

## **4. RECOMMENDATIONS**

It is recommendable to install a system of prevention of introduced species and to have contingency plans ready to execute when species introduction occur.

## 5. REFERENCES

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