The Translocation of Red Squirrel (*Sciurus vulgaris*) to Belleek Forest Park, Mayo – Phase One

Project carried out under NPWS contract D/C/214
March – October 2007

Laura Finnegan

Contents

Introduction 3

IUCN Guidelines for Reintroductions/Translocations 5

1) Selection and evaluation of source populations 5

2) Translocation of individuals 13

3) Post translocation monitoring 15

Discussion 16

Post-release activities 17

Recommendations 22

Acknowledgements 23

References 24

Appendix: IUCN /SSC guidelines for re-introductions 26

Tables, Figures and Plates

Table 1: Dates of trapping sessions which were carried out in each site 10

Table 2: Details and body measurements of each squirrel caught 12

Figure 1: Map of the northwest of Ireland 7

Figure 2: Aerial map of Lough Key Forest Park 8

Figure 3: Aerial map of Union Wood 9

Plate 1: The soft release enclosure in Belleek Forest Park 14

Introduction

The red squirrel (*Sciurus vulgaris*) is considered native to Ireland, probably colonising the island after the retreat of the ice sheets at the end of the last glacial maximum. Extensive forest clearance in the 16th century possibly led to its extinction in Ireland, resulting in translocations of individuals from Britain to Ireland in the 1800s (Barrington 1880). The current Irish population is now largely descended from this translocated stock (Finnegan et al. in press). The North American grey squirrel (*Sciurus carolinensis*) was introduced in Castle Forbes, Co. Longford, in 1911. From that introduction point it spread to the east and north of the country, while spread west and southwest has been impeded by geographical barriers such as rivers and unsuitable habitat (Ó Teangana et al. 2000). Similar to the situation which has been found in Britain (Lurz et al. 2005), the spread of the grey squirrel in Ireland has resulted in the disappearance of the red squirrel (Ó Teangana et al. 2000), primarily due to resource competition between the two species (Kenward and Holm 1993; Wauters et al. 2000). There is therefore an increasingly urgent need to conserve the red squirrel in Ireland.

Translocation and reintroduction of species has been used as a conservation tool worldwide (e.g. Aubry and Lewis 2003; Bendel and Therres 1994; Smith and Clark 1994; Towns and Ferreira 2001), including Ireland (O'Toole et al. 2002; Poole 2007). Populations derived from translocated individuals have re-introduced populations in areas where the species has become extinct and expanded species range to areas which it would not reach naturally. Source individuals can be captive bred or wild stock, although, to increase the chance of success, IUCN guidelines recommend the individuals are from wild populations when possible.

In 2003 a translocation of red squirrels was undertaken by NUI Galway (Poole 2007). The aim of that project was to establish a red squirrel population in western Galway, in an area which was at a distance from the boundary of grey squirrel distribution, and where extensive mature coniferous plantations exist. Large areas of similar plantations, which were planted by the state forestry board, Coillte Teoranta, ~50 years ago (Fitzpatrick 1975; Garrett 2001), occur across western Ireland. These plantations are now at seed bearing age and they

are therefore good red squirrel habitat (Gurnell 1987), however their isolation from other forests inhabited by red squirrels means the species is unlikely to reach them naturally. The translocation in Galway was successful, with 19 individuals moved into Derryclare Connemara, and post translocation monitoring detected no adverse effects to the source population and good survival rate in the translocated squirrels.

Following the success of that translocation, it was decided to undertake a second translocation of red squirrels in Ireland. The chosen translocation site was Belleek Forest Park, Co. Mayo. Although suitable red squirrel habitat, the isolation of the forest may mean the value of the translocation to that area may not help with conservation of the species, with probable exchange of individuals and further translocations necessary to avoid inbreeding. However there is large public interest in the site and its wildlife, making the translocation important from an educational point of view.

A feasibility assessment of the site was carried out in 2006 (Lawton 2006). It was estimated that the forest could support a population of 65 squirrels, recommending that a minimum of 12 individuals would be required to act as breeding stock. Based on the rates of over-winter mortality seen at Derryclare, 15 – 20 individuals might need to be translocated into the site to achieve this. This report details the translocation of the first of those individuals; Phase One of the project. The study was carried out from March to October 2007. The aims of this phase of the study were to 1) identify possible source populations for the translocation and carry out pre-removal monitoring of these populations, 2) trap and translocate up to 12 red squirrels from these source populations (should the population estimations support this number) to Belleek Forest Park and 3) conduct post translocation monitoring of the source populations. The overall objective of the project is to establish a viable population of red squirrel in Belleek Forest Park.

The translocation was carried out under NPWS contract D/C/214, under the supervision and direction of Dr Ferdia Marnell NPWS, the advisement of Dr Colin Lawton NUI Galway, and in collaboration with the Belleek Forest Park Enhancement Committee (BFPEC).

IUCN Guidelines for Reintroductions/Translocations

The IUCN (1998) gives a number of guidelines for the translocation of wild animals (see Appendix) and Lawton (2006) outlined and discussed many of these in relation to this translocation in the feasibility report. This study involved the pre translocation assessment of source stock, the translocation of individuals and the post translocation monitoring. The biological aspects of the IUCN Guidelines associated with that part of the translocation will be addressed throughout this report (the relevant section of the Guidelines are highlighted in italics throughout). Other socio-economic and legal requirements are addressed in the IUCN guidelines and all of these were adhered to (see Appendix).

The translocation was carried out in three parts: 1) Selection and evaluation of source populations, 2) Translocation of individuals and 3) Post translocation monitoring of the source populations.

1) Selection and evaluation of source populations

It is desirable that source animals come from wild populations. The source population should ideally be closely related genetically to the original native stock and show similar ecological characteristics.

Detailed genetic analysis of the Irish red squirrel population (Finnegan et al. in press, Finnegan 2007) has found that the red squirrel population in Ireland is genetically homogenous, and probably largely derived from translocations from Britain in the 1800s (Barrington 1880) with some evidence, particularly in the south-west of the country, of possible residual native lineage (Finnegan et al. in press). However, tests of genetic relationships between populations in Ireland detected significant genetic structure in the country (Finnegan 2007). This, together with apparent morphological divergence between regions in Ireland (Finnegan 2007), as well as the need to limit transportation time to a minimum, confined potential source sites to the northwest of Ireland. Furthermore, the limited time frame involved in this study meant that long term monitoring of the source populations was not possible, therefore, larger sites, which would be more likely to have larger populations of red squirrels, were chosen.

⇨ *Study sites*

Two potential source populations were identified based on results from a squirrel distribution survey of the west of Ireland (Poole and Lawton, unpublished data) and field surveys. Both sites were within 50 km of Belleek Forest Park (Figure 1), with journey time to the release site no more than an hour. The first site chosen was Lough Key Forest Park (G825 075, Figure 2), just outside Boyle, Co. Roscommon. It is a large mixed species site (~ 200ha) managed as an amenity forest, bordered to the north by Lough Key, to the south by the N4 and to the west and east by open farmland. Within the coniferous areas the predominant species was sitka spruce (*Picea sitchensis*), with some Scots pine (*Pinus sylvestris*). The broadleaf areas were mainly beech (*Fagus sylvatca*). Hazel (*Corylus* sp.), horse chestnut (*Aesculus hippocastanum*), oak (*Quercus* sp.) and birch (*Betula* sp.) were also present.

The second site was Union Wood, Ballysadare, Co. Sligo (G685 285, Figure 3). This was a large forest (~300 Ha), predominantly conifer, and managed for commercial purposes, with large areas clearfelled throughout the course of this study, and large blocks of newly planted, immature trees. It is at the western edge of a large forested area (~2000ha) extending east to Co. Leitrim which is transected by secondary roads (R284 and R287) and upland areas. To west it is bordered by the N4 and to the south and north by open pasture, residential, or commercial buildings. Sitka spruce was the dominant species in this forest, although some large specimen oak and hazel were scattered throughout the area, as well as sycamore (*Acer pseudoplatanus*), elm (*Ulmus* sp.) and beech. Some large areas of rhododendron (*Rhododendron ponticum*) were also present.

Figure 1: Map of the northwest of Ireland showing the translocation site (Belleek Forest Park) and the two potential source populations (Union Wood and Lough Key Forest Park). Detailed maps of the two potential source sites are given in Figures 2 and 3.

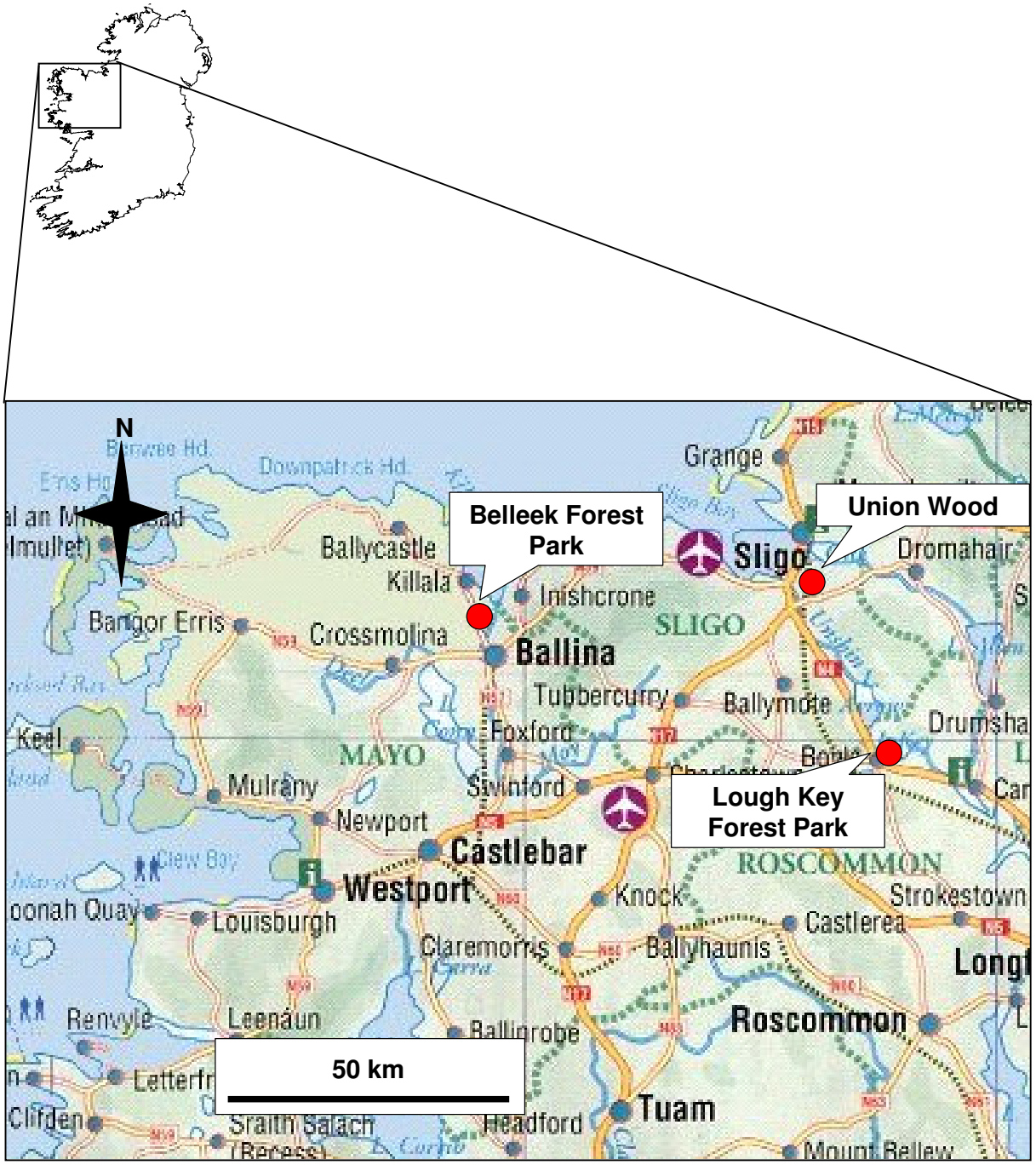
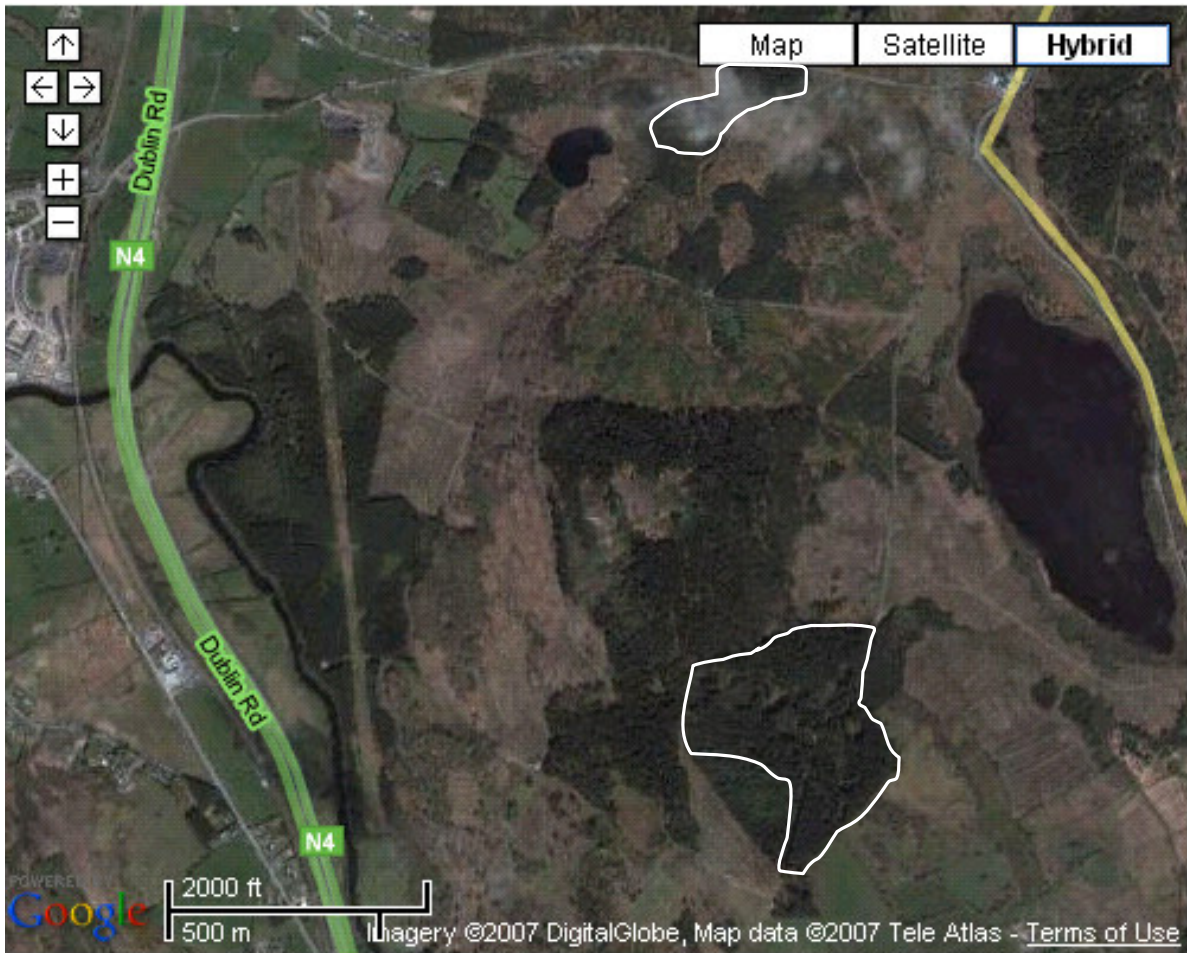


Figure 2: Aerial map (© GoogleEarth) of Lough Key Forest Park. The two regions within the forest which were trapped are outlined.

Figure 3: Aerial map (© GoogleEarth) of Union Wood. The two regions trapped in the forest are outlined.



⇨ *Monitoring*

Individuals should only be removed from a wild population after the effects of translocation on the donor population have been assessed.

Monitoring of the red squirrel population in Lough Key began in March 2007 with the first trapping session in early April. Surveying in Union began in late April and the first trapping session was in early June (see Table 1). As each site was so large (>200 Ha) it was decided to trap two small areas within each site. In Lough Key two areas of approximately 30 ha were trapped, while in Union one area was approximately 40 ha and the other 20ha. 22 traps were placed in Lough Key and 20 in Union Forest. Trapping consisted of a prebaiting period, 14 days for the initial trapping session and 5 days before each session thereafter, followed by 6 days trapping. Traps were baited initially with a 3:1 mix of peanuts and sunflower seeds, and later, following poor trapping success, with a 3:1 mix of whole maize and peanuts. The number and dates of, trapping sessions carried out in each site are given in Table 1.

Table 1: Dates of trapping sessions which were carried out in each site. Although some sessions appear longer than 6 days, poor weather conditions throughout the summer meant in some cases trap days could not be concurrent. When this occurred traps were prebaited between trap days. The average number of days spent trapping in each site was 25 days.

Site	Trap session	Date	Squirrels caught	
			Total	New individuals
Lough Key	1	13/04/07-18/04/07	4	4
	2	14/05/07-31/05/07	7	4
	3	11/06/07-16/06/07	7	2
	4*	02/08/07-10/08/07	8	3
	5: Translocation	23/08/07-31/08/07, 14/09/07	5	0
Union	1	05/06/07-08/06/07	10	7
	2	21/06/07-03/07/07	5	2
	3	12/08/08-16/08/07	0	0
	4: Translocation	06/09/07-12/09/07	1	1

*this fourth trapping session was meant to be the translocation session however, as the nest boxes had not been installed in the soft release enclosure no squirrels could be moved. This was unfortunate as trapping success in that session was the highest experienced in that site.

Each trapped squirrel was handled and processed using methods which have been described in detail elsewhere (Reilly 1997, Hamilton 2006). Briefly, trapped squirrels were transferred into a handling cone where body measurements; weight (g) and shin length (mm), and general appearance, were used to assess the health of the individual squirrel. The sex and age status of each individual were also determined based on external genitalia and body weight. Each squirrel was marked with a PIT (Passive Implantable Transponder) tag, allowing mark recapture estimates of the population to be determined.

A simple method of estimating squirrel densities was used, the minimum number present (MNP), where the total number of squirrels trapped in each site was expressed as squirrels/ha. This figure was then used to estimate the total number of squirrels present in each site.

- ⇨ *Results*

A total of 13 squirrels were trapped in Lough Key, 7 males and 6 females. 10 squirrels were caught in Union, 6 males and 4 females, one of the latter being a very young squirrel which was too small to tag (see Table 2). Estimated densities in Lough Key and Union were 0.22 squirrels/ha and 0.16 squirrels/ha respectively, giving an estimated total of 44 squirrels in Lough Key and 50 in Union.

Table 2: Details and body measurements of each squirrel caught trapped in both Lough Key Forest Park and Union Wood during the course of this study. The 5 individuals which were translocated are shown in italics, and the dates of their translocation are also given. MJuv: juvenile male; MAd: adult male; FJuv: juvenile female); FAd: adult female. Individuals which are labelled 'no tag' were caught only before the PIT tags arrived.

Date (first caught)	ID	Sex	Weight (g)	Length (mm)	Date translocated
Lough Key					
13/04/07	6A28E0D	FJuv	310	65	
14/04/07	'B' no tag	MAd	295	65.8	
16/04/07	*6A29700*	*FAd*	*320*	*63.7*	*23/08/07*
18/04/07	'D' no tag	MAd	295	67.4	
14/05/07	'E' no tag	MJuv	245	70.8	
15/05/07	6A29061	MAd	295	65.8	
27/05/07	6A2B3F2	MAd	300	67.7	
31/05/07	*6A29F94*	*MAd*	*315*	*64.1*	*23/08/07*
11/06/07	*6A40769*	*FJuv*	*260*	*62.8*	*23/08/07*
13/06/07	6A28650	FAd	300	66.9	
09/08/07	6A2AFFB	FAd	285	70	
09/08/07	6A25BAC	MAd	310	72.4	
10/08/07	*6A29C25*	*FAd*	*280*	*64*	*14/09/07*
Union					
05/06/07	69E3AB0	FAd	320	64.4	
05/06/07	6A28479	MJuv	335	65.2	
06/06/07	Too small	FJuv	180	47	
06/06/07	6A2990C	FAd	320	60	
06/06/07	69E6EC6	MJuv	245	67.4	
08/06/07	6A28EEA	FAd	285	67.2	
08/06/07	6A28148	MAd	310	69.7	
08/06/07	6A27A0D	MAd	260	66.8	
03/07/07	6A2B344	MAd	300	70	
07/09/07	*6A28EBD*	*MAd*	*295*	*68*	*07/09/07*

2) Translocation of individuals

⇨ *Removal of individuals from source forests*

Removal of individuals for re-introduction must not endanger the captive stock population or the wild source population.

The original aim of this study was to translocate 12+ individuals to Belleek Forest Park in 2007. However, the previous translocation study (Poole 2007), suggested that no more than 7.23% of the source population should be removed, and population estimates indicated that 7.23% of the populations in Lough Key and Union would be equivalent to 6 squirrels in total. Although recent modelling work has revealed that squirrel populations can recover from large population crashes (reducing a population of 56 by as many as 22 individuals carried a <5% probability of extinction (Poole 2007)), it was decided, given the limited monitoring of the source populations that was carried out here, and the relatively poor trapping success in some sessions, to not exceed the previously used figure of 7.23%. Therefore the revised aim was to move a total of 6 individuals in 2007, with further translocations to be carried out in 2008, possibly using the same source sites, depending on the results of post translocation monitoring and further population estimates.

⇨ *Translocation*

Trapping success during the translocation phase of the study was quite poor and it took considerable time to trap the individuals for the translocation. Individuals chosen for translocation were based on condition (only healthy looking individuals were chosen), maturity status (very young individuals were unlikely to survive), reproductive state (removal of pregnant or nursing females was avoided), and sex (aiming to have a 1:1 ratio of males to females in the translocation site). A soft release system was used in the translocation. Squirrels were transported from the source to the release site in re-enforced cardboard pet carriers and then released into a holding enclosure built by the BFPEC (see Plate 1). This enclosure was equipped with 6 nest boxes and a large feeding platform. Food provided consisted of a mixture of nuts, mainly peanuts, maize, sunflower seeds, with some walnuts and hazelnuts and pine cones also provided. Sliced apple and free water were used as a water source and food and water

were checked every two days. It was aimed to retain squirrels in the enclosure for a minimum of 4 weeks.

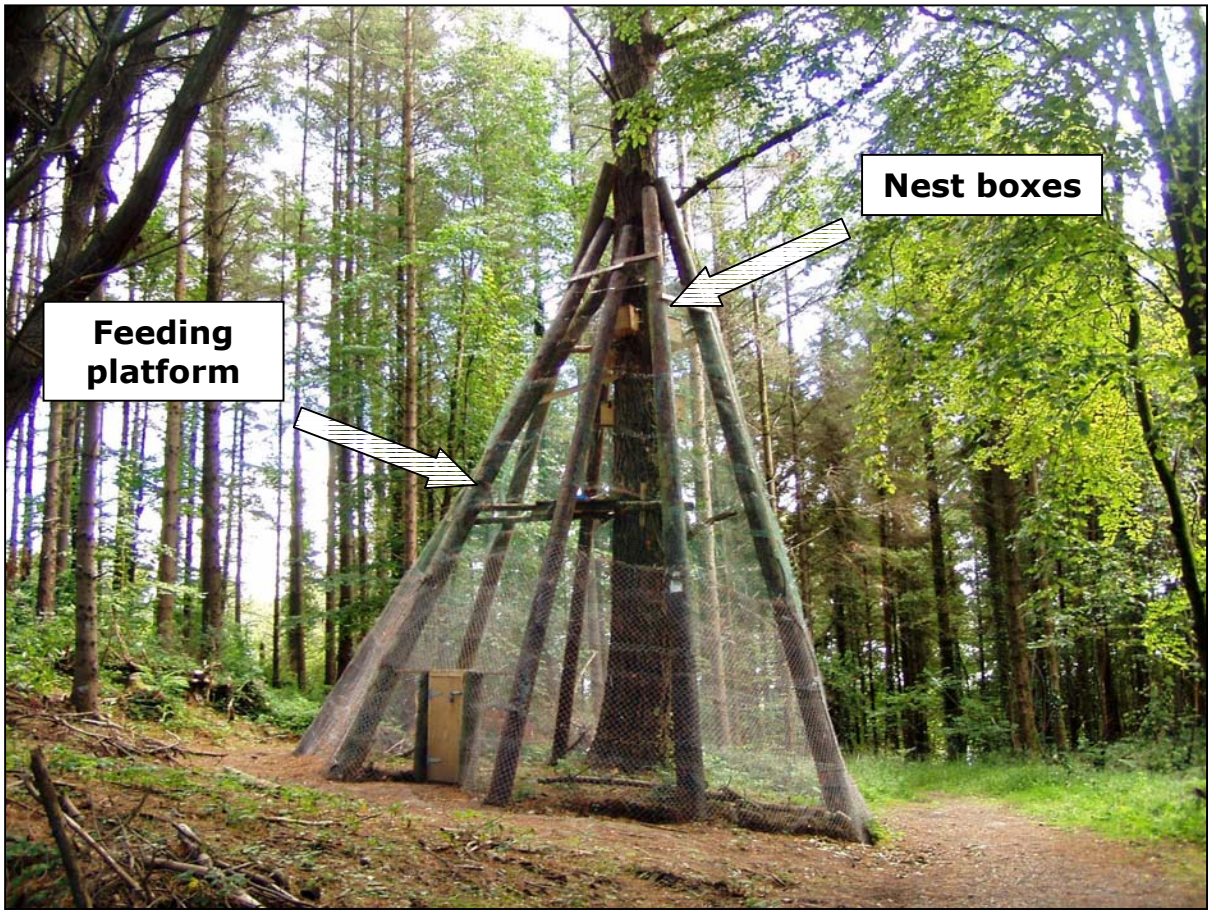


Plate 1: The soft release enclosure in Belleek Forest Park. The enclosure was equipped with 6 nest boxes and a feeding platform (labelled). Squirrels were retained in the enclosure for 4 weeks with food and water checked every second day.

The first movement of individuals took place in late August where 3 squirrels, 1 male and 2 female, were removed from Lough Key (see Table 2). A fourth individual was moved on the 7th of September from Union Wood. The fifth and final individual, a female, was moved from Lough Key to Belleek on 14th September. The total number of squirrels moved was therefore 5, with a 2:3 mixture of males:females. The details of these individuals are given in Table 2.

Unfortunately 2 individuals were inadvertently released from the enclosure on the 8th of September when the door was left open. It is unknown which individuals escaped, therefore the soft release period for the two that escaped

may have been 15 days, or may have been one day, if one of them was the individual which was moved the day before.

The roof of the enclosure was opened on 5th October to allow the three remaining squirrels to come and go as they please.

3) Post translocation monitoring of the source populations

Due to difficulties encountered with the capture of individuals, and other delays, no post translocation monitoring was possible within the scope of this contract. This work will be carried out in Phase 2 of this project (see below).

Discussion

A translocation cannot be deemed successful until the translocated population survives and produces young in the next breeding season. The objective of this study was to establish a population of red squirrels in Belleek Forest Park, and whether the overall translocation itself was a success will not be known until further phases of the project are completed. However, there are now red squirrels in Belleek Forest Park which has expanded red squirrel range in Ireland, highlighted the plight of the species through public involvement and media attention, and, most importantly, increased experience and knowledge of the use of translocation as a conservation tool for red squirrels in Ireland

Unfortunately, although post removal monitoring of the source populations was originally encompassed in this phase of the project it was not possible due to unforeseen delays; notably the problem of catching squirrels in the source populations which extended the time spent trapping, and decreased the number of individuals which were moved to Belleek Forest Park. By picking two large source populations it was envisaged that trapping and removing 12 squirrels for the translocation would not be a problem within the time frame, and would not endanger survival of the source populations. Unfortunately this was not the case. Trapping success in the source populations fluctuated widely, and at some times was quite poor. This resulted in the population calculations for these two forests being correspondingly low (<100 individuals).

Portumna Forest Park, the source forest for the translocation which was carried out by NUI Galway, was of a similar size and composition to that of Union Wood, and was poorer habitat than the diverse mixed broadleaf/coniferous site, Lough Key, used in this study. Trapping estimates in Portumna calculated the population at 263 animals. It is probable that the actual squirrel numbers in both source sites in this study are similar to those in Portumna. The lower numbers trapped in this study can be explained by a) the limited trapping time available in comparison to the 2 years spent monitoring the population in Portumna; b) the extremely poor weather throughout the trapping period and c) the possible deterrent effect of pine martens which were caught in several of the traps in Lough Key. However, without the actual data to support the fact that populations in the source forests were indeed higher than the trapping detected, it was

impossible to justify removing more than the 7.23% of the estimated populations.

As previously mentioned, modelling work completed by Poole (2007) found that the extinction risk to the source population was extremely low even when a large % of the population was removed. Therefore, theoretically, a larger number of individuals could have been removed from the source forests. However, more extensive trapping, leading to more accurate population estimates would be required to underpin such an approach. In any case, the trapping patterns in both sites, where there were a considerable number of individuals which were never re-trapped, meant that collecting 6 individuals for translocation took a considerable amount of time and in the end, only 5 individuals were moved.

This low number of translocated individuals is disappointing. Squirrel mortality over the winter can be quite high. Of the 19 squirrels which were translocated to in the Galway study, only 13 are known to have survived the first winter. However it is hoped that the large variety of food resources available in Belleek Forest Park, combined with ongoing supplemental feeding, will result in high survival rates of the five translocated individuals in this study. Further translocations into the site will be necessary to complete the project, with 15 – 20 animals required to ensure sufficient genetic variation within the translocated population and to increase the chance that the translocation will be a success. New population estimates for each of the two source populations will be required in 2008 to establish whether the same woodlands can be used for further translocations to Belleek, or whether the removal of further individuals would harm the source populations.

Post-release activities

To assess whether a translocation is successful it is necessary to undertake post release, and post removal, monitoring of the translocated and source populations respectively. Although originally it was aimed to do short term post release monitoring within the time frame allocated to this project, difficulties and delays encountered meant that it became impossible. However, even had this monitoring occurred, it was going to be extremely limited, and long term monitoring would have been necessary nevertheless, as only through long term

monitoring can survival, home range movements, adaptation etc., of the population be determined.

Post release monitoring is required of all (or sample of) individuals. This ***most vital aspect*** *may be by direct (e.g. tagging, telemetry) or indirect (e.g. spoor, informants) methods as suitable.*

Short term monitoring (at least 1 year) of the three populations involved in this study is needed. The translocated population should be monitored using both trap/release and radiotelemetry. This will allow continual monitoring of the health of individuals, detection of possible mortalities and assessments of whether the population is reproducing. Radio tracking will allow habitat use, and possible dispersive movements, to be monitored. Monitoring of the source populations is also necessary. These could be monitored directly, as described above, or indirectly using hair tubes, feeding signs, visual counts, although direct monitoring would be needed were further individuals to be removed from the same (or other) sites.

Demographic, ecological and behavioural studies of released stock must be undertaken.

Study of processes of long-term adaptation by individuals and the population.

This is related to more long term monitoring. Determining whether the translocated population is reproducing each year, whether individuals are dispersing, their ecological responses to food availability etc. are all required and could be achieved through a mixture of direct and indirect methods. Monitoring of the genetic diversity of the population would also be useful, given the isolation of the site, to determine whether further introductions are necessary to avoid inbreeding within the population.

Collection and investigation of mortalities.

All the individuals which were translocated were implanted with PIT tags. Should a dead red squirrel be found in or around the area, whether it was one of the translocated individuals can easily be ascertained by scanning the individual. Compatible scanners are held by Dr Colin Lawton, Zoology Dept., NUI Galway

and Dr John Rochford, Zoology Dept, TCD. The cause of death of any of the translocated individuals found dead should be determined.

Interventions (e.g. supplemental feeding; veterinary aid; horticultural aid) when necessary.

Supplementary feeding stations were positioned throughout Belleek by the BFPEC and this group are ensuring that the squirrels are provided with a wide mixture of seeds – hazelnuts, walnuts, peanuts, maize, sunflower seeds, beech nuts and some fruit – apple. These will stay in place all winter and should stay in place until post release monitoring of the population deems they are no longer necessary.

Decisions for revision, rescheduling, or discontinuation of programme where necessary.

Revision of the study took place as the project progressed: the number of squirrels translocated was reduced, and the timing of the reintroduction altered. The initial phase of this project has been completed and while fewer animals were translocated than envisaged there are no reasons to suggest that the programme should be discontinued at this stage. However, as this project is a collaboration between two separate groups, scientists and members of the public (BFPEC), some issues arose which should be addressed, and in some cases rectified, prior to further translocations into Belleek:

Practical considerations:

- Initially there were some problems with the mesh size used in the enclosure. The enclosure was re-covered in a smaller mesh size and, despite some doubts, proved capable of retaining squirrels safely. Later on in the study the translocation was delayed as nest boxes had not been placed in the enclosure. This delay is partly my fault as I should have contacted the BFPEC earlier to arrange this. However, once it had been arranged, three weeks lapsed before the nest boxes were installed. Although this will no longer be a problem in Belleek it should be remembered for any future translocations where both enclosure design etc should be carefully planned before the actual translocation begins.

- Access to the enclosure needs to be severely restricted. Although the enclosure was padlocked closed, during one of the feeding sessions by BFPEC another member entered the enclosure, leaving the door open, allowing two squirrels to escape. A bolt on the inside of the enclosure may prevent this from happening in the future.

- As only BFPEC had a barrier key to the forest they had to be contacted before any squirrels could be moved into the enclosure. In one case they could not be contacted. This resulted an extra ½ hour between squirrel capture and release, as the enclosure had to be reached by foot. The individual carrying out further translocations should have a barrier key from the start.

Education:

- Should any further translocations involve collaboration between scientists and members of the public it must be ensured that the members of the public are ether aware of the basic ecology of the species involved (suitable food etc) or are willing to learn.

- Of particular concern was the proposed idea by the BFPEC of translocating the further 6 squirrels into the forest themselves. Not only did this demonstrate, even after repeated explanations, the lack of understanding of the need for a scientific basis to all translocations, but also showed no regard for the required ecological knowledge and skills (and government license) needed to trap, tag, assess the health of, and translocate this protected species. The ecological, ethical, and possible legal ramifications, of such an unauthorised translocation should be clearly explained to the BFPEC.

Habitat protection or restoration to continue where necessary.

Belleek Forest Park is owned by Coillte Teoranta. It is not a commercial forest therefore it is highly unlikely that large areas of the forest will be clearfelled. However, on-going liaison with Coillte is needed to ensure their continual cooperation with the project, and to ensure appropriate management of the site for red squirrels.

Continuing public relations activities, including education and mass media coverage.

BFPEC intend to erect a large sign in the forest outlining the translocation so far and, from the number of the members of the public and newspaper coverage on the release date, it is apparent that there is a lot of interest in the forest. BFPEC frequently bring school groups and nature walks around the forest, therefore education of the forest, and therefore the translocation, will be continual. However it is recommended that NPWS provide advice on the content of any educational material provided by BFPEC.

Evaluation of cost-effectiveness and success of re- introduction techniques.

As the project itself is not completed an overall evaluation of the cost effectiveness of the project will only be possible once the further translocations and monitoring have been carried out.

However at this stage it can be noted that, even with the problems already outlined regarding the collaboration with BFPEC, the involvement of the group in the project greatly reduced the costs involved. The BFPEC paid for all materials, and provided all labour, for the construction of the soft-release enclosure, and nest boxes and feeding stations provided around the forest. They also reduced costs by checking and feeding the squirrels in the enclosure. Although the latter did have its problems (incorrect food provided, squirrels escaping).

Regular publications in scientific and popular literature

As no post release monitoring has been carried out the data from this study is not suitable for publication in scientific literature. However once the post translocation monitoring in both the release and source forest has been carried out it may be suitable, and would be interesting to compare with both the translocated and source populations in Galway.

Recommendations

A further 10-15 squirrels need to be moved to Belleek, ideally in the first half of 2008. It is possible that the same two source forests could be used, however trapping sessions in each site would be needed to ensure that they can sustain further removals. If they cannot, other woodlands will need to be assessed.

Translocations are long term projects which should be thought of in terms of years, not months. Although post release monitoring of all populations involved is necessary (~ 1 year) allowances should be made for frequent (if possible annual) monitoring of the translocated population for a considerable period into the future. It is therefore recommended that post release monitoring be conducted as soon as possible but also that long term monitoring must be planned for. Monitoring at Belleek, in combination with further work at Derryclare, would provide vital data towards the development of a scientifically based translocation strategy for red squirrels in Ireland.

This report has detailed some of the advantages and disadvantages which were associated with working in collaboration with a local community group. Should the recommendations given be followed there should be few major problems in the future. However it is strongly recommended that ongoing liaison with the BFPEC continues to ensure their continued cooperation with the red squirrel translocation project.

Acknowledgements

Thanks to Dr Ferdia Marnell for supervising this study. Thanks also to Dr Colin Lawton and Alan Poole for their advice throughout and for providing information and data from the Derryclare translocation. I am grateful to Coillte and NPWS for their help throughout and to the Zoology Depts of NUI Galway and Trinity College for the loan of equipment. Thank you to the BFPEC for their interest and for building the enclosure etc, and particularly to Cyril Collins for all his help and enthusiasm.

References

Aubry KB, Lewis JC (2003) Extirpation and reintroduction of fishers (*Martes pennanti*) in Oregon: implications for their conservation in the Pacific states. *Biological Conservation* **114**: 79-90

Barrington R (1880) On the introduction of the squirrel into Ireland. *Scientific Proceedings of the Royal Dublin Society* **2**: 615-631

Bendel PR, Therres GB (1994) Movements, site fidelity and survival of Delmarva Fox squirrels following translocation. *American Midland Naturalist* **132**: 227-233

Finnegan LA (2007) *A genetic and morphological investigation of the forces shaping the distribution and diversity of the red squirrel (*Sciurus vulgaris*).* PhD Thesis, University of Dublin

Finnegan LA, Edwards, CJ, Rochford JM (in press) Origin of, and conservation units in, the Irish red squirrel (*Sciurus vulgaris*) population. *Conservation Genetics* **DOI**: 10.1007/s10592-007-9419-7

Fitzpatrick HM (1965) *The Forests of Ireland.* The Record Press, Bray

Garrett W (2001) *Woodland History Survey of the Coillte Estate.* Unpublished report for Coillte

Gurnell J (1987) *The Natural History of Squirrels*. Christopher Helm, London

Hamilton GD (2006) *The ecology of the red squirrel,* Sciurus vulgaris*, in commercial coniferous forests: A GIS approach*. M.Sc. Thesis, University of Dublin

IUCN (1998) *Guidelines for Re-introductions.* Prepared by the IUCN/SSC Re-introduction Specialist Group. IUCN Gland Switzerland and Cambridge UK

Kenward RE, Holm JL (1993) On the replacement of the red squirrel in Britain: a phytotoxic explanation. *Proceedings of the Royal Society of London, series B.* **13**: 187-194

Lawton C (2006) Belleek Wood as a potential translocation site of red squirrels (*Sciurus vulgaris*) – An assessment. Unpublished report for NPWS

Lurz PWW, Gurnell J, Magris L (2005) *Sciurus vulgaris*. *Mammalia* **769**: 1-10

Ó Teangana D, Reilly S, Montgomery WI, Rochford, J (2000) Distribution and status of the red squirrel (*Sciurus vulgaris*) and grey squirrel (*Sciurus carolinensis*) in Ireland. *Mammal Review* **30:** 45-56

O'Toole L, Fielding AH, Haworth PF (2002) Re-introduction of the golden eagle into the Republic of Ireland. *Biological Conservation* **103**: 303-312

Poole A (2007) *An investigation of translocation as technique to conserve the red squirrel (*Sciurus vulgaris*) in Ireland.* PhD Thesis, NUI Galway

Reilly SS (1997) *The Ecology of the Red Squirrel,* Sciurus vulgaris, *in Commercial Conifer Forests in the Republic of Ireland.* Ph.D. Thesis, University of Dublin

Smith KG, Clark JD (1994) Black bears in Arkansas: characteristics of a successful translocation. *Journal of Mammalogy* **75**: 309-320

Towns DR, Ferreira SM (2001) Conservation of New Zealand lizards (Lacertilia: Scinidae) by translocation of small populations. *Biological Conservation* **98**: 211-222

Wauters LA, Lurz PWW, Gurnell J (2000) The interspecific effects of grey squirrels (*Sciurus carolinensis*) on the space use and population dynamics of red squirrels (*Sciurus vulgaris*) in conifer plantations. *Ecological Research* **15**: 271-284

Appendix: IUCN/SSC Guidelines for Re-Introductions (IUCN 1998)

1. DEFINITION OF TERMS

"Re-introduction": an attempt to establish a species in an area which was once part of its historical range, but from which it has been extirpated or become extinct ("Re-establishment" is a synonym, but implies that the re-introduction has been successful).

"Translocation": deliberate and mediated movement of wild individuals or populations from one part of their range to another.

"Re-inforcement/Supplementation": addition of individuals to an existing population of conspecifics.

"Conservation/Benign Introductions": an attempt to establish a species, for the purpose of conservation, outside its recorded distribution but within an appropriate habitat and ecogeographical area. This is a feasible conservation tool only when there is no remaining area left within a species' historic range.

2. AIMS AND OBJECTIVES OF RE-INTRODUCTION

a. Aims:

The principle aim of any re-introduction should be to establish a viable, free-ranging population in the wild, of a species, subspecies or race, which has become globally or locally extinct, or extirpated, in the wild. It should be re-introduced within the species' former natural habitat and range and should require minimal long-term management.

b. Objectives:

The objectives of a re-introduction may include: to enhance the long-term survival of a species; to re-establish a keystone species (in the ecological or cultural sense) in an ecosystem; to maintain and/or restore natural biodiversity; to provide long-term economic benefits to the local and/or national economy; to promote conservation awareness; or a combination of these.

3. MULTIDISCIPLINARY APPROACH

A re-introduction requires a multidisciplinary approach involving a team of persons drawn from a variety of backgrounds. As well as government personnel, they may include persons from governmental natural resource management

agencies; non-governmental organisations; funding bodies; universities; veterinary institutions; zoos (and private animal breeders) and/or botanic gardens, with a full range of suitable expertise. Team leaders should be responsible for coordination between the various bodies and provision should be made for publicity and public education about the project.

4. PRE-PROJECT ACTIVITIES

4a. BIOLOGICAL

(i) Feasibility study and background research

• An assessment should be made of the taxonomic status of individuals to be reintroduced. They should preferably be of the same subspecies or race as those which were extirpated, unless adequate numbers are not available. An investigation of historical information about the loss and fate of individuals from the re-introduction area, as well as molecular genetic studies, should be undertaken in case of doubt as to individuals' taxonomic status. A study of genetic variation within and between populations of this and related taxa can also be helpful. Special care is needed when the population has long been extinct.

• Detailed studies should be made of the status and biology of wild populations (if they exist) to determine the species' critical needs. For animals, this would include descriptions of habitat preferences, intraspecific variation and adaptations to local ecological conditions, social behaviour, group composition, home range size, shelter and food requirements, foraging and feeding behaviour, predators and diseases. For migratory species, studies should include the potential migratory areas. For plants, it would include biotic and abiotic habitat requirements, dispersal mechanisms, reproductive biology, symbiotic relationships (e.g. with mycorrhizae, pollinators), insect pests and diseases. Overall, a firm knowledge of the natural history of the species in question is crucial to the entire re-introduction scheme.

• The species, if any, that has filled the void created by the loss of the species concerned, should be determined; an understanding of the effect the re-introduced species will have on the ecosystem is important for ascertaining the success of the re-introduced population.

• The build-up of the released population should be modelled under various sets of conditions, in order to specify the optimal number and composition of individuals to be released per year and the numbers of years necessary to promote establishment of a viable population.

• A Population and Habitat Viability Analysis will aid in identifying significant environmental and population variables and assessing their potential interactions, which would guide long-term population management.

(ii) Previous Re-introductions

• Thorough research into previous re-introductions of the same or similar species and wide-ranging contacts with persons having relevant expertise should be conducted prior to and while developing re-introduction protocol.

(iii) Choice of release site and type

• Site should be within the historic range of the species. For an initial re-inforcement there should be few remnant wild individuals. For a re-introduction, there should be no remnant population to prevent disease spread, social disruption and introduction of alien genes. In some circumstances, a re-introduction or re-inforcement may have to be made into an area which is fenced or otherwise delimited, but it should be within the species' former natural habitat and range.

• A conservation/ benign introduction should be undertaken only as a last resort when no opportunities for re-introduction into the original site or range exist and only when a significant contribution to the conservation of the species will result.

• The re-introduction area should have assured, long-term protection (whether formal or otherwise).

(iv) Evaluation of re-introduction site

• Availability of suitable habitat: re-introductions should only take place where the habitat and landscape requirements of the species are satisfied, and likely to be sustained for the for-seeable future. The possibility of natural habitat change since extirpation must be considered. Likewise, a change in the legal/ political or cultural environment since species extirpation needs to be ascertained and evaluated as a possible constraint. The area should have sufficient carrying

capacity to sustain growth of the re-introduced population and support a viable (self-sustaining) population in the long run.

• Identification and elimination, or reduction to a sufficient level, of previous causes of decline: could include disease; over-hunting; over-collection; pollution; poisoning; competition with or predation by introduced species; habitat loss; adverse effects of earlier research or management programmes; competition with domestic livestock, which may be seasonal. Where the release site has undergone substantial degradation caused by human activity, a habitat restoration programme should be initiated before the reintroduction is carried out.

(v) Availability of suitable release stock

• It is desirable that source animals come from wild populations. If there is a choice of wild populations to supply founder stock for translocation, the source population should ideally be closely related genetically to the original native stock and show similar ecological characteristics (morphology, physiology, behaviour, habitat preference) to the original sub-population.

• Removal of individuals for re-introduction must not endanger the captive stock population or the wild source population. Stock must be guaranteed available on a regular and predictable basis, meeting specifications of the project protocol.

• Individuals should only be removed from a wild population after the effects of translocation on the donor population have been assessed, and after it is guaranteed that these effects will not be negative.

• If captive or artificially propagated stock is to be used, it must be from a population which has been soundly managed both demographically and genetically, according to the principles of contemporary conservation biology.

• Re-introductions should not be carried out merely because captive stocks exist, nor solely as a means of disposing of surplus stock.

• Prospective release stock, including stock that is a gift between governments, must be subjected to a thorough veterinary screening process before shipment from original source. Any animals found to be infected or which test positive for non-endemic or contagious pathogens with a potential impact on population levels, must be removed from the consignment, and the uninfected, negative remainder must be placed in strict quarantine for a suitable period before retest. If clear after retesting, the animals may be placed for shipment.

• Since infection with serious disease can be acquired during shipment, especially if this is intercontinental, great care must be taken to minimize this risk.

• Stock must meet all health regulations prescribed by the veterinary authorities of the recipient country and adequate provisions must be made for quarantine if necessary.

(vi) Release of captive stock

• Most species of mammal and birds rely heavily on individual experience and learning as juveniles for their survival; they should be given the opportunity to acquire the necessary information to enable survival in the wild, through training in their captive environment; a captive bred individual's probability of survival should approximate that of a wild counterpart.

• Care should be taken to ensure that potentially dangerous captive bred animals (such as large carnivores or primates) are not so confident in the presence of humans that they might be a danger to local inhabitants and/or their livestock.

4b. SOCIO-ECONOMIC AND LEGAL REQUIREMENTS

• Re-introductions are generally long-term projects that require the commitment of longterm financial and political support.

• Socio-economic studies should be made to assess impacts, costs and benefits of the reintroduction programme to local human populations.

• A thorough assessment of attitudes of local people to the proposed project is necessary to ensure long term protection of the re-introduced population, especially if the cause of species' decline was due to human factors (e.g. over-hunting, over-collection, loss or alteration of habitat). The programme should be fully understood, accepted and supported by local communities.

• Where the security of the re-introduced population is at risk from human activities, measures should be taken to minimise these in the re-introduction area. If these measures are inadequate, the re-introduction should be abandoned or alternative release areas sought.

• The policy of the country to re-introductions and to the species concerned should be assessed. This might include checking existing provincial, national and international legislation and regulations, and provision of new measures and required permits as necessary.

• Re-introduction must take place with the full permission and involvement of all relevant government agencies of the recipient or host country. This is particularly important in reintroductions in border areas, or involving more than one state or when a re-introduced population can expand into other states, provinces or territories.

• If the species poses potential risk to life or property, these risks should be minimised and adequate provision made for compensation where necessary; where all other solutions fail, removal or destruction of the released individual should be considered. In the case of migratory/mobile species, provisions should be made for crossing of international/state boundaries.

5. PLANNING, PREPARATION AND RELEASE STAGES

• Approval of relevant government agencies and land owners, and coordination with national and international conservation organizations.

• Construction of a multidisciplinary team with access to expert technical advice for all phases of the programme.

• Identification of short- and long-term success indicators and prediction of programme duration, in context of agreed aims and objectives.

• Securing adequate funding for all programme phases.

• Design of pre- and post- release monitoring programme so that each re-introduction is a carefully designed experiment, with the capability to test methodology with scientifically collected data. Monitoring the health of individuals, as well as the survival, is important; intervention may be necessary if the situation proves unforseeably favourable.

• Appropriate health and genetic screening of release stock, including stock that is a gift between governments. Health screening of closely related species in the re-introduction area.

• If release stock is wild-caught, care must be taken to ensure that: a) the stock is free from infectious or contagious pathogens and parasites before shipment and b) the stock will not be exposed to vectors of disease agents which may be

present at the release site (and absent at the source site) and to which it may have no acquired immunity.

• If vaccination prior to release, against local endemic or epidemic diseases of wild stock or domestic livestock at the release site, is deemed appropriate, this must be carried out during the "Preparation Stage" so as to allow sufficient time for the development of the required immunity.

• Appropriate veterinary or horticultural measures as required to ensure health of released stock throughout the programme. This is to include adequate quarantine arrangements, especially where founder stock travels far or crosses international boundaries to the release site.

• Development of transport plans for delivery of stock to the country and site of reintroduction, with special emphasis on ways to minimize stress on the individuals during transport.

• Determination of release strategy (acclimatization of release stock to release area; behavioural training - including hunting and feeding; group composition, number, release patterns and techniques; timing).

• Establishment of policies on interventions (see below).

• Development of conservation education for long-term support; professional training of individuals involved in the long-term programme; public relations through the mass media and in local community; involvement where possible of local people in the programme.

• The welfare of animals for release is of paramount concern through all these stages.

6. POST-RELEASE ACTIVITIES

• Post release monitoring is required of all (or sample of) individuals. This most vital aspect may be by direct (e.g. tagging, telemetry) or indirect (e.g. spoor, informants) methods as suitable.

• Demographic, ecological and behavioural studies of released stock must be undertaken.

• Study of processes of long-term adaptation by individuals and the population.

• Collection and investigation of mortalities.

• Interventions (e.g. supplemental feeding; veterinary aid; horticultural aid) when necessary.

- Decisions for revision, rescheduling, or discontinuation of programme where necessary.
- Habitat protection or restoration to continue where necessary.
- Continuing public relations activities, including education and mass media coverage.
- Evaluation of cost-effectiveness and success of re- introduction techniques.
- Regular publications in scientific and popular literature.