Northern Spotted Owl Population Enhancement and Recovery in British Columbia

Proposed Five-Year Action Plan

Prepared by the

Spotted Owl Population Enhancement Team (SOPET)

for the Government of British Columbia

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Executive Summary

In April 2006 the British Columbia government announced its Spotted Owl Recovery Action Plan. The Plan included three components, one of which was population enhancement. Aspects of population recovery and enhancement include captive breeding and release, translocation, prey augmentation, and removal of potential competitors or predators. In December 2006 government established the Spotted Owl Population Enhancement Team (SOPET), an independent science team charged with providing advice regarding the variety of approaches that could potentially contribute to recovery of the Spotted Owl. This document provides that advice.

The SOPET evaluated a number of approaches to population enhancement and has made the following recommendations to government based on professional judgment, personal experience and an understanding of the scientific literature on population augmentation actions and how these actions might translate to Spotted Owl population performance in British Columbia. However, population enhancement actions have never been comprehensively applied to Spotted Owls. The perspectives expressed herein are our collective expert judgment and are characterized by an unknown amount of risk and uncertainty. Ultimately the success of any population enhancement program will depend on adequately addressing the threats that originally placed the species at risk – the loss and fragmentation of habitat in the case of Spotted Owls in British Columbia. Other significant risk factors must also be addressed.

Each approach was evaluated in terms of feasibility, risk, uncertainty, and likelihood of contributing to an increase in British Columbia's Spotted Owl population. The SOPET's recommendations are summarized as follows:

1. *No population enhancement*
   This approach involves taking no deliberate management action to augment or enhance Spotted Owl populations, and relies solely on implementation of a habitat management strategy. Taking no action would not address the steep population decline and is not likely to increase the population.
   This approach is not recommended.

2. *Translocation of single adult Spotted Owls to form new pairs in the wild*
   This approach involves capturing owls from sites occupied by single owls and moving them to sites occupied by single owls of the opposite sex to create pairs. It is uncertain that: a) owls would remain in the new territory, b) the new territory would be sufficient to support the new pair, or c) that mates of newly created pairs would be compatible.
   This approach is feasible but with little likely positive effect, and is not recommended.

3. *Overwintering and release of juvenile Spotted Owls*
   This approach involves capturing juvenile Spotted Owls before dispersal and holding them in captivity for the winter, and releasing them to the wild in spring. Though feasible, this is not recommended as a primary strategy at this time as: a) released juveniles raised in captivity are inexperienced and therefore vulnerable, b) potential recruitment is hindered by low productivity in the current population, meaning that few owls are available for this action, and c) as in translocations, juvenile owls may not remain in the release area.

This approach is feasible but with little likely positive effect, and is not recommended.

4. Supplemental feeding in the wild

This approach would involve provisioning adult and juvenile owls with food on a regular basis to help maintain their physical condition. The benefit of this approach is increased survival in both age cohorts. Though theoretically feasible this approach requires regular relocation of owls and use of radio-telemetry and great logistical costs. We believe it would be extremely difficult to do, would likely have little positive effect, and could have the negative effect of conditioning owls to approach humans for food.
This approach is not recommended.

5. Prey enhancement

This approach involves increasing prey populations, principally flying squirrels and bushy-tailed woodrats in areas used by Spotted Owls. This could be beneficial in particular owl territories and could, in time, be done as a controlled experiment, but there are too few owls at present to allow for an experimental design. In the future this may be difficult to do at a scale large enough to affect many pairs of owls, and it is possible that other predators or competitors could respond more favorably to this action than would the target Spotted Owls.
This approach is not recommended in the short term.

6. Control of predators and/or competitors

This approach is a direct means of addressing one of the two most significant current threats to the Spotted Owl (the other being habitat loss). This approach may be feasible at the scale of individual Spotted Owl territories, but its feasibility as a method of overall population control is not currently clear and must be evaluated. It involves removing Barred Owls and possibly Great Horned Owls from sites or landscapes occupied by Spotted Owls. This approach may be considered in the longer term for local management needs during reintroductions. This approach may also be considered as a controlled experiment at larger scales to determine potential management value but there are too few owls at present to allow for an experimental design. **This approach is recommended in the short term to enhance nesting success for pairs of Spotted Owls now breeding in the wild.**

7. Captive breeding and reintroduction

This approach entails removing all or some of the remaining Spotted Owls from the wild in British Columbia, establishing a captive breeding population and subsequently reintroducing owls from this population to the wild. One option (Option A) would be to remove all known Spotted Owls from the wild in 2007. Another option (Option B) would be to remove four adults of each sex and all known juveniles from the wild in 2007.
This is our recommended approach (either Option A or Option B) as we believe this is the most valuable population enhancement measure for British Columbia. Selection of Option B means also implementing Approach 6.

In addition to these recommendations on approaches, the SOPET provides the following implementation recommendations:

- That government makes a decision expeditiously as this will allow efficiencies in planning and costs, and will maximize the results of the spring 2007 Spotted Owl inventory being conducted by the Ministry of Environment.
- That ***coordination*** of activities and ***communication*** among partner agencies will be critically important elements for the success of a captive breeding and reintroduction program for the British Columbia Spotted Owl.
- If Option A or B is selected by government, the SOPET recommends that short-term implementation actions, April to September 2007, include:
  - Obtain British Columbia Spotted Owls from the wild.
  - Establish cooperative relations with other jurisdictions and partners in the United States, including state wildlife agencies in Washington and Oregon, and the Pacific Northwest Zoo Alliance.
  - Establish a British Columbia Spotted Owl Coordinator and Captive Breeding Working Group.
  - Hold a Captive Breeding Working Group inaugural workshop in late spring 2007 to determine all logistics and information requirements and contractual considerations related to captive breeding of Spotted Owls in British Columbia.

Alternative models for captive breeding facilities exist, including (a) establishing government 'in-house' facilities; (b) using existing university or research animal care facilities; (c) contracting with privately-operated animal breeding centres, zoos or wildlife parks; and (d) a combination of facilities. The SOPET recommends using a series of privately-operated animal breeding centres, zoos or wildlife parks. To avoid unforeseen risks to captive owls, the SOPET recommends a minimum of two facilities to start, and a third facility once more owls are available.

The SOPET identifies short- and long-term funding requirements, including funding for a coordinator's position, establishing a captive breeding working group and holding an inaugural workshop, building facilities, training staff, operating funds, and ongoing inventory and monitoring. Estimated budget for Year 1 is **$527,000.00**. Estimated budget over five years is **$3,424,000.00**. It is expected that flexibility around funding would include in-house support (government), in-kind-support (facilities), support from Foundations, potential contributions from fund-raising initiatives, and volunteer contributions.

Finally we recommend that the British Columbia government, if deciding to implement captive breeding, make explicit the commitment to protect habitat in the areas where captive bred owls settle, regardless of whether those areas are in previously designated owl management areas. We do not recommend implementing the captive breeding and reintroduction approach without such a commitment, as one without the other is not likely to succeed.

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The Northern Spotted Owl population in British Columbia is very small (fewer than 25 known owls), isolated both within the province and at the metapopulation level (e.g., relative to the owl population in Washington), and is therefore listed as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). There is concern that the species will be extirpated in British Columbia without intensive and focused conservation action (Chutter et al. 2004). The estimated population trend for Spotted Owls in British Columbia indicates a decline of about 7.2% per year (Blackburn et al. 2001, Blackburn and Harestad 2002), comparable to rates estimated from Washington and elsewhere in the United States (Anthony et al. 2006).

Given concerns about the owl's status and low prospects for persistence in the province, the Canadian Spotted Owl Recovery Team (CSORT), convened in 2002, produced a recovery strategy for the species (Chutter et al. 2004). CSORT subsequently produced an additional document that provides guidance to the British Columbia government on elements of action planning (Chutter et al. 2007). Recommendations from the two CSORT documents include the need to augment Spotted Owl populations in the province (Chutter et al. 2004, 2007).

In April 2006 the British Columbia government announced its Spotted Owl Recovery Action Plan that included a population enhancement component. The intent of the population enhancement component of the action plan is to identify, develop and implement actions that will lead to the recovery of Spotted Owls in British Columbia. Aspects of population augmentation include captive breeding and release, translocation, prey augmentation, and removal of potential competitors or predators.

In December 2006 the government of British Columbia established the Spotted Owl Population Enhancement Team (SOPET), an independent science team charged with providing advice regarding a variety of augmentation approaches that could potentially contribute to recovery of the Spotted Owl in British Columbia. The SOPET terms of reference are provided in Appendix 1. Following the SOPET's first workshop, held in January 2007, the team submitted interim recommendations on February 1, 2007 to the Ministry of the Environment, the Ministry of Forests and Range, and the Ministry of Agriculture and Lands (see Table 1).

Table 1: SOPET Interim Advice to Government - February 1, 2007

1.	Develop an Inventory Plan for 2007.
2.	Carry out genetic analysis of British Columbia's Spotted Owls from existing animals/specimens as soon as possible.
3.	Obtain blood samples from as many wild Spotted Owls as soon as possible.
4.	Do not remove any Spotted Owls from the wild in the spring of 2007.
5.	Retain any injured or other Spotted Owls that come into captivity and retain current captive birds in captivity.
6.	Identify a regional Ministry staff person who will be responsible for ensuring that transport, care, and handling protocols are understood and their provisions met.
7.	Initiate a draft Memorandum of Understanding between Canada and the US for cooperation on

Spotted Owl Recovery.

8. Improve Spotted Owl data and record management, and provide ready access to these data to appropriate parties.
   - 8.1 The British Columbia Ministry of Environment should ensure that all activities, records and other information related to Spotted Owls (e.g., inventory or other owl site data for all current or historic sites, management plans, survey effort, survey protocols, unpublished summaries or analyses of data, etc.) are thoroughly documented and submitted to a Spotted Owl data custodian.
   - 8.2 Establish a secure British Columbia Spotted Owl data website for access by CSORT and SOPET members.
   - 8.3 Update the current Spotted Owl website or develop a new site that is more comprehensive and includes all related material that is in the public domain**.**

2. Evaluation of Approaches

Seven approaches for enhancing Spotted Owl populations were considered by the SOPET. The approaches were derived from recommendations developed by the CSORT (Chutter et al. 2004). These approaches to population enhancement range from "no enhancement" to increasingly more intensive population management efforts (Table 2).

Table 2: Description of population enhancement approaches evaluated by the SOPET

Approach to enhance owl populations directly	Brief description of the approach
1. No enhancement	Do not actively manage or augment Spotted Owl populations; rely on habitat protection and management measures alone.
2. Translocation of single adult Spotted Owls to form pairs in the wild	Move single Spotted Owls to a territory of another single owl to establish breeding pairs.
3. Overwintering and release of wild juvenile Spotted Owls	Remove juvenile Spotted Owls and hold them in captivity for the winter to increase over-winter survival, and reintroduce them to suitable habitat.
4. Supplemental feeding of adult or juvenile Spotted Owls	Direct feeding of Spotted Owls to improve physical condition and survival.
5. Prey enhancement	Indirect prey enhancement to improve physical condition and survival of Spotted Owls.
6. Control of predators and competitors	Remove Barred Owls or Great Horned Owls from Spotted Owl territories in coordination with reintroduction of Spotted Owls.
7. Captive breeding and reintroduction to wild	Remove Spotted Owls from the wild, establish a captive-breeding population, and subsequently reintroduce owls to suitable habitat.

At the team's first workshop (January 16-17, 2007) we evaluated each of the approaches and discussed them relative to a number of threats or issues of concern, several of which were extremely influential in the group's decision-making. The threats and issues of concern were derived from CSORT documents (Chutter et al. 2004, 2007) and are summarized below. Some of the threats relate to habitat issues (see Chutter et al. 2004, 2007) and were not discussed at length at our workshops because the focus of the group's responsibility, based on the terms of reference, is directed at recommendations for population enhancement, not habitat management.

2.1 Threats and Issues of Concern

The section that follows is an overview of the threats and issues of concern that were included in our discussions. The summaries are necessarily brief, as we felt each had been well described by the CSORT (Chutter et al. 2004, 2007) or in other documents, as indicated. A number of the factors listed below are related but are included individually for discussion purposes (e.g., several threats are likely not significant under conditions of a large and stable population, but become important when populations are substantially reduced).

1. Age of owls in the wild. Spotted Owls are reproductively active until they are at least 20-25 years of age (E. Forsman, unpublished data). The majority of known Spotted Owls in British Columbia are at least 13 years old (Chutter et al. 2007), and these older birds may be approaching reproductive senescence.
2. Barred Owl competitive effects. Although relationships between Barred Owls and Spotted Owls aren't fully understood, there is growing concern that the former species may hold a competitive advantage over Spotted Owls and that this relationship may be contributing to the current status of Spotted Owls (Gutiérrez et al. in press). Should a competitive effect occur, it likely involves direct competition for space, as both species are territorial.
3. Climate change effects. It has been posited that climate change will result in changes to moisture and fire regimes, and lead to changes in tree species composition in temperate forests. Although these changes may be occurring we felt the potential effects of climate change on Spotted Owls were not the primary causes of their rapid decline.
4. Direct human mortality. Spotted Owls are generally curious and readily approach humans, potentially increasing their exposure to human-caused mortality in areas where human activity occurs near owl habitat. Information regarding this threat is limited.
5. Disease. A variety of diseases are known to occur in raptorial birds (Cooper 1993), although most are not known to limit populations (Newton 1979). The short-term effects of West Nile Virus are of concern, especially for species in which mortality rates are high or where populations are small (e.g., this risk factor is likely greater in small populations). This virus is known to kill other owl species in North America (Gancz et al. 2004). Vaccines are being developed in an attempt to protect vulnerable animals, but their effectiveness and feasibility for application to Spotted Owls in the wild are unknown.
6. Habitat fragmentation. This threat is beyond the scope of the SOPET's terms of reference and is therefore not addressed. This factor is discussed in other documents (e.g., Chutter et al. 2004, 2007); the effects of habitat fragmentation are not well understood (Courtney et al. 2004).

7. Habitat loss. This threat is beyond the scope of the SOPET's terms of reference and is therefore not addressed. This factor is discussed in various other documents (e.g., Chutter et al. 2004, 2007; Courtney et al. 2004, and citations therein).
8. Hybridization. There currently is a low incidence of hybridization between Spotted Owls and Barred Owls (Kelly and Forsman 2004). Compared to competition, this factor is considered a low risk to the Spotted Owl, although its significance may be elevated for small or isolated populations (Chutter et al. 2004).
9. Inbreeding depression. Because of small population size, limited mate choice, short juvenile dispersal distances, and individual isolation, Spotted Owls in British Columbia have few genetically diverse mate choices. This is a classic example of a situation in which the negative effects of inbreeding may be playing a role in significantly reducing fitness.
10. Isolation. The fact that the few Spotted Owls that remain in British Columbia are widely separated means that the effective population size is smaller than the actual population size, because some single birds are unable to obtain mates.
11. Population trend. The most recent trend data from British Columbia indicate a decline in the Spotted Owl population of about 7.2% per year (Blackburn et al 2001, Blackburn and Harestad 2002). The continuation of this trend could result in extirpation of Spotted Owls in the province in the near future.
12. Predation of Spotted Owls by Barred Owls. Predation of Spotted Owls by Barred Owls has been suspected but not conclusively demonstrated (Leskiw and Gutiérrez 1998). The significance of this threat is difficult to evaluate due to lack of supporting data.
13. Predation of Spotted Owls by other species. The two primary causes of death in dispersing Spotted Owls are starvation and predation (Forsman et al. 2002). The primary predator of the Spotted Owl is thought to be the Great Horned Owl (Forsman et al. 2002).
14. Small population size. The surveyed population of Spotted Owls in British Columbia was 23 birds in 2005, and the actual number is likely not much greater. Small populations are disproportionately vulnerable to a variety of stochastic events and influences and this seems likely the case now in British Columbia (Chutter et al. 2004, 2007).

2.2 Evaluation of Approaches

We evaluated the seven management approaches in discussions held at each of two workshops convened for the team. The approaches were evaluated relative to many of the threats and issues of concern listed above, as well as four measures of population performance (Table 3). Many of the threats and issues of concern have been well documented in the scientific literature on Spotted Owls (Courtney et al. 2004) or other species. The possible responses by Spotted Owls (as presented in Table 3) to the seven management approaches are based on personal experience, professional judgment or our understanding of the scientific literature on the population augmentation actions and how these might translate to Spotted Owl population performance. Because population enhancement actions have never been comprehensively used with Spotted Owls, the perspectives expressed herein are our collective expert judgment and are characterized by an unknown amount of risk and uncertainty. Nonetheless, we believe population enhancement is necessary and believe it is an essential component of any recovery option. We emphasize here that addressing the threat that originally placed the species at risk – loss of habitat – must be adequately accomplished for recovery to occur. Inadequate strategies to protect and recruit habitat will compromise the effectiveness of population enhancement.

Table 3: Likely influence of population enhancement actions on aspects of population performance by Northern Spotted Owls in British Columbia (increase [+], decrease [-], no change [0], unknown [U]).

Population performance[a]	POPULATION ENHANCEMENT APPROACHES						
	No enhance-ment	Trans-locate adults	Over-winter and release of juveniles	Direct feed	Enhance prey	Predator/ competitor control	Captive breeding and re-introduction[b]
Number of occupied sites	-	-	U	U	U	+	+
Number of breeding pairs	-	U	U	U	U	+	+
Annual juvenile survival	0	0	U	(+) U	U	+	U
Annual adult survival	0	0	0	(+) U	U	+	U

[a] Our ratings of approaches reflect their influence on current aspects of population performance, and do not reflect longer-term trends. To clarify, a rating of no change in annual adult survival under the no enhancement approach means there would be no change in this metric from its current status (i.e., annual adult survival would continue to decline).

[b] The success of this approach is likely dependent on successful competitor (and perhaps predator) control and adequate suitable habitat.

3. Elements of the Approaches and Recommendations

The seven management approaches are presented in the sections that follow. Each approach is briefly described, its relative benefits and limitations explained, and its likely value as a strategy is stated in a SOPET recommendation. The discussion of each approach is limited to the salient information regarding the particular approach. We encourage interested readers to consult the references cited to obtain more information.

3.1 No population enhancement action

This approach involves taking no deliberate management action to augment or enhance Spotted Owl populations, and instead relies solely on implementation of a habitat management strategy. We believe the number of risk factors (e.g., declining population trend, small population size, and competition with Barred Owls; Blackburn and Harestad 2002, Chutter et al. 2004, Gutiérrez et al. in press) would continue to exert negative influence on Spotted Owl populations following implementation of a strictly habitat-based approach. Moreover, we believe the other risk factors are very likely, if not addressed, to result in (or contribute to) the extirpation of Spotted Owls in British Columbia in the near-term. This approach is not recommended.

3.2 Translocate adult Spotted Owls to establish breeding pairs

This approach would involve capturing owls from sites occupied by singles and moving them to sites occupied by single owls of the opposite sex for the purpose of creating a pair. Translocation in this manner would be conducted to improve the likelihood of adult owls finding mates, and

possibly moving owls to territories with better landscape-level habitat conditions. Given the current extremely small known number of extant owls, translocation could result in an increase of up to five new pairs in the population (as of 2006, there were 6 known single females and 5 known single males; Chutter et al. 2007). Any attempts to translocate owls should be done with consideration of the timing required for the owls to form pair bonds prior to the breeding season.

Although the translocation approach is feasible (i.e., it would not be difficult to capture and translocate owls) it is not clear how well translocated owls would adjust to a new territory, or whether a) they would remain in the new territory, b) the new territory was of higher quality than the one vacated by the translocation, or c) the newly created pairs would be compatible. A soft release might serve to promote a successful pair bond, but this would be feasible only at sites with ready access, as this release technique would require construction of a structure within which the new pair would be temporarily housed while becoming acquainted. Another risk associated with translocation is that existing pairs may be inadvertently disrupted because of the translocation, a distinct possibility given that some owls (especially females) are less detectable and that some owls are less responsive in the presence of Barred Owls (Crozier et al. 2006), indicating that survey results may wrongfully indicate single status at a site occupied by a pair.

Translocation of adults is not recommended as a strategy to enhance the Spotted Owl population because the risks appear to outweigh the benefits. The adults and any offspring produced would be exposed to risk factors that may influence site persistence, and the future success of natal or breeding dispersal (e.g., small population size, isolation of owls, and competition with Barred Owls). These problems would require that translocation be an ongoing management action. The approach does not directly address the issue of low breeding success, and low juvenile survival and subsequent recruitment into the adult population. Moreover, it does not clearly reduce risks associated with factors such as age of owls in the population and Barred Owl competition. This approach is not recommended except as potentially relevant during releases following captive breeding.

3.3 Capture and over-wintering of juvenile Spotted Owls

This management approach entails capturing juvenile Spotted Owls before dispersal commences, holding them in captivity for the winter, and releasing them to the wild in spring (Blackburn et al. 2001). As is true for many raptors (Newton 1979), survival rates of juvenile Spotted Owls are generally low (Burnham et al. 1996). The intent of this approach is therefore to improve the survival rate of juveniles by raising them in captivity during the season of most severe environmental conditions (e.g., low temperatures, deep snow cover) that may influence adequate thermoregulation and/or access to sufficient prey.

The potential benefit of the approach is the recruitment of owls into the breeding population by enhancing survival of juveniles in their first winter. This recruitment would be important to address issues of small population size and advancing age of known adults in the wild (Chutter et al. 2004).

Although aspects of the approach are feasible (e.g., we know that juvenile Spotted Owls can be captured and adequately maintained in captivity), the outcome of such a management approach has limitations. These limitations include: a) the likelihood that released owls will be

inexperienced and therefore vulnerable, b) potential recruitment is hindered by low productivity in the current population, and c) as in translocations, juvenile owls may not remain in the release area. This approach does not appear to contribute substantially to recovery and we do not recommend it.

3.4 Supplemental feeding

Spotted Owls in Washington and northern Oregon have very large home ranges (Forsman et al. 1984, 2004) within which they obtain their prey. Home range size of Northern Spotted Owls generally increases from south to north and home ranges in Washington are the largest documented for this subspecies (Courtney et al. 2004). Home range sizes in British Columbia and Washington are probably similar. Home range size is likely influenced to some degree by the abundance and availability of prey (Forsman et al. 1984, Carey et al. 1992, Newton 1979). If prey populations have been reduced through loss or degradation of suitable habitat or competition with Barred Owls, the amount of available prey could be a limiting factor for Spotted Owls. The supplemental feeding management approach is based on the premise that food is currently a limiting resource and that directly augmenting caloric intake relative to foraging risk could improve the physical condition of owls.

This management approach would involve provisioning adult and juvenile owls with food on a regular basis to help maintain their physical condition. The benefit of this approach is increased survival in both age cohorts and retaining birds in the wild. If survival rates increase, or breeding occurs earlier, or breeding success is higher compared to controls, those differences would indicate a positive effect of feeding. This approach did not seem feasible because of the great logistic costs associated with tracking birds through rugged terrain and the effort required to access those areas once the owl was found. There are also associated human risks of winter travel in remote backcountry. Moreover, this does not address issues of concern such as small population size, isolation of owls within the province, and competition with Barred Owls (e.g., if the two owls are competing for space, prey augmentation likely does not resolve the competitive dynamic). We are also concerned that supplemental feeding would require that owls be fitted with radio transmitters, which could have a negative effect on survival or reproduction. For these reasons we do not recommend adoption of this approach (although this may have limited utility in the recommended approach).

3.5 Prey enhancement

The prey enhancement approach involves increasing prey populations in areas used by Spotted Owls. It is similar to the previous approach except that food augmentation does not involve direct feeding, but rather an augmentation of food supply by manipulating the environment (e.g., prey habitat manipulation, placement of prey nest boxes for flying squirrels, direct feeding of bushy-tailed woodrats). Achieving actual enhancement of forest habitat through silvicultural experiments would likely require decades of experimentation and evaluation, and is therefore beyond the scope of this document. Using cavity creation or nest boxes to increase northern flying squirrel abundance has promise as an enhancement tool, as research in younger forests indicates that squirrels respond favorably to an increase in the availability of nest structures (Carey 2002). A positive response by prey species to the placement of nest structures would in theory result in improved physical condition of Spotted Owls. It is unclear to us if population

enhancement of bushy-tailed woodrats is feasible because, to our knowledge, it has never been attempted. Much of their diet consists of green vegetation, and it is unclear to us what would be used as a supplemental feed. Prey augmentation may also result in augmenting prey for Great Horned Owls or Barred Owls.

There are several limitations to using this approach to enhance Spotted Owl populations in British Columbia. First, it assumes that Spotted Owl populations in British Columbia are currently limited by prey availability. Second, enhancement of prey populations may result in a numerical response by Barred Owls and increased competition for the augmented prey resource. Third, because Spotted Owls may use areas 10-20 km or more from the nest core area during winter (Forsman et al. 2005), and these areas may change from one year to the next (Carey and Peeler 1995), it would be difficult to clearly establish the bounds of the owl use area for prey enhancement activities. Fourth, it is possible that the owls would simply not use the enhanced area for unanticipated reasons (e.g., presence of potential predators, unfavorable microclimate, and aspects of patch size or configuration). Moreover, the approach does not address significant issues of concern for Spotted Owls in British Columbia such as isolation of owls, small population size (and poor recruitment), and Barred Owl competition. For these reasons we do not recommend this as a viable management approach for immediate use in population recovery. We note, however, that silvicultural or other manipulations designed to enhance prey populations may have long-term value in accelerating the functional quality of younger-aged forests for Spotted Owls (Chutter et al. 2004).

3.6 Understanding and control of competitors and predators

There is a growing body of correlative information that Barred Owls, having only recently expanded their range to western North America (Dunbar et al. 1991; Mazur and James 2000) are competing with Northern Spotted Owls for resources and space (Gutiérrez et al. in press). Barred Owls appear to have a substantial advantage in this competitive relationship due to several aspects of their ecology and behavior (Gutiérrez et al. in press). The management approach to address this threat involves removing Barred Owls from sites or landscapes occupied by Spotted Owls. We believe that experimental removals should be encouraged to allow for an evaluation of the feasibility of using removal as a control measure (Buchanan et al. in press). Anecdotal information from northern California suggests that removal of Barred Owls may be feasible and effective in promoting Spotted Owl occupancy (L. Diller, personal communication).

Great Horned Owls are a significant predator of the Spotted Owl (Forsman et al. 2002). Within the forest landscape they are more strongly associated with openings and recently harvested areas. Their significance as a predator of the Spotted Owl in British Columbia is not understood, and the primary focus of this approach is on the relationship between Spotted Owls and Barred Owls.

Key limitations to the use of removal experiments or population control to minimize potentially deleterious effects of Barred Owls on Spotted Owls include cost and possible public opposition. Removals conducted as part of experiments or small-scale local efforts may provide essential information about both feasibility and cost of implementing a larger-scale and ongoing effort (Buchanan et al. in press). Even if annual costs for local control efforts appear reasonable, it must be realized that control will almost certainly require ongoing effort (Buchanan et al. in

press). Such removals may be essential during the next few years, but are almost certainly insufficient by themselves to rescue the Spotted Owl population. Given the successful use of species removal in numerous similar situations in North America and around the world (Byrd et al. 1994; Coates and Delehanty 2004; Manchester and Bullock, 2000), we believe a public outreach and education program may be effective at addressing concerns about public reaction.

The primary benefit of this management approach is its direct means of addressing one of the two most significant current threats to the Spotted Owl (the other being habitat loss; Courtney et al. 2004). This action does not address issues like small population size or isolation of owls in the province, but by addressing one of the most important threats it appears likely to be an essential component of a successful recovery strategy (Chutter et al. 2004, 2007). We recommend that removal be used immediately for local management needs (see Option B, below). This approach may be considered in the longer term for local management needs during reintroductions and may also be considered as a controlled experiment at larger scales to determine potential management value. In the event that removal experiments conducted in British Columbia or elsewhere prove effective in reducing the effects of competition from Barred Owls, we recommend the implementation of a coordinated Barred Owl control program designed to facilitate Spotted Owl recovery in the province.

3.7 Captive breeding and reintroduction

Captive breeding and reintroduction entails removing all or some of the remaining Spotted Owls from the wild, establishing a captive population and subsequently reintroducing owls from this population back to the wild, as has been done for species like the Peregrine Falcon and Mauritius Kestrel. The goal of the captive breeding approach is to increase the effective population size quickly and reintroduce birds back to the wild as soon as is possible after the identified threat factors have been addressed. Implementation details of this approach are presented in Section 4, below.

The SOPET has confidence that Spotted Owls can be bred in captivity because they have already been bred in captivity in two facilities in the United States. In two cases, captive-bred fledglings from one of these facilities were fostered to adult nests in the wild as the means of reintroduction. The success of these releases was not determined, although at least one juvenile was relocated in the year following its release (Janice Reid, personal communication). While we have confidence that Spotted Owls can be bred in captivity, there is greater uncertainty regarding the survival and persistence of captive bred offspring in the wild.

We developed two possible options to implement a captive breeding program. Although the options differ, we were unable to clearly determine that one was superior to the other. Under Option A all known Spotted Owls in British Columbia would be removed from the wild and put into a captive breeding program. Option B would include the removal of four adult/subadult owls of each sex, plus all fledglings produced in 2007-2008. Both options include incorporation of any injured Spotted Owls into the captive breeding population and collaboration with wildlife agencies in the United States to obtain Spotted Owls that might be available in Washington and / or Oregon. Strategies for captive breeding and release of owls are similar in both options. A key element of reintroduction is that adequate habitat strategies must be in place and that Barred Owl

effects must be understood or otherwise addressed. This includes a plan that specifically addresses how habitat will be protected in all sites where captive bred owls settle.

Benefits and limitations common to the two options are described in this paragraph, and issues unique to each are described in sections 3.7.1 and 3.7.2, below. The common risks we identified were that birds from the wild may not reproduce while in captivity and that reintroduction efforts may not succeed. Although we acknowledge the possibility that many of the known Spotted Owls in British Columbia are approaching the age of likely reproductive senescence, information from Oregon indicates that owls >15 years of age have bred in captivity and in the wild (E. Forsman, unpublished data). Similarly, numerous captive breeding and reintroduction programs have been used successfully for highly endangered species throughout the world (e.g., Cade et al. 1988, Cade 2000). Consequently, we believe there is a reasonable likelihood these limitations can be adequately addressed. Benefits of the approach include: a) rebuilding the population, b) increasing the life expectancy and lifetime productivity of individual owls brought into captivity, and c) reducing the probability of permanent extirpation in the province. This more active approach is strongly preferred. The Spotted Owl conservation problem has moved beyond the stage where gradual enhancement measures are realistic or feasible to consider.

3.7.1 Option A

Under Option A all known Spotted Owls would be removed from the wild in 2007. Reproductive pairs would be taken after removal of any young produced. Confirmed or likely singles could be taken earlier in the breeding season. Because it is unlikely that the location of all Spotted Owls in the province is known, surveys and additional removals should be conducted (see explanation in budget section, below) for several years or until it is evident that the probability of additional birds remaining in the wild is negligible. Reintroduction may be possible within several years but a more likely scenario is that the captive population will not be large enough for significant numbers of releases to occur for at least 5-10 years.

In addition to the risks common to both options described above, we identified two risks and two benefits unique to Option A. The risks were immediate short-term extirpation from the wild and reduction of biodiversity within the landscape. It was difficult to evaluate the significance of either limitation because the Spotted Owl population has become so small that biodiversity effects (e.g., altered community dynamics) are probably insignificant and may already have occurred in many landscapes, and the risk of extirpation is high in either option. An additional risk of Option A involves the possibility of a disease or management error occurring in captivity due to chance factors or lack of knowledge that would result in the death of many or all individuals in captivity. Benefits included rapid establishment of the largest possible founder population and a possibly earlier date of initial releases back to the wild, compared to Option B.

3.7.2 Option B

This option differs from Option A in several ways. First, four adults of each sex and all known juveniles would be removed from the wild in 2007. Priority would be placed on removing singles, but paired adults could also be taken. The target of four of each sex was based on the understanding that this represented the majority of known singles from 2006 and is about 50% of the known wild population in 2006 (Chutter et al. 2007). Second, pairs would generally be left in

the wild and given a chance to reproduce in 2008 (unless they were needed to achieve the target of four owls of each sex). Third, Barred Owl removal would begin immediately (in 2007) and continue at all Spotted Owl pair locations to evaluate and potentially minimize any negative effects of competition and increase the likelihood these pairs might reproduce. The success of removal activities in 2007, in concert with any acquisitions of Spotted Owls from the United States, should be evaluated relative to a possible need to conduct a similar removal in 2008. We recommend that any juveniles produced in 2008 also be removed from the wild.

There are three limitations and two benefits unique to this option. The limitations are as follows. First, the initial founder population would be smaller. Second, birds left in the wild may have lower survival and productivity than those held in captivity (i.e., fewer wild birds will survive to contribute to the captive breeding population for 2008, and birds not taken into captivity may not contribute to either wild or captive populations). Third, the number of occupied territories would decline. The first two of these limitations are most significant and certainly entail risk, but we believe there is value in leaving birds with recent reproductive history in the wild to produce offspring that can then be captured and taken into captivity. This value must be weighed against the possibility of losing the pair and their subsequent productivity. The primary benefits of this option, relative to Option A, are a lesser risk of failure of the captive breeding and reintroduction program and a lesser reduction in biodiversity (see comments in 3.7.1).

3.7.3 Recommendations

Of the seven population enhancement options considered we believe that captive breeding and reintroduction is the most valuable population enhancement measure to implement in British Columbia. It is the recommended approach. The differences between Options A and B are difficult to assess because both options have multiple common benefits and risks so we do not recommend one option over the other. In summary, the significant risk in Option A is that it relies on the ability of captive breeding and reintroduction to succeed, whereas the risk associated with Option B resides with the relationship between productivity and mortality in the wild population and how this will influence future population status, either in the wild or in captivity. Regardless of the option chosen, a substantial habitat protection strategy will be required, including protection of areas in which captive bred owls settle; in addition, Barred Owl removal is recommended under Option B (see approach 6) and will likely be an important component of the approach during reintroductions.

3.8 Summary of recommendations related to recovery approaches

Approach 1: No population enhancement action

This approach is not recommended.

Approach 2: Translocate Adult Spotted Owls to establish breeding pairs

This approach is not recommended except as potentially relevant during releases following conservation breeding.

Approach 3: Capture and overwintering of juvenile Spotted Owls

This approach does not appear to contribute substantially to recovery and we do not recommend its use as a primary strategy.

Approach 4: Supplemental feeding

For a number of reasons (above) we do not recommend adoption of this approach (although it may have limited utility in the recommended approach).

Approach 5: Prey enhancement

For a number of reasons (above) we do not recommend this as a viable management approach for immediate use in population recovery.

Approach 6: Control of competitors and predators

This approach is recommended to enhance nesting success for pairs of owls now breeding in the wild. Experiments should be conducted to evaluate its value as a longer-term management strategy.

Approach 7: Captive breeding and reintroduction

This is the recommended approach (either option A or option B) is the most valuable population enhancement measure for British Columbia. Option B includes Approach 6.

3.9 Caveat to the SOPET's recommendations for captive breeding and reintroduction

Of the seven approaches to population enhancement that we considered, we concluded that the immediate initiation of a captive breeding and reintroduction program is the only option that is likely to prevent the extirpation of Spotted Owls from British Columbia. The SOPET emphasizes the following essential considerations regarding the captive breeding and reintroduction approach to population enhancement.

(1) The captive breeding and reintroduction approach should only be initiated with a commitment to a broader policy of developing a demographically self-sustaining population of Spotted Owls in the wild in British Columbia (IUCN 1995). This policy requires addressing the main threats to the British Columbia Spotted Owl population, including the loss and fragmentation of suitable habitat (see Chutter et al. 2004, 2007) and an understanding of the effects of competition with Barred Owls.

(2) Spotted Owls released to the wild will move across the landscape before establishing a territory, and many will likely settle in landscapes that fall wholly or partly outside areas designated for owl conservation. Owls in these landscapes may be vulnerable to impacts resulting from management activities that were planned prior to the owl colonization. We recommend that the suitable habitat occupied by reintroduced owls outside of protected areas be protected from harvest for as long as those areas are occupied so that the reintroduced birds will have a chance of surviving and breeding, thereby enhancing the owl population. Without such protection we do not think a captive breeding program is scientifically defensible. This issue needs to be resolved as soon as possible, as there is little point in establishing a captive breeding program if there is no consensus regarding what will be done to protect owls once they are

released. Therefore, we recommend that government immediately form a committee to develop a general set of management guidelines for habitat management in areas where captive-bred owls settle.

(3) A captive breeding and reintroduction approach to population enhancement will require a long-term commitment. Captive breeding is adopted when species are reduced to critically low numbers and is a 'triage' approach to conservation. While 'triage' approaches are more challenging and more expensive than early prevention measures, the captive breeding and reintroduction approach has proved successful when implemented in conjunction with the adequate management of threats (e.g., Mauritius Kestrel, Jones, et al. 1994; European Eagle Owl, Frankenberg, et al. 1984; Peregrine Falcon, Cade, et al. 1988; Vancouver Island Marmot, Janz et al. 2000) provided there is a long-term commitment.

4. Implementation of Captive Breeding and Reintroduction

The following section contains a discussion of the important components of a captive breeding and reintroduction program and some recommendations for implementing a captive breeding and reintroduction action plan for the Spotted Owl in British Columbia.

4.1 Governance

4.1.1 Program Oversight

The Province of British Columbia is responsible for the recovery of the British Columbia Spotted Owl population under the Federal *Species at Risk Act* (2003) and retains the 'ownership' and legal responsibility for all Spotted Owls and their progeny in British Columbia under the *British Columbia Wildlife Act* (1980). The British Columbia Ministry of Environment is the provincial agency responsible for the welfare, management and recovery of Spotted Owls, including inventory and monitoring initiatives. Removing Spotted Owls from the wild to initiate a captive breeding program will require permits and staff support from the British Columbia Ministry of Environment. The Ministry of Forests is the provincial agency responsible for management of forests in consultation and cooperation with other ministries and agencies of the government and with the private sector.

Captive breeding and reintroduction programs typically involve multiple partners and collaborators from multiple jurisdictions, including government agencies, non-government organizations, colleges and universities, breeding centers and/or zoos. There are a number of examples of governance models for captive breeding programs in North America (e.g., Vancouver Island Marmot Recovery Foundation, http://www.marmots.org; Peregrine Fund, www.peregrinefund.org). The SOPET did not comprehensively review existing governance models for captive breeding and reintroduction programs and does not make specific recommendations on a model. However, important elements for a successful captive breeding and reintroduction program were discussed in depth at our second workshop. The *coordination* of activities and *communication* among partner agencies will be crucial elements for the success of a captive breeding and reintroduction program for the Spotted Owl. In addition, the selection

of suitable breeding facilities/personnel, adequate science and technical support, and personnel capacity and funding are all fundamental components of a successful program.

While captive breeding and reintroduction programs require strong governance for success, the development of new models or adapting existing models can take time to implement. While the SOPET stresses the importance of a solid governance model for a captive breeding and reintroduction program for the Spotted Owl, this should not be at the expense of the immediate implementation of key steps towards establishing a Spotted Owl captive breeding program.

4.1.2 An Example Governance Model: The Vancouver Island Marmot

The Vancouver Island Marmot captive breeding and reintroduction program provides an example of a potential governance model for the Spotted Owl in British Columbia. The program was established a decade ago and has demonstrated excellent success in breeding marmots in captivity and has begun reintroducing marmots to the wild which are now breeding in the wild.

The Vancouver Island Marmot captive breeding and reintroduction model (see http://www.marmots.org/recovery_partner.htm) comprises three teams or working groups: 1) a species recovery team, led by the British Columbia Ministry of Environment (MOE), consisting of wildlife managers and biologists from agencies, industry and non-government biologists; 2) a working group managing captive breeding consisting of technical expert members from zoos and breeding facilities (this group has a full-time coordinator); 3) a field-focused working group that focuses on reintroductions. The captive breeding planning elements (e.g., annual work plans, budget approvals) are overseen by the Marmot Recovery Foundation, a publicly registered charity, through a board of directors from key Canadian and British Columbia conservation agencies.

4.1.3 Short-term implementation

The British Columbia Spotted Owl population has been reduced to very few adults in the wild (estimated at fewer than 25 based on the 2005 inventory; Chutter et al. 2007). Establishing a captive breeding program will require the removal of some or all of the remaining animals from the wild during the 2007 breeding season. While this timeframe requires immediate attention for planning, additional delay may increase the likelihood that British Columbia would be significantly or entirely dependent on the United States to provide owls for a population enhancement program. The SOPET highlights some immediate steps for implementation for 2007.

(i) Obtain Spotted Owls from the Wild in British Columbia
The British Columbia Ministry of Environment should obtain birds from the wild during the 2007 Spotted Owl breeding season. Removal of owls should be done in coordination with the planned 2007 inventory for Spotted Owls to be conducted by British Columbia Ministry of Environment. The SOPET recommends that British Columbia MOE owl experts be consulted with regards to timing of adult and fledgling capture and removal, and if Option B is chosen, the selection of single and/or paired owls for captive breeding.

(ii) Establish Cooperative Relations with other Jurisdictions

The number of available Spotted Owls in the wild in British Columbia is very low and may need to be augmented with other owls to establish an adequate captive founder population. A Memorandum of Understanding (MOU) involving the Canadian and United States Federal governments, the province of British Columbia, and Washington and Oregon state governments will be needed to facilitate the potential transfer of additional birds to supplement captive breeding population established in 2007. It is expected that the process required to arrange for transfer of owls across the international border may take at least one year. Therefore, the SOPET suggests establishing informal relations among the jurisdictions in the short-term.

(iii) Establish a Spotted Owl Coordinator and Captive Breeding Working Group
The SOPET recommends the appointment of a British Columbia Spotted Owl captive breeding and reintroduction coordinator and the establishment of a captive breeding working group.

(1) The coordinator position will be a key element in the initial implementation of a 2007 captive breeding and reintroduction action plan. The position would involve establishing the recommended captive breeding working group (and others if needed), and liaising with government and the SOPET. The coordinator will be responsible for implementing this action plan and will require experience in project management, establishing partnerships, and familiarity with the Spotted Owl situation in British Columbia.

(2) The captive breeding working group should include representation from selected breeding facilities, individuals with experience breeding owls and raptors in captivity, and government agencies. The scope of membership should be expanded to help establish informal relations with individuals and organizations from the United States or other countries with relevant expertise. The working group should have clear terms of reference and be tasked with coordinating the development of Spotted Owl handling and care protocols, policies for data collection and archiving, and the coordination and transparency of activities across all facilities and partner agencies.

4.2 Logistics of Captive Breeding

4.2.1 Captive Breeding Working Group: Inaugural Workshop

The SOPET recommends that the captive breeding working group hold an inaugural workshop in late spring 2007 to determine all logistics and information requirements related to captive breeding of Spotted Owls in British Columbia. An outcome of the inaugural workshop would be development of guidelines for contractual agreements with potential facilities including facility specifications, care and handling procedures and protocols, communication and cooperation requirements between facilities, as well as data management, data sharing and data ownership expectations.

Considerable advice and experience is available from a number of effective models for breeding owls in captivity, particularly from Europe (Parry-Jones and Ferguson, 2003) but also in North America (e.g., San Diego Zoo, Bronx Zoo, Ontario Owl Foundation (Kay McKeever), Jemima Parry-Jones, Society for the Conservation and Research on Owls (Rolf Krahe)). Members of the SOPET have provided some technical advice on guidelines for facilities for captive breeding of Spotted Owls (see Appendix 2). These guidelines summarize the basic structural features

required to keep Spotted Owls under safe and healthful conditions. They consider enclosures for breeding, holding and exercise, and for release, including modifications of existing structures to meet these requirements.

4.2.2 Contractual considerations for Captive Breeding Facilities

Contractual requirements for facilities should be discussed and agreed to by the Spotted Owl captive breeding working group at its inaugural workshop. The working group should address at a minimum:

a) communications and the chain of command between government and the facility; communications and cooperation between facilities and with other partners and parties to the MOU;
b) facility design and management;
c) use of Canadian Association of Zoos and Aquariums (CAZA) guidelines and protocols regarding handling and care of the owls;
d) expectations and standards related to the collection of reliable data, data storage, and data sharing and data ownership, including partnership agreements;
e) facility staffing requirements for the owls (experience, knowledge); and
f) evaluation and reporting mechanisms, including contract sunset clauses.

4.2.3 Options for Captive Breeding Facilities

There are a number of alternative models for captive breeding facilities including (a) establishing government 'in-house' facilities; (b) using existing university or research animal care facilities; (c) contracting with privately-operated animal breeding centres, zoos or wildlife parks; and (d) a combination of facilities.

Government in-house facilities are the least feasible in terms of initial infrastructure cost, start-up time, and staffing. University facilities usually have *per diem* costs that would exclude opportunities for in-kind support, although they could best provide the opportunity for a science-based, research approach to captive breeding. Existing zoos and private facilities are the most likely to be able to provide a cost-effective program that has the flexibility to include in-kind and volunteer support. The SOPET recommends using a series of private breeding operations, zoos or wildlife parks.

To reduce the risk of disease or other unforeseen events to the captive Spotted Owl population, the SOPET recommends that at least two facilities be used, and preferably three once enough pairs of owls are available. The SOPET recommends that participating facilities be accredited by the Canadian Association of Zoos and Aquariums (CAZA) or in the process of seeking such accreditation. In addition, the facilities must agree to work cooperatively with each other in all aspects of this endeavor. The SOPET recommends a target of up to ten pairs of owls for each facility.

4.3 Genetics Issues

The decision to obtain Spotted Owls from the wild to begin a captive effort, as well as trying to rebuild a viable wild population in British Columbia calls for serious consideration of genetic

and demographic factors effecting the wild and captive populations (Snyder et al. 1996). To begin, managers need a realistic idea of what they have (genetically and demographically) and what they can hope for given careful planning (Lacy 1987). To date, we know that the BC owls are members of the Northern Spotted Owl (*S. o. occidentalis*) subspecies (Barrowclough et al. 1999, Haig et al. 2004), we are easily able to identify any Spotted-Barred Owl hybrids should they occur in BC (Haig et al. 2004, Funk et al. 2006), and there are genetic and demographic suggestions that genetic diversity and effective population size is low (Funk et al. in prep.). Thus careful genetic planning will be an important priority for re-establishing a viable population in BC.

Several short- and long-term population goals have been proposed in the captive breeding literature. Primarily, the maintenance of genetic diversity will increase with more individuals in a population and an increased effective size (N_e) (Frankel and Soulé 1981, Frankham 1996). More specifically, Franklin (1980) suggested a short-term management goal of $N_e = 50$ and a long-term management goal of $N_e = 500$ to maintain within-population viability. However, goals proposing an optimum effective population are controversial because these goals are too general and may be unrealistic for many populations (e.g., an N_e of 50 for many rodents would be much easier to attain than a N_e of 50 for Grizzly Bears) and do not take into account population-specific life history characters and demography (Lande and Barrowclough 1995).

Thus, owl population viability goals will be viewed with respect to effective population size but there will be a need to develop goals specific to British Columbia owls to maintain genetic diversity in a realistic fashion. Clearly, there are few options for Spotted Owls in British Columbia; hence special care is needed to meet as many goals for maximizing N_e as possible. This would include maintaining equal sex ratios, equal family sizes, trying to increase the population size as quickly as possible, and trying to insure that no close relatives are bred.

While it is beneficial to work with larger populations, there are quite limited options for the Spotted Owl population in British Columbia. A balance must be struck between offsetting the effects of drift, preserving local adaptation and providing enough individuals to overcome genetic and demographic threats. Thus, population viability modeling may help provide managers with more realistic goals (see Haig et al. 1993). Some general guidelines for increasing N_e and assuring a genetically fit and demographically stable population include the following (Ralls and Ballou 1992; Frankham et al. 2005):

1. Begin with 20-30 unrelated founders.
2. Increase population size as quickly as possible.
3. Equalize founder contribution/mean kinship.
4. Minimize inbreeding.
5. Equalize family size.
6. Establish a demographically-stable population.

Meeting any or all of these management objectives may be difficult for the British Columbia owl population. However effectively addressing any of them will increase N_e and result in a more stable population than had there been no attempt at any of the goals.

It will be essential to monitor progress towards recovery. Genetic diversity should be measured via molecular and pedigree analyses during various phases of population growth as a means of diagnosing progress toward viability (e.g., Stockwell et al. 1996, Gompper et al. 1997). For example, during the founder phase, the number of founders and their relatedness has the most critical effect on future genetic diversity. However as the population begins to increase, a slow population growth rate, an extended duration of growth phase, or a small carrying capacity can reduce genetic diversity. Once the carrying capacity has been reached, a small carrying capacity or short duration of the capacity phase can also result in loss of diversity.

During any phase of population establishment, inbreeding, outbreeding, or the loss of founder lines can become a problem. Thus, managers need to carefully monitor productivity of adults and survivorship of young. Inbreeding can be examined in a variety of ways, but fundamental to any analysis will be establishment of a pedigree, determined by banding and molecular analyses (currently underway) from the beginning of the population establishment in captivity (Haig and Ballou 2002). Separating pairs of suspected relatives may be advised if reduced survivorship is observed and appears to have a genetic basis. If new populations are too small or it is too intrusive to alter pairings, introduction of new individuals may help. In general, inbreeding in the captive population can best be avoided by increasing the population size quickly and selectively formulating pairs to minimize mean kinship and equalize founder contribution.

4.3.1 Short-term Recommendations to manage genetic issues.

Genetic profiles must be taken for each bird in order to determine the closeness of their relationships. A stud book should be maintained to make sure that birds of close genetic relationship are not paired together.

4.4 Reintroduction

(i) Risk Factors
Any attempts at population enhancement will be compromised if the risk factors to the wild population are not satisfactorily addressed (IUCN 1995). This element is particularly evident during the reintroduction phase of a captive breeding and reintroduction recovery plan. In the case of the Spotted Owl in British Columbia, this requires addressing the loss and fragmentation of suitable habitat and an understanding of the effects of competitors and predators, particularly the Barred Owl.

(ii) Pre-release Monitoring and Assessment
Prior to any release activity there will need to be a thorough assessment of the landscape conditions of the release site(s). The conditions to be evaluated will include the amount, quality, and distribution of habitat; the proximity of the release area to other known Spotted Owls; and information on the abundance of Barred Owls and possibly Great Horned Owls in the focal landscape(s). Obtaining some of this information will require survey and monitoring efforts.

(iii) Post-release Habitat Protection
Spotted Owls released to the wild will move across the landscape before establishing a territory. Some owls will likely settle in landscapes that fall wholly or partly outside land areas designated

for owl conservation. Owls in these landscapes may be vulnerable to impacts resulting from management activities that were planned prior to the owl colonization. As mentioned earlier in Section 4, we recommend that a planning process, developed by government and possibly advised by CSORT, be in place to address such situations.

iv) Timeframe and Release Methods
Operational or large-scale reintroductions of captive-bred Spotted Owls should not begin until a self-sustaining, captive Spotted Owl population has been established, which may be possible to achieve within several years (Barclay and Cade 1983; Jones et al., 1994; von Frankenberg 1984). Details concerning the best approaches and methods for release of captive-bred Spotted Owls to the wild should be developed during the first five-year phase of the captive breeding and reintroduction plan.

(v) Opportunities for Learning
Depending on the success of the captive breeding program, it may be prudent to attempt some small-scale reintroductions towards the end of the first five-year period to build knowledge and understanding of this phase of recovery. These initial reintroductions should be experimental in nature with ongoing investigation and evaluation. Reintroduction strategies should incorporate principles of adaptive management, and use new information to improve efficiency and effectiveness of the program.

(vi) Funding
Reintroduction is the most expensive element of a captive breeding and reintroduction recovery plan (Snyder et al. 1996). The reintroduction phase is costly due to the expense of inventory efforts and monitoring of introduced owls over a significant period of time. Costs at this phase could be offset through collaboration with universities on reintroduction research programs and by fund-raising or an endowment fund, depending on the overall governance structure of the program.

Based on annual financial statements of The Peregrine Fund the annual cost to raise and release 150-200 peregrine falcons per year in the period 1985-1995 ranged from approximately $1 million–$1.5 million US. About half went to captive breeding and half to reintroduction. In the past five years or so, the annual cost to raise and release 100-150 Aplomado falcons per year has been approximately $700K-800K US; in the same time period it has cost approximately $1.2-1.3 million US to raise and release an average of 10 California condors per year.

4.5 Monitoring and evaluation

Monitoring and evaluation are critical elements for successful implementation and for adequate tracking and assessment of a captive breeding and reintroduction program (Snyder et al. 1996). Each implementation phase should include explicit objectives with identified measures for monitoring and evaluation.

(i) Governance Model and Communication
The overall effectiveness of a Spotted Owl captive breeding and reintroduction governance model could be assessed using many benchmarks including: how well certain implementation timeframes were met, such as hiring a Spotted Owl Coordinator; the degree of collaboration and

effective communication among partner agencies and facilities; the establishment of a functional captive breeding working group; the completion of an MOU among jurisdictions and the resulting transfer of individual Spotted Owls across jurisdictional boundaries; consistent inventory and captive breeding data collection; and adequate inventory and captive breeding data management and data sharing.

(ii) Logistics of Captive Breeding
Evaluation and monitoring of the captive breeding component is vital for learning and improving on captive breeding protocols. Survival and reproduction of Spotted Owls in captivity, the maintenance of genetic diversity within the captive population, and protocols for minimizing the threat of disease (e.g., West Nile Virus) in captive situations are all important elements for monitoring and evaluation of captive breeding.

(iii) Reintroduction
Success of a captive breeding and reintroduction program is measured by the survival and successful reproduction of captive-bred animal released in the wild and ultimately, by the establishment of a self-sustaining population in the wild (Seddon 1999). Captive-bred Spotted Owls reintroduced into the wild will require intensive post-release monitoring to determine survival and reproductive success.

4.6 Summary of short-term implementation recommendations

The BC Ministry of Environment should obtain birds from the wild during the 2007 Spotted Owl breeding season.

A Memorandum of Understanding (MOU) between the Canadian and US Federal governments, the province of BC and Washington and Oregon state governments should be developed as soon as possible.

The SOPET strongly recommends the appointment of a BC Spotted Owl conservation breeding and reintroduction *coordinator* and establishing and a *conservation breeding working group*.

SOPET recommends that the conservation breeding working group holds an inaugural workshop in late spring 2007 to determine all logistics and information requirements related to conservation breeding of Spotted Owls in British Columbia.

Contractual requirements for facilities should be discussed and agreed to by the Spotted Owl Conservation Breeding Working Group at its inaugural workshop.

The SOPET recommends that at least two facilities be used, and preferably three once enough pairs of owls are available.

The SOPET recommends that facilities be either accredited by the Canadian Association of Zoos and Aquariums (CAZA) or seeking CAZA accreditation and that facilities agree to work cooperatively with each other.

The SOPET recommends a target of up to ten pairs of owls for each facility.

5. Short- and Long-Term Activities, Timelines and Budget

5.1 Short-Term Activities, Spring and Summer 2007

Initiation of a population enhancement program will require the coordination of a large number of people and activities over a relatively short period, April to September, in 2007. The short-term objective is to have the targeted number of Spotted Owls (depending on whether Option A or B is chosen) in breeding facilities by mid- to late-summer. Captive breeding facilities need to be planned, commitments obtained, facilities built and staff trained by September 2007.

A government decision is needed early in April if a captive breeding and reintroduction program is to benefit from the Ministry of Environment's 2007 Spotted Owl inventory. The SOPET's recommended April to September tasks and schedules are planned to mesh with the life history cycle of the owl and an early government decision will provide cost efficiencies. After step 1 in Table 4 it is assumed that a government decision has been made to proceed with captive breeding and reintroduction. Owl inventories need to begin early in April and the status of breeding pairs and potential fledglings need to be determined. If the SOPET Option B is implemented then the SOPET recommends that Barred Owls be removed from territories where Spotted Owl breeding pairs are located. The short-term budget is identified in Table 5.

Table 4: Anticipated short term activities and scheduling, 2007 (April - September field season)

Steps	Decisions and Actions	Apr	May	Jun	Jul	Aug	Sept
1.	Government briefing and decision						
2.	Committee established to address future habitat protection for captive-bred owls						
3.	Spotted Owl coordinator appointed and implements action plan						
4.	SOPET evaluation and advice on facilities						
5.	Spotted Owl captive breeding working group formed; inaugural workshop						
6.	Facility contracts in place						
7.	Breeding facilities built						
8.	International MOU developed *						
9.	SOPET advice as needed (for steps 3, 4, and 5)						

* MOU means Memorandum of Understanding

1) Briefing Government and obtaining a decision on captive breeding

A government decision on a Spotted Owl captive breeding and reintroduction action plan is needed as early as possible in spring 2007. The 2007 inventory will not change the SOPET's recommendation for population enhancement, and a delay of another year will likely decrease options for obtaining stock from British Columbia. An early decision is required as capturing owls, especially juveniles, becomes more difficult past mid-summer. Other activities need to proceed concurrently so that appropriate facilities and trained personnel are ready to accommodate captured owls by late June and early July.

2) Committee established to address future habitat protection for captive-bred owls

The SOPET recommends that the BC government make explicit the commitment to protect habitat in the areas where captive bred owls settle, regardless of whether those areas are in previously designated owl management areas or not. The BC government should immediately form a committee to develop habitat management guidelines for areas where captive-bred owl settle.

3) Spotted Owl coordinator appointed

Immediate identification of a Spotted Owl population enhancement coordinator is considered a high priority. The coordinator may need to be selected on an interim basis due to time constraints, followed by a more complete selection process and long-term commitment.

4) SOPET evaluation and advice on facilities

Interest in the captive breeding of Spotted Owls has been expressed by four existing facilities in British Columbia (see Appendix 3). The SOPET is able to assist government staff on evaluation of facilities based on team members' experience with successful breeding facilities and the Canadian Association of Zoos and Aquariums (CAZA) accreditation and evaluation criteria. Members of the SOPET have provided Spotted Owl guidelines necessary for facility development (see Appendix 2). Care and handling guidelines are proposed in a workshop with experts (see step 5).

5) Spotted Owl captive breeding working group formed and inaugural workshop

This technical group should include a member from each breeding facility. Additional members may include expertise from zoos, known owl breeders, and (ideally) the provincial wildlife veterinarian. Members from the United States should be sought to develop cooperative relationships between owl breeders and agency staff (see step 8). Such participation may include representatives from the Pacific Northwest Zoo Alliance. The objectives of the inaugural workshop would be:

a) Share expertise and ensure cooperation between facilities.
Bringing together breeding expertise will ensure all breeding working group members gain understanding on the facility requirements, quarantine procedures, care and handling procedures, etc. Experts such as Jemima Parry-Jones could be invited to share their experience (see Parry-Jones and Ferguson 2003).

b) Develop a common understanding of owl breeding facility and operational costs.
The breeding working group would develop detailed facility requirements, and provide clarity on facility construction and operating costs and expectations, including items such as utilities and overhead, food for owls, staff support, record keeping, meetings, training, veterinary care and staff salaries. These costs may be borne directly by government or could be offered by facilities as their contribution towards owl recovery. This level of detail will support contractual arrangement between government and facilities.

6) Contractual arrangement with Spotted Owl breeders

Because the owls remain the property of the provincial government contractual agreements between government and breeding facilities are needed.

7) Building of breeding facilities

Cost estimates for facilities are based on developing 3 separate facilities (see Table 5). The first year requires the availability of 8+ holding pens with additional areas for incubation, breeding, exercise (flight cages), and sufficient space for other activities such as exams, data entry, and so forth. The number of owls available this year could be housed in two facilities and a third facility should be added as needed. Cost-sharing arrangements need to be in place and be ready before construction begins. Ideally building or renovating facilities would take place when birds are brought in over the summer, however arrangements to use existing or temporary holding facilities for owls captured in 2007 need to be in place in the event that the more permanent facilities are not ready.

8) International Memorandum of Understanding (MOU)

An international effort increases the likelihood of success of the captive breeding program. The exchange of birds and eggs, and information access and ownership considerations are expected to form some of the content of the MOU. The MOU would establish the intent of all parties to support captive breeding efforts in British Columbia and may expedite efforts to move birds across the international border.

The MOU would outline a working relationship between regulatory agencies in Canada and the United States. Signatories from Canada would be Environment Canada (EC) and the British Columbia Ministry of Environment (MOE). Signatories from the United States would be the Department of the Interior and Regional Director of the Fish and Wildlife Service as well as the state wildlife agencies from Washington and Oregon.

The SOPET recommends that the BC Ministry of Environment begin with the following initial contacts:

Lynda Maltby (Environment Canada, CITES Office,)
Director Canadian Wildlife Service (CWS)
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Dave Brittell (Washington Department of Fish and Wildlife)
Assistant Director, Wildlife Program
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brittjd@dfw.wa.gov

9) SOPET advice as needed (steps 3, 4, and 5)

The SOPET terms of reference allow the team to continue to provide advice to government as needed. Given the tight timeframe and the need to select facilities and quickly develop working groups and agreements, the SOPET will offer ongoing assistance and advice to government upon request. Specific SOPET members have expertise in the evaluation of existing facilities (step 3), formation and participation in the inaugural workshop of breeding working group (step 4) and contractual arrangements (step 5).

5.2 Short-Term Activities, 2007-2012

The first five years of this program will focus on breeding owls in captivity. A self-sustaining breeding population may be possible within several years but it may not be feasible to reintroduce birds to the wild while maintaining adequate captive breeding capacity until the second five-year planning stage (2013 – 2018). A reintroduction budget is included towards the end of this five year period in the event that it is possible to begin reintroductions in first five year period. It may be possible (and prudent) towards the end of the first five-year period to carry out some reintroductions to build understanding of this phase of the effort. Reintroductions are considered more intensive than inventory as introduced owls need to be monitored in the wild over a longer period. The reintroduction budget is estimated to be $450,000 + annually and would continue through the remainder of the recovery program.

Table 5: Estimated Population Enhancement Plan Budget (estimated in thousands of dollars) – 2007-2012.

TASK	2007-08	2008-09	2009-10	2010-11	2011-12
Coordinator position salary and operational funds	75	100	100	100	100
Spotted Owl captive breeding working group - operational funds	5	5	5	5	5
Captive breeding working group - inaugural workshop	10	0	0	0	0
Build facilities to approved standards	40	40	80	80	0
Operating expenses of facilities (utilities, food etc.)	10	15	30	40	45
Operating expenses of facilities (salaries)	40	80	160	240	240
Veterinary bills and stud book maintenance	17	17	17	17	17
Staff training (facilities staff)	20	10	10	10	10
Operational funds – inventory & monitoring	300	300	200	100	100
Staff training (field crews)	20	10	10	10	10
Reintroductions; monitoring Spotted Owls; Barred Owl control	0	0	0	200	450
SOPET advisory	10	5	5	5	5
Annual Budget Estimate	527	573	610	800	9750
FIVE YEAR BUDGET ESTIMATE					**3,424**

Budget figures are the best estimates available from SOPET. The Spotted Owl captive breeding working group inaugural workshop is expected to refine facility and operational costs. It is expected that flexibility around funding would include in-house support (government); in-kind

support (facilities); support from Foundations; potential contributions from fund-raising initiatives; and volunteer contributions.

5.3 Long-Term Activities, 2012 – 2018 and beyond

Captive breeding and reintroduction is a long term commitment. The focus in the first five year period is to learn to successfully breed in captivity so that, as quickly as possible, there are birds available for reintroduction. The second five year period needs to continue with captive breeding and add the field component of reintroductions and learning to reestablish the birds in the wild. Since it may take five years and possibly longer before operational-level reintroductions begin the commitment to habitat needs to be made at the initiation of captive breeding and maintained while there are low or no owls in the wild. In the case of the Vancouver Island Marmot Recovery Program the time period from learning to successfully captive breed to operational-level reintroduction took almost a decade. Budget needs in the second 5 year period are expected to exceed those of the first five year period as captive breeding and field reintroduction components are occurring simultaneously (see 4.4 (vi) for examples of budgets of other long term raptor recovery programs).

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Appendix 1: SOPET Terms of Reference

Northern Spotted Owl Population Enhancement Team (SOPET)
Terms of Reference
November 2006

1. BACKGROUND

In Canada, the Northern Spotted Owl (*Strix occidentalis caurina*) was designated Endangered in 1986 (renewed in 2000) by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). In Canada it occurs only in the southwest mainland of British Columbia, accounting for about 8% of its global range. The Canadian Spotted Owl Recovery Team (CSORT) has developed a recovery strategy, which provides science advice to government, see http://www.sararegistry.gc.ca/virtual_sara/files/plans/rs%5Fspotted%5Fowl%5Fcaurina%5F1006%5Fe%2Epdf . The Recovery Strategy states:

> ***"Small populations are highly vulnerable to extinction, and it is thought that the Spotted Owl population in British Columbia may become extirpated within a few years…it is recommended that population augmentations be considered (i.e., assessed and evaluated for feasibility) immediately, and implemented – if deemed appropriate – to prevent further declines and extirpation."***

The BC Government reviewed the Recovery Strategy along with other considerations and announced the Province's Spotted Owl Recovery Plan on April 28, 2006, see: http://www2.news.gov.bc.ca/news_releases_2005-2009/2006AL0012-000514.htm This plan includes three components: protecting known active owl sites; revising habitat areas to better meet recovery goals; and initiating measures to rebuild Spotted Owl populations:

> ***"These measures will include captive breeding and release, moving spotted owls to new locations, increasing food sources for spotted owls, and managing competing species such as barred owls."***

2. PURPOSE OF THE SOPET

The BC Government has committed to establishing an independent science team to provide recommendations on the third component of its Recovery Plan – initiating measures to rebuild Spotted Owl populations. The purpose of the SOPET is to develop independent, science-based recommendations regarding the feasibility, planning, practice, and implementation of population enhancement measures for Spotted Owl, over the next five years, prior to Government's evaluation of the success of the recovery plan. These measures include, but are not limited to, captive breeding and future release, translocation of individuals, prey enhancement, and competitor and/or predator control. Ultimately it is hoped that population enhancement, along

with other components of the Recovery Plan, will bring about recovery of the Spotted Owl in British Columbia.

3. GUIDING PRINCIPLES

3.1 Uncertainty:

The SOPET acknowledges uncertainty around the outcomes of its recommendations. It recognizes that population enhancement actions are 'test cases' and may have uncertain outcomes for individual birds, as well as for the population as a whole.

3.2 Direct Actions:

The SOPET will focus its recommendations on direct actions to implement population enhancement. It is hoped that these actions may demonstrate the short-term (within five years) potential for population growth. Indirect research projects, habitat supply and population modelling (Spotted Owl or competitor species) are not considered direct population enhancement actions.

3.3 Risk to Wild Birds:

The SOPET may recommend actions that pose some risk for wild birds where the SOPET is of the opinion that, without the proposed action, there is a low likelihood of those individuals contributing naturally to growth of the population.

3.4 Habitat:

The SOPET will limit recommendations on habitat to the needs of known birds and potential numbers of owls that may be projected in the short term (five years).

4. ROLES AND RESPONSIBILITIES

4.1 Role of the SOPET Coordinator:

- Establish and confirm appropriate, science-based membership in the SOPET.
- Summarize and present to the SOPET existing knowledge and research around Spotted Owl, including status, threats, biology, current population size and distribution, and the results of habitat supply and population modeling in British Columbia.
- Organize, conduct, and report on regular team meetings according to accepted rules of procedure.
- Produce materials for meetings and ensure team members receive these in a timely manner prior to meetings, to allow for their review.
- Ensure maintenance of SOPET files and provide copies to the BC government as appropriate.
- Monitor and coordinate communication between team members.
- Provide administrative and secretariat services for the SOPET.
- Manage financial and budgeting services for the SOPET in conjunction with the Fraser Basin Council.

- Consolidate the recommendations of the SOPET and develop workplans that confirm actions, methodology, timing, budget, and performance/evaluation measures. (The coordinator is not considered a SOPET member for the purposes of providing science-based recommendations).
- Present the SOPET's recommendations and workplans to government. Where feasible, fundraise and build partnerships for Spotted Owl recovery.
- Communicate with stakeholders, government and the public as necessary.

4.2 Role of the SOPET Members:

- Provide recommendations, based on science and expert opinion, on the technical and biological feasibility of a captive breeding program, through liaison with Canadian & US experts, geneticists, veterinarians, wildlife biologists, volunteers and facilities providers.
- Provide recommendations on a founder population, breeding stock and genetic diversity, disease risk factors, owl care requirements, handling protocols, etc.
- Provide recommendations on the planning, protocols and timing of other population enhancement actions, including but not limited to:
    - monitoring, capture and tracking of existing populations in the wild
    - supplemental feeding of juvenile owls through the winter
    - removal of predator and competitor species from Spotted Owl habitat
    - translocation of birds to vacant or single-bird sites
    - capture and over-wintering of juveniles
    - use of nest boxes
    - prey enhancement.
- Recommend inventory and monitoring planning initiatives to support the population enhancement program.
- Liaise as needed with government's interagency team tasked with revising the boundaries of current Spotted Owl management areas (see 3.4).
- Evaluate the performance of the SOPET coordinator and report to the BC Species at Risk Coordination Office.

4.3 Role of the BC Government:

- The BC Ministry of Environment has the statutory authority to implement population enhancement measures for provincial wildlife.
- The BC Ministry of Environment will review the recommendations of the SOPET and may request clarification or additional advice.
- The BC Ministry of Forest has the statutory authority to implement habitat management measures that may be recommended to address active sites or future habitat needs (see 3.4).

4.4 Role of the Fraser Basin Council:

- The Fraser Basin Council will manage invoices and expenditures associated with the work of the SOPET, in conjunction with the SOPET Coordinator and the Species at

Risk Coordination Office. Reimbursement for travel and per diem expenses will be consistent with FBC and provincial government rates.

5.0 SOPET OPERATING PRINCIPLES

5.1 Membership:

- Members will commit to the goals, process and timing of the SOPET until recommendations and an action plan have been developed (see 6.0 below), and will have the capacity to continue after this date if required.
- Members will bring a high degree of scientific and technical credibility to the SOPET.
- Members may be from government agencies, academic institutions, zoos, breeding facilities, etc. but will provide independent expertise and will not represent their agency or employer.
- Members must be willing to participate in a team environment.
- Members may be 'core' members (full participation) or 'advisory' members (specialists as needed).
- Members must be willing and available to respond quickly to changing information and make emergency recommendations if needed.

5.2 Participation:

- Members will endeavour to participate in all SOPET meetings, whether in person or by conference call.
- Members may specify attendance of other experts on an ad hoc basis at SOPET meetings if helpful to the population enhancement goal.
- Members will prepare for meeting by reviewing and/or providing materials, as requested by the Coordinator, prior to meeting dates.
- Members will seek peer evaluation of recommendations wherever possible.

5.3 Decision-making:

- Decisions will be made by consensus if possible. Consensus means that everyone feels that the decision is technically sound and supported by the best available information, with the view to reaching the overall goal of recovering the Spotted Owl in BC.
- If consensus is not possible, recommendations will be made by majority vote, with dissenting opinions and rationales recorded in the Population Recovery Action Plan and meeting minutes.
- Decision-making will be transparent: agendas, minutes, reports and other documents will be made available to the Species at Risk Coordination Office.

5.4 Confidentiality:

- Members will not represent the opinion of the SOPET to the public or the media. Public communications remain the role of the Coordinator.

6.0 DELIVERABLES

- Elements of a Five-Year action Plan for Spotted Owl recovery in British Columbia.
- A Short-term priority action plan for Spring 2007.
- The plans (above) will include short-, mid-, and long term recommendations for population enhancement, including priorities, protocols, plans, practices, implementation, and approximate budget.

Terms of Reference developed by:

Species at Risk Coordination Office,
Integrated Land Management Bureau, BC Ministry of Agriculture and Lands
Mailing Address: PO Box 9301 Stn Prov Govt. Victoria, BC V8W 9M3
Location: 3rd Floor, 780 Blanshard St., Victoria, BC

Appendix 2: Breeding Facility Requirements

GUIDELINES FOR HOUSING CAPTIVE SPOTTED OWLS FOR BREEDING AND RELEASE

Dr Tom J. Cade and Dr William A. Rapley

Introduction

A wide variety of cages and enclosures can be used successfully to house captive owls. A search of the internet will reveal many variations. The guidelines presented below summarize the basic structural features required to keep Spotted Owls under safe and healthful conditions. They consider enclosures for breeding, holding and exercise, and for release, including modifications of existing structures to meet these requirements.

Enclosures for Breeding Owls

A. Location and general features.—Although some reintroduction programs for owls (e.g., Swedish Eagle Owl program) have relied on the maintenance of single breeding units, which also serve as release sites, widely scattered within the release region and operated by local collaborators, most captive breeding programs employ centralized facilities with multiple breeding units manned by a professional staff. This arrangement seems best for the Spotted Owl given that most release sites will likely be remote from local sources of caretakers. It is a good plan to have the breeding facility associated with a zoo, research station, or university so that it can have access to various supportive organizations such as a veterinary clinic, biology department, and poultry and laboratory animal production units. Regardless of where located, at a minimum it needs to be near other facilities for food storage, emergency veterinary care, quarantine, laboratory, incubation and rearing rooms, and office.

Consideration should be given to environmental factors such as prevailing wind direction, ground drainage, and precipitation. Open portions of enclosures should face away from the wind as much as possible, and drainage should be directed away from the facility. Potential snow loads on the overhead structures should be anticipated during construction to make sure supporting beams are adequate. Some overhead protection from precipitation is essential. A shaded landscape with tall trees provides protection from wind and summer sun.

B. Size of enclosure.—Based on experience with owls and diurnal raptors of similar size, a pair of Spotted Owls probably needs an enclosure of about 10 X 20 feet in area and 10 or more feet in height. Larger spaces will also serve but are more expensive to build and to maintain. Pens could be made with removable walls or partitions so that more space can be provided if bird numbers are low. Successful breeding of Spotted Owls at the High Desert Museum, Bend, Oregon, has occurred in an entirely indoor, exhibit room 20 X 40 feet in area and 20 feet high with artificial light. Some experimentation with enclosures smaller than the recommended size would be worth trying.

Owls that are sexually imprinted on humans and that are to be used as semen donors for artificial insemination or as egg producers have to be kept singly in smaller units on the order of 8 X 10 feet by 8 feet high. Under those conditions the keeper can more easily interact with the owls in the breeding season.

C. Construction and materials.—Pole-barn construction with 6 X 6 inch studs and 2 x 6 inch framing supports offers a serviceable and relatively inexpensive "breeding barn." A convenient arrangement is to have two parallel rows of breeding enclosures separated by a double deck utility and observation corridor, say, five breeding units to a side with enclosures 10 X 20 feet in area, the hallway 7 feet wide, and the roof pitched from 14 feet at the eves to 20 feet high at the peak. The entire barn would encompass 2,350 square feet, and the height of the enclosures would vary from 14 feet at the eves to about 18 feet at the back wall.

Pairs of breeding owls housed in adjacent enclosures require visual isolation, because they become highly territorial and aggressive toward one another in the nesting season. For that reason, and also to provide better protection from weather and possible predators, the sidewalls and back wall should be made of solid, opaque materials such as marine plywood or metal sheeting. The front should be open with outside screening of weld-wire mesh and inside barring or open slating. One-half inch aluminum conduit makes excellent barring but is expensive. Cedar slats 1 X 2 inches and spaced two inches apart are suitable substitutes. This arrangement provides good predator-proofing and also prevents the owls from flying against the wire mesh and possibly injuring themselves, as the bars and wire are separated by six inches on either side of the supporting frame.

An open top can be constructed the same way as the front, but it is necessary to have solid overhead roofing extending at least six feet from the back wall for shelter from precipitation and wind. It is best to have a solid roof extending about one foot beyond the eves with one or two translucent fiberglass panels to provide some sky-lighting. An alternative is to have an open barred section in the roof, but rain and snow will fall through to the floor. The roofing material can be metal or, for better insulation and moisture barrier, concrete-fiber, corrugated panels.

If the floor is made of concrete, rock slabs, or other hard surface, it must be covered with 4 to 6 inches of loose sand or pea gravel, or other soft material (e.g., wheat straw if it can be kept dry to reduce the occurrence of Aspergillus spores). Soft landing surfaces are required to prevent foot injuries and bumblefoot when the owls fly down and land. Owls are especially prone to bumblefoot.

D. Maintenance and observation hallways.—The upper and lower hallways are used for feeding, watering, clean-up, and other care of the birds and for making unobtrusive observations into the breeding enclosures. Each enclosure should have a standard-sized door opening into the lower hall. Screened or barred air vents located at the very top of the back wall of each unit should open into the upper hallway space. There should also be larger vents at each end of the upper hall and exhaust fans to move air to the outside to

reduce temperature build-up in summer. (These features may not be necessary in the mild summer climate of coastal southern British Columbia.) Observation peep-holes, panels of one-way viewing glass, and ports for video equipment can be located in various positions on the back wall of enclosures at both the upper and lower levels. A port between the enclosure and the lower hall for a shallow, sliding food tray should be located directly beneath the nest-box, where it will be protected from falling droppings.

E. Utilities.—At minimum, the facility should be supplied with electricity and water. There should be at least one electric ground fault outlet in each enclosure located out of effect of wet weather. It is also convenient to have water faucets in each enclosure for washing down walls and floors periodically and for easy access to water for the combined drinking and bathing pan.

F. Furnishings.—1. Perches should be arranged around the periphery of the enclosure and fastened to the walls, at varying heights above the floor, leaving most of the interior space open for flight. These perches can be natural tree branches or artificial structures with rounded surfaces. They should be about two feet in length and vary from one to three inches in diameter. An "astroturf" cover should be placed wherever the owls perch frequently. At the front of the enclosure, place one or two horizontal perches running from wall to wall and positioned about 12 to 18 inches away from the front bars or slats, one about two feet below the top of the enclosure and one at mid-level. They should be covered with "Astroturf." These perches provide places for the owls to land before crashing against the front bars or slats after a headlong flight from the back of the room. A variety of perch sizes and surfaces will help to keep the owls' feet in good condition, including one or two upright rocks placed on the floor, where beaks and talons can be trimmed. In enclosures with open, wire-mesh siding (a feature that should be avoided), nowhere should perches abut the wire, as the owls will often push up against the wire to perch, possibly damaging feathers, beaks, and feet, but more importantly exposing themselves to harassment and injury from marauding predators. In this situation side perches should be mounted so that the horizontal perching surfaces are held one foot or more away from the wire by a support that angles up and away from the side.

2. Nest-boxes should be about 12-14 inches wide, 24 inches long and 12 inches high. They should be positioned horizontally, high up on the back wall (but not so high that they cannot be easily serviced from the upper hall). The entrance located at one end should be about six by six inches, positioned about three inches above the bottom of the box, and should have a short outside perch next to the hole. The wood should be untreated or treated with a non-toxic preservative such as linseed oil. The bottom should be covered with litter about 4 inches deep. Wood or bark chips and shavings, and pea gravel are suitable, but the best material is corn-cob litter, which is non-toxic, can be swallowed safely by baby owls, and is highly absorbent. There should be at least two nest-boxes per enclosure to give the owls some choice of exposure and position and to provide separate chambers for roosting. From the upper hallway provide an access door and peep-hole near the back of the box. It may also be necessary to mount a small video system inside the box to monitor the behavior of the adults and young.

An alternative roost consists of a vertical box mounted on a sidewall with an entry hole near the top and an open bottom. A horizontal perch positioned about midway between top and bottom provides a place for the owl to sit and sleep; its droppings and pellets fall through the open bottom, making it less often necessary to clean the box.

3. Feeding port and tray.—Food provisioning is done by means of a sliding tray on a shelf positioned directly below the nest-box (to protect from owl droppings} and operated from the lower corridor. The bottom of the tray should be plexiglass or some other non-porous surface that can be periodically washed.

4. Bath and drinking pan.—The pan should be about two feet in diameter with a water depth of four inches. Its rim should be thick enough and of a texture that will allow an owl to perch easily on it. Some of the thick, rubberized animal feed pans meet these requirements. The pan should be elevated on a pedestal or small table two to three feet above the floor in a space with no perches above it. Such a position will help to prevent debris from the floor and droppings from getting into the water and fouling it. For convenience in servicing, it should be located near the back wall and door.

G. Maintenance. A well-constructed pole-barn will last for 30 years or more with minimal care. Exposed wood should be periodically coated with linseed oil or other non-toxic preservative. Siding and roofing materials should be checked before and after the breeding season to make sure they remain securely fastened to their supporting structures.

1. The interior of enclosures should be thoroughly cleaned and sanitized about two months prior to the breeding season (February) and again after the breeding season when the young have been removed. The owls will need to be removed to temporary quarters when cleaning is underway.

2. Wall splattering.—If there is persistent splattering of droppings on a wall surface, a removable plastic sheet can be stretched over the area and periodically removed for cleaning. Otherwise, perches can be positioned away from walls as described above; but owls actually seek walls for protection and feel more at ease than when perched in the open; therefore, a plastic sheet is the best option for this problem. Once droppings accumulate on a wall and form a dry cake, they are extremely difficult to wash off.

3. Substrate.—If the substrate is sand, weekly raking of areas where droppings and pellets accumulate is a good way to clean up. If pea gravel, use a hose and nozzle to wash the droppings down into deeper layers of the gravel (such sites will still need to have the gravel replaced periodically). If straw is used, sections where dropping cake in the straw are easily removed and replaced with fresh straw. Alternatively, shallow trays with sand, pea gravel, or corn-cob litter can be placed under perches where droppings accumulate. They can be dumped as needed into a wheelbarrow and refilled with fresh material.

4. Bath and drinking water should be replaced often enough to prevent the build up of algae and other matter (droppings, pellets, food remains) from fouling the water.

5. Unused and decaying food remains need to be removed periodically. Check food caches where uneaten items often accumulate. Try to regulate the amount of food provided each day, so that it is just enough to satisfy *ad libitum* intake.

6. Advantage of nocturnality.—The fact that these owls are nocturnal and hide away to sleep during daylight makes human entry for routine maintenance of the enclosure easier and less disturbing than when dealing with diurnal raptors. Slow, deliberate movements without making noise will allow work without undue disturbance. If an owl does become disturbed and flighty, quietly leave the enclosure and come back later when it has settled down.

H. Perimeter protection from humans and other animals. An unclimbable 10-foot high cyclone or chain-link fence with a topping of barbed wire strands or razor-wire coils should be placed around the entire holding facility at least 10 feet out from the building. In addition to the solid metal panel or skirt running along the bottom outside edge of the building it is also advisable to have an electric "hot wire" elevated about 12 to 18 inches above ground and a few inches out from the wall for predators such as cats that may get past the fence. Depending on the construction at ground level, it may be necessary to have buried metal flashing or weld-wire extending out from the base of the wall for two or more feet and bent up at a right angle to overlap a foot or so with the siding. This arrangement helps to keep small vermin such as rats and weasels from digging into the areas occupied by the owls. These precautions are especially important if the facility is located in a natural setting away from human development, where wild predators are likely to be more common.

I. Husbandry Procedures. A detailed daily animal care protocol needs to be developed for the facilities and a significant record keeping system developed.

J. Veterinary care. Protocols and procedures will need to be developed to include quarantine, daily health monitoring, veterinary assessment and preventative medical care to include fecal and parasite monitoring and treatment, vaccination and blood studies.

K. Breeding. Procedures for breeding, incubation and rearing or young will need to be established. DNA analysis will be routinely conducted. A population management program will need to be established by the captive breeding working group responsible to set up to plan the breeding strategy. An external population management consultant is required to set up a detailed and proper studbook record keeping system from the beginning. A field working group is likely needed to plan reintroductions.

Other Enclosures

A. Holding and Exercise Facilities.

1. Small single units.--Units for temporary holding, recuperation, care of imprinted birds, etc., can be constructed basically as wire-covered cages with inside bars or slats. They should have at least one solid wall with a double door entry way and enclosed service area to

prevent disturbance. Some overhead protection from precipitation and sun is also necessary.

2. Large exercise and conditioning enclosures.— These can be made in a variety of shapes and sizes depending on their location and use. They are mostly used for post-fledgling owls during their first year of life or until released to the wild. The typical shape is rectangular to give a reasonably long uninterrupted flight distance. An enclosure of 100 X 20 feet provides adequate exercise for 20 or so owls. Each owl should have a protected roosting box. Again, at least part of one end should have solid paneling with an attached work space and double doors. The floor can be natural ground with some low growing vegetation. Predator-proofing is particularly important for these large enclosures. An area for introducing live prey should be built in the central part of the enclosure.

In recent years falconers have devised a new design for an enclosed exercise area, as a substitute for the old system of hacking young falcons before training begins. These big enclosures are either circular or dough-nut shaped with perches arranged on the sidewalls leaving the middle open for flight. In such systems the birds can make continual circular flights of long duration before landing on a perch. Whether such an arrangement is needed to exercise owls is questionable, because owls typically sit-and-wait and then pounce on their prey over relatively short distances, and they do not require great flying endurance to be successful. Still, such a structure provides a potentially valuable opportunity to maximize physical strength and endurance before release.

3. Release enclosures.— These are field units that are set up in areas where owls are to be released. They should be about 10 X 20 feet in area and 8 feet high, with the typical wire-mesh and slat or bar design for siding and top. The back end should have some overhead protection from precipitation and sun with a solid back and work shed attached with double doors. Predator protection is essential. Such an enclosure can easily accommodate four to six owls. It should be possible to make this structure in modules that can be assembled in the field and later taken down for use elsewhere.

Modification of Existing Structures

Many existing enclosures can be made suitable by modifying them to meet the requirements outlined above and summarized below.

1. Structures larger than those specified are fine, but are more laborious to maintain and can make it more difficult to catch the owls up when it is necessary.
2. Peripheral protection from humans and predators must be in place.
3. Any wire-mesh siding or roofing must be modified by bars or slats placed inside the wire and if possible spaced at least four inches from the mesh.
4. Hard substrates must be covered with soft materials four to six inches deep.
5. Perches should be arranged around the sides to maximize open space for flying.
6. Some solid, waterproof material must cover at least six feet of the top and be located at the back where the utility area is situated.
7. If there is no utility room or hallway, then a double door entry into the enclosure is required.

8. No perches should be placed flush with open wire-mesh siding or other open covering.

Facility Personnel

The best facilities in the world are worth nothing if they are not operated by skilled, devoted, and zealous personnel. Breeding birds of prey in captivity is not a routine task. Especially in the breeding season it involves long days and no days off. Consequently the staff must love what they do and be devoted to success. They do not need Ph.D. degrees, but they must have a strong intuitive rapport with the birds. In short, a good breeder is a very special person, and they are hard to find.

A 10-unit facility such as the one described above can be operated successfully with three qualified people. A fourth person will probably be needed if the production of food (quail, mice, rats, etc.) is part of the operation. At least one and preferably two of these people should have a minimum of three years of proven success in breeding raptors in captivity. It does not matter whether the person was involved with owls or with diurnal raptors. What is important is that he or she can do it. Experience in the rehabilitation of sick and injured raptors alone is not sufficient.

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Appendix 3: Captive Breeding Centres

A number of different groups in British Columbia have expressed interest in captive breeding of Spotted Owls. Facilities that have expressed interest and that have experience with some or all phases of captive breeding of endangered wildlife are:

Grouse Mountain Refuge for Endangered Wildlife
Ken Macquisten, DVM, Ph: 604 998 4229
Andrea Worrall, Wildlife Manager, Ph: 604 998 4229; Fax: 604 998 4316
6400 Nancy Greene Way, North Vancouver, British Columbia, Canada V7R 4K9
http://www.grousemountain.com/adv_wilref.cfm

Mountain View Conservation and Breeding Centre Society
Gordon and Yvonne Blankstein
23898 Rawlison Cresent
Langley, BC Canada V1M 3R6
Ph: 604 882 9313 Fax: 604 881 1221
Email: visit@mtnviewfarms.com
http://www.mtnviewfarms.com/

BC Wildlife Park (Kamloops, British Columbia)
Paul Wilson, animal care supervisor
Ph: 250 573 3242
Email: acd@bczoo.org
Rob Purdy General Manager
Ph: 250 573 3242 ext. 225
Email: gm@bczoo.org
http://www.kamloopswildlife.org/

Society for the Conservation and Research of Owls
Rolf Krahe, Vic President/Executive Director
9866 Adams Rd.
Smithers BC VOJ 2N7
Ph: 250 847 3289
http://www.scro.org

A significant body of knowledge on captive breeding of is available. The SOPET contacted Owl Foundation of Ontario (Kay McKeever) http://www.theowlfoundation.ca/ and other successful owl breeders such as Jemima Parry-Jones, Rolf Krahe, Wolfgang Scherzinger and Sigrid Ueblacke.