Biological Challenges of Augmenting Small Grizzly Bear Populations

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Abstract: The North Cascades grizzly bear population unit was considered threatened under the British Columbia Grizzly Bear Conservation Strategy, so a comprehensive recovery plan was developed. The main strategy proposed to increase the number of grizzly bears (*Ursus arctos*) was population augmentation, that is, transplant of bears into the recovery area from outside. The augmentation proposal has raised a number of social, political, and biological issues. In the context of social and political concerns, we review some of the biological challenges of grizzly bear augmentation, including (1) source area and selection of individual bears, (2) timing of capture, transport, and release, (3) release methods and areas, and (4) mitigation strategies associated with release.

Key Words: grizzly bear, *Ursus arctos*, *Ursus arctos horribilis*[1], augmentation, recovery, reintroduction, transplant, British Columbia

Introduction

The British Columbia (B.C.) Grizzly Bear Conservation Strategy was launched in 1995 with a mandate of ensuring the continued existence of grizzly bears (*Ursus arctos*) and their habitats for future generations (B.C. MELP 1995). Under the Grizzly Bear Conservation Strategy, grizzly bear populations units were outlined, and their boundaries were features that largely restricted grizzly bear movement. Each unit was assigned a conservation status of extirpated, threatened, or viable (Fig. 1). The North Cascades grizzly bear population unit was considered threatened; therefore, a recovery plan was developed by a North Cascades Grizzly Bear Recovery Team (NCGBRT 2004). The goal of the recovery plan was to restore the North Cascades grizzly bear population unit to viable status by (1) providing habitat of sufficient quality and quantity to support a viable population, (2) preventing population fragmentation and maintaining genetic diversity, (3) increasing the number of grizzly bears, (4) minimizing the potential for bear-human conflicts, (5) minimizing the human-caused mortality of grizzly bears, (6) increasing public knowledge of, and support for, the recovery plan, and (7) facilitating interagency cooperation and management.

[1]NatureServe Explorer (version 4.0, July 2004) lists *Ursus arctos* as the brown bear, and *Ursus arctos horribilis* as the grizzly bear.

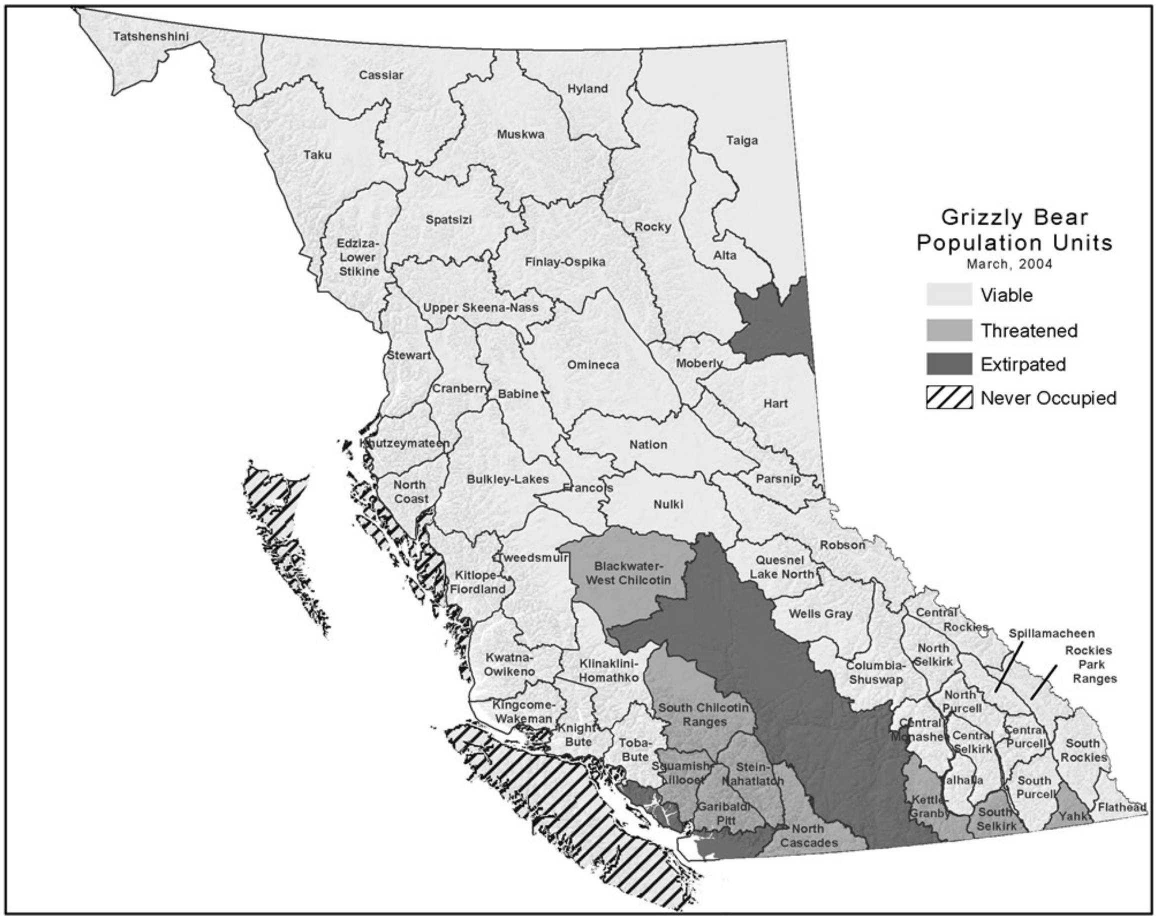

Figure 1. The status of grizzly bear population units in British Columbia.

The main method proposed in the recovery plan to increase the number of grizzly bears in the North Cascades was population augmentation (NCGBRT 2004). Augmentation refers to the translocation or transplant of bears from outside the recovery area into the recovery area to supplement the existing population. The rationale for augmentation was that the estimated number of grizzly bears in the North Cascades was very small and likely not to survive over the long term without the addition of bears from other areas. There were no viable grizzly bear populations contiguous to the North Cascades, therefore, no bears were likely to contribute toward recovery by natural dispersal (NCGBRT 2004).

In general, the success of mammal population reintroductions, such as through augmentation, is enhanced in instances when there are a large number of founders, low environmental variation, and access to refuges, and for species with high genetic variability, a high rate of population increase with low variance and low intraspecific competition (Clark et al. 2002). Unfortunately, bears exhibit low population growth with high variance, are subject to high environmental variation (e.g., annual fluctuations in food production), and have low genetic variability relative to their population size. In addition, bears have a strong homing instinct and experience increased mortality following translocation. Consequently, there are many challenges associated with bear augmentations. Historically, few bear reintroductions occurred; fewer still were successful (Clark et al. 2002). Recently, there has been renewed interest in bear reintroductions. There have been at least four reintroductions of American black bears (*U. americanus*) in the U.S. since 1991 and four augmentations of grizzly bear populations in Europe and the U.S. since 1989 (Servheen et al. 1995; Rauer 1997; Quenette et al. 2001; Clark et al. 2002).

Subsequent to release of a draft North Cascades grizzly bear recovery plan in 2001, public input was received during a consultation period (NCGBRT 2002), and the B.C. Minister of Water, Land and Air Protection appointed a public task force to provide further recommendations on changes to the draft plan (NCGBT 2003). Task force members included representatives from the ranching, mining, and forest industries, local residents, conservationists, outdoor recreationists, and local First Nations. In June 2003, the Minister of Water, Land and Air Protection directed the North Cascades Grizzly Bear Recovery Team to finalize the grizzly bear recovery plan based on public input and recommendations of the task force. The final recovery plan was approved by the minister in June 2004 (NCGBRT 2004).

Several conditions on population augmentation were suggested by the North Cascades Grizzly Bear Recovery Team in 2001 and further suggestions came from public input (NCGBRT 2002) and the public task force (NCGBT 2003). These included the following:

For the source area,

- the population of bears must be viable;
- the area must be closed to grizzly bear hunting; and
- the area should have ecological similarity to the North Cascades.

For selection of individual grizzly bears,

- there should be a high likelihood of selecting bears that do not rely on salmon or other fish for a significant portion of their diet and that do not have a history of interaction or conflict with humans; and
- preference should be given to females over males and subadults over adults.

For grizzly bear release,

- initially, three bears should be translocated to determine if translocation works, and if successful, up to three more bears could be translocated during a five-year augmentation trial;
- augmentation should not occur until the recovery team is satisfied the necessary work to reduce the likelihood of bear-human conflicts has been completed;
- bears should be marked and fitted with a radio-telemetry device to allow their movements to be tracked; and
- bears should be released in high quality habitat with low levels of human activity.

The above conditions on grizzly bear population augmentation arose through a variety of social, political, and biological rationale. Regardless of their origin, these conditions increase the biological challenges associated with augmentation. We review some of these biological challenges and specifically address (1) source area and selection of individual bears, (2) timing of capture, transport, and release, (3) release methods and areas, and (4) mitigation strategies associated with release.

Study Area

The North Cascades grizzly bear population unit extends from the Canada/U.S. border north to the Thompson and Nicola River watersheds of southcentral British Columbia and covers an area of about 9807 km^2 (Fig. 2). The Cascade Mountains in British Columbia are a minor representation of a large physiographic region that begins at the southern border of Oregon and terminates near Lytton in the Fraser River canyon. Three mountain ranges, the Skagit, Hozameen, and Okanagan, make up the Cascade Mountains in B.C. The climate of the area is highly variable due to extreme topographic variability, but generally reflects the interplay of maritime and continental influences resulting in warm, dry summers and cold, cloudy winters. Mean annual temperature at Manning Park is 3.4ºC with temperatures ranging from a high of 34.2ºC and an absolute low of -43.1ºC.

The North Cascades grizzly bear population unit occurs in an area of coast to interior transition. About 33% of the unit is coastal influenced. Four coastal ecosections occur in the unit: the Hozameen Range, Eastern Pacific Ranges, Leeward Pacific Ranges, and Pavillion Ranges. Two interior ecosections also occur: the Southern Thompson Upland and Okanagan Ranges. The Biogeoclimatic Ecosystem Classification zones in the unit are the Alpine Tundra, Coastal Western Hemlock, Engelmann Spruce–Subalpine Fir, Interior Douglas-fir, Mountain Hemlock, and Montane Spruce with a very minor inclusion of the Ponderosa Pine zone near Lytton. Almost half (49%) of the grizzly bear population unit is higher elevation Mountain Hemlock, Engelmann Spruce-Subalpine Fir, and Alpine Tundra habitat.

Source Area and Selection of Individual Grizzly Bears

Viable Population Closed to Hunting

The source area should have a healthy grizzly bear population so removal of bears will not affect population viability and so there is greater probability of capturing bears that meet selection criteria (Servheen et al. 1987). The most promising class of bear to be moved are subadult females, so their removal should not reduce the future reproductive potential of the donor population. In British Columbia, viable grizzly bear population units are primarily on the central and north coast, and in the north and southeast interior (Fig. 1).

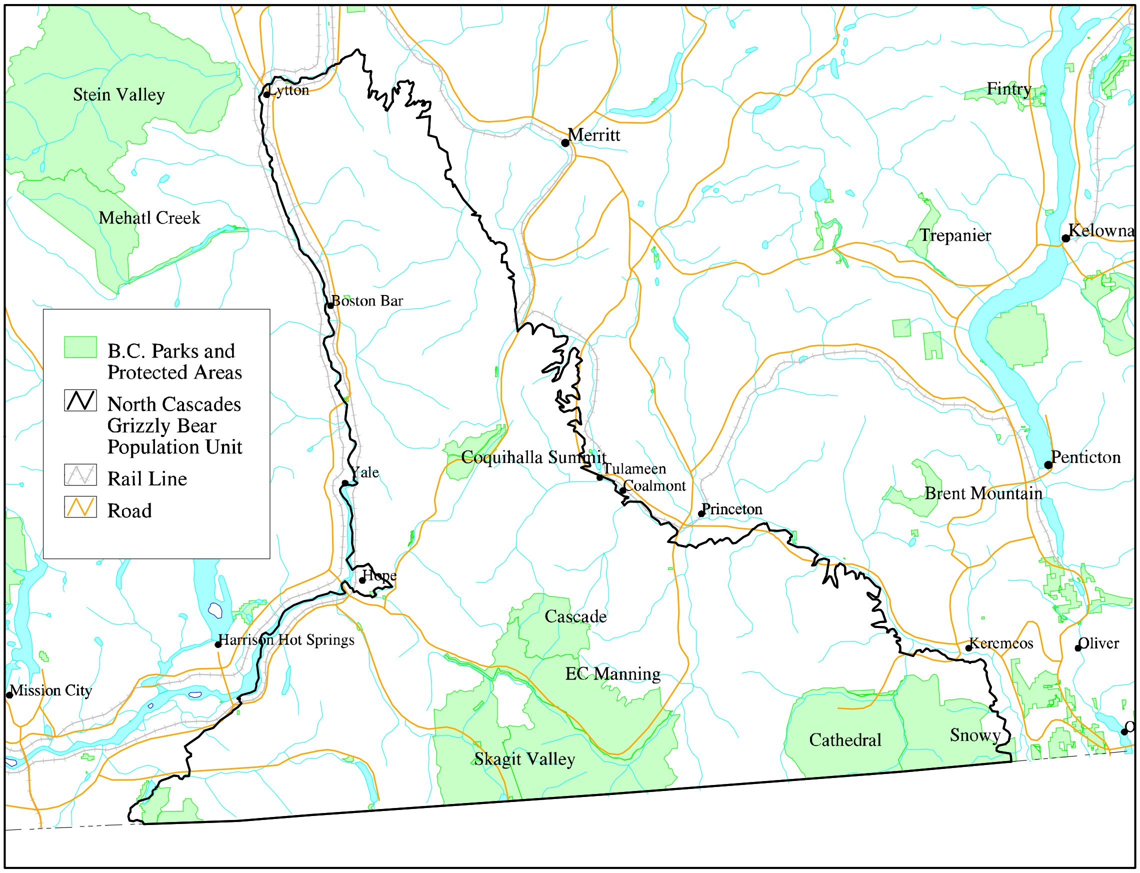

Figure 2. The North Cascades grizzly bear population unit in southwest British Columbia.

All unoccupied area and threatened grizzly bear population units in B.C. are closed to grizzly bear hunting. In most areas of B.C., viable grizzly bear populations are open to grizzly bear hunting; it is largely because they are viable that hunting is allowed. It is challenging, therefore, to find a viable population that is closed to hunting.

Ecological Similarity to Release Area

Source and release areas should have habitat with similar topography and vegetation so transplanted bears are able to find similar food distribution and seasonal habitat in the release area (Mace and Haroldson 1984; Servheen et al. 1987). This is particularly important for bears that have inherited habitat use patterns based on specific forage availability. Having known foods available in the release area would likely enhance a bear's adjustment to the new environment.

Salmon Use

Grizzly bears are well adapted to exploit seasonal and yearly variations in the distribution and abundance of high quality foods. Individual grizzly bears (MacHutchon et al. 1993; MacHutchon and Mahon 2003) or even subpopulations of grizzly bears (Schoen et al. 1986; Munro 1999) can have very different strategies for exploiting available foods, and these may change over time. It can take many years of research to uncover all foods used by a grizzly bear population (Mattson et al. 1991, 1992). In most of central and southern B.C., salmon streams are within the potential movement distance of grizzly bears even if the majority of a bear's home range is some distance from the stream; consequently, it is difficult to say that an individual grizzly bear never feeds on salmon. Conversely, it is likely that some bears in every population infrequently (MacHutchon and Mahon 2003) or never fish for salmon even when salmon streams are relatively close by (Schoen et al. 1986).

To minimize the chance of selecting bears that rely on salmon, the focus of capture efforts should be on grizzly bears that are most likely to be elevation migrants and which primarily exploit berries, roots, or rodents in fall rather than salmon. In addition, bears should be captured from a remote area as far from salmon spawning drainages as possible. However, other methods likely will be necessary to establish if an individual bear is reliant on salmon; two complementary methods are collaring and monitoring bears and staple isotope analysis of hair samples.

Collaring and Monitoring

Collaring and monitoring bears for a period of time, especially over the salmon spawning period, can help determine their reliance on salmon. It is also useful for assessing their behavioral history around humans, proximity to human development or roads, other food habits, seasonal habitat use, and movements.

A variety of ground trapping techniques for capturing bears is available, and ground traps can be accessed by road, boat, or helicopter. Helicopter access is more expensive than road or boat access, but helicopters are essential for reaching remote areas without roads, and they increase capture efficiency because more area can be covered, more trap sites can be set, and specific habitats can be targeted. Aerial darting a free-ranging bear from a helicopter is an even more efficient way of capturing bears in open habitats. It also allows subadult bears to be targeted, logistic preparations are lower than for ground trapping, and several bears can be captured in a relatively short time. However, most bears in southern B.C. are only active seasonally in open habitats. In spring, they may be in high elevation open habitats following denning. Occasionally, bears may be found in open wetlands, meadows, or clearcuts in spring and early summer, but the openings have to be large enough for a safe chase to occur. In fall, bears are often in high elevation open habitats when seeking berries, late developing forbs, and ground squirrels or marmots. We recommend helicopter over road or boat access for bear capture, and when there is a choice, aerial darting over ground trapping.

The biggest disadvantage of monitoring bears before moving them is that it requires capturing the bear twice, once to collar it and once to move it. This increases risk to the bear of injury or death, although this risk can be minimized with appropriate capture and handling techniques. The more time there is between capture and recapture, the more information there will be on a bear's activity, but there is a higher probability of lost or failed collars, and bears will be more established in the source area. The main challenge, however, is that it can be logistically difficult to capture a bear a second time, particularly if capture has to occur within a specific period of time. Ground trapping a bear twice is more difficult than aerial darting it twice, but the level of difficulty is relative. It can be difficult to aerial dart a bear a second time if (1) the bear is not active in open habitats when the second attempt occurs, (2) the bear moves to cover when the helicopter approaches, a behavioral response that is often learned from the initial aerial darting, or (3) the bear loses its collar, or the collar malfunctions and the bear can not be found. Capture crews should be prepared to selectively ground trap by helicopter if aerial darting is unsuccessful during recaptures. Ear tag or small button transmitters deployed on bears when they are initially captured can be an alternate way to find bears if collars fail.

Stable Isotope Analysis

Determining the stable carbon and nitrogen isotope signatures of a bear's hair can provide insight into its feeding ecology such as the relative contribution of vegetation, terrestrial meat, and marine meat (e.g., salmon) to its diet (Hilderbrand et al. 1996; Jacoby et al. 1999; Hobson et al. 2000). If stable isotope analysis is used to measure salmon use in bears then (1) bears would have to be captured and held captive while stable isotope analysis is done, or (2) bears would have to be captured, released while tests are done, and then recaptured. Holding bears in captivity requires an adequate holding facility and likely will stress the bear. Servheen et al. (1987) suggested feeding bears in a holding cage could habituate them to humans, but this likely depends on how long bears are held and how they are fed. Capturing bears a second time can be difficult, but there are advantages to monitoring them in the source area while isotope analyses are done, so we recommend option 2.

Behavioral History Around Humans

Servheen et al. (1987) suggested one strict criteria of population augmentation was that transplanted grizzly bears have no history of positive attraction to humans, human-use areas, or human-related foods, that is, not be human-food conditioned (Gilbert 1989). The authors also felt it was important that bears not have a neutral response to humans, that is, not be human-habituated (McCullough 1982; Gilbert 1989).

Human food-conditioned bears generally have low survival because they are frequently killed in control actions, they are killed to defend life or property, or they are translocated. They are also more vulnerable to illegal kills near settled areas, and the attractants they eat may compromise their health. Food-conditioned bears may destroy human property in their search for non-natural attractants, and they occasionally cause human injury, or rarely, human death. Population augmentation will have a greater chance of success if human food-conditioned bears are not transplanted. It also is important to strictly control situations that might lead to food-conditioning in the augmentation area.

Human-habituated grizzly bears are not usually a risk to humans if people behave in a predictable manner and bears do not learn to associate humans with food or garbage; however, people are usually not tolerant of grizzly bears in close proximity. Increased encounters between bears and humans usually lead to bears being killed or moved; consequently, a transplanted bear's chances of survival are higher if it is not human-habituated.

Sex and Age Class of Bear

Mace and Haroldson (1984), Maguire and Servheen (1992), Rauer (1997), and Clark et al. (2002) all suggested that subadult female grizzly bears were the best sex and age class for population augmentation because of their small home range size, less established home range, and reduced potential for long range movement. Adult females have a substantial investment in the establishment and maintenance of their home range so their long distance return to such a range is worth the cost. Adult and subadult males have larger home ranges than females and would be expected to move longer distances after translocation. Using decision theory analysis, Maguire and Servheen (1992) concluded that subadult females placed in the target area when natural foods were most available were the age and sex class with the lowest probability of leaving the target area and of having conflicts with humans. In addition, subadult females remaining in a release area would potentially contribute the most to the population because of their long reproductive life span (Servheen et al. 1987). Reintroductions using subadult American black bears and grizzly bears have been more successful than reintroductions of adults (Clark et al. 2002).

Potential Source Areas

A few viable grizzly bear population units in British Columbia encompass large protected areas that are closed to hunting, including Wells Gray and Tweedsmuir South Provincial Parks. We recommend east central portions of Wells Gray Park as the primary source area for grizzly bears for North Cascades population augmentation, and the central portion of Tweedsmuir South Park as a secondary source area.

Overall, Wells Gray Park appears to be more ecologically similar to the proposed augmentation area in the North Cascades than Tweedsmuir South Park. There is a relatively high abundance of salmon in watersheds adjacent to Wells Gray, which suggests it will be difficult to find bears that do not ever eat salmon; however, there are remote areas of Wells Gray where bears likely rarely or never feed on salmon. There is an even higher abundance of salmon in watersheds adjacent to and within Tweedsmuir South Park, which suggests it will be difficult to find bears that do not ever eat salmon. In addition, most grizzly bears that use the valley bottom of major rivers, particularly in the salmon season, likely have a history of bear-human interaction, and some may be human food-conditioned. Subadult bears are preferred for augmentation, but they are the most habituated to people, therefore, they are the most likely to have exploited human food or other attractants (MacHutchon et al. 1998).

Timing of Capture, Transport, and Release

There are advantages and disadvantages associated with any time of year for the capture, transport, and release of bears used for population augmentation (Table 1). Weighing the various costs and benefits requires consideration of a bear's health and safety as well as logistic factors, such as method of capture, whether bears will be monitored in the source area or not, and whether stable isotope analysis will be done (see above). In three previous augmentations, grizzly bears were captured and moved in spring or early summer (Servheen et al. 1995; Rauer 1997; Quenette et al. 2001). Servheen et al. (1995) timed the capture and release of grizzly bears to July because it was the time when food availability in the release area was highest; shrub fruits, which were the major food in the area, were ripe and available to bears. Before July, shrub fruits were not ripe and after July the ease of capture in the source area declined because bears had moved into habitats with an abundance of fruit and were less interested in baited trap sites. In the other two augmentations, it was not clear if the timing was to deliberately benefit bears in the release area or because spring and summer were the best times to ground trap bears in the source area; we suspect the latter.

If bears are to be collared and monitored before transplant, then initial capture could occur in either spring or fall when it is easiest. The challenge is to determine when to recapture bears for transport and release. Bears released in the North Cascades in late summer would have abundant shrub fruit available and ample time to explore their new environment. They would still gain sufficient weight for denning, so it may be the best time to ensure the bear's well-being. However, late summer is the most difficult period to efficiently recapture bears. If recapture is to occur in late summer, it may be best to initially capture a large sample of bears (e.g., seven) to increase the chance of success in recapturing three for transplant. Bears recaptured in spring may experience some food stress and wander widely upon release, but provided they do not get into conflict with humans, they should have sufficient time to adjust to their new environment and prepare for denning.

Table 1. Advantages and disadvantages associated with the timing of capture, recapture, transport, and release of grizzly bears for augmentation of the North Cascades, British Columbia population.

Time of year	*Aerial darting success*	*Ground trapping success*	*Available natural food*	*Other advantages*	*Other disadvantages*
Spring (mid April to early June)	Good, declines over time	Good	Poor	Bears have lots of time to adjust to the release area before denning; stable isotope analysis will reflect salmon use the previous year; temperatures are relatively cool so there is less chance of heat stress during capture and transport.	Released bears may become nutritionally stressed because they are unfamiliar with the location of natural food and may move toward home or to human occupied areas with alternative foods.
Early summer (early June to mid July)	Poor	Fair	Fair	Release occurs when natural food abundance is increasing; bears have ample time to adjust to the release area before denning.	Determining salmon use can only be done if a bear is monitored through the salmon season as stable isotope analysis will only reflect diet since hair started to grow in early summer; temperatures are warm so there is more chance of heat stress during capture and transport.
Late summer (late July to mid September)	Poor	Poor	Good	Release is during the peak of fruit production when there is abundant high quality food; bears have ample time to adjust to the release area before denning.	Determining salmon use can only be done if a bear is monitored through the salmon season as stable isotope analysis will only reflect diet since hair started to grow in early summer; temperatures are hot so there is more chance of heat stress during capture and transport.
Fall (mid September to early October)	Good	Fair	Good	Fat and healthy bears can be chosen for transplant to reduce concern about overwinter survival; bears that den shortly after release may be more inclined to stay in the release area upon den emergence; a bear caught well away from where salmon are available is less likely to feed on salmon; stable isotope analysis of hair will reflect salmon use in the current year; temperatures are cooler so there is less chance of heat stress during capture and transport.	Released bears may become nutritionally stressed because they are unfamiliar with the location of high quality food and may move toward home or to human occupied areas with alternative foods, all of which could compromise their overwinter survival.

There is little previous experience to judge how grizzly bears will respond if they are released in fall. On one hand, bears could become nutritionally stressed because they are unfamiliar with the location of high quality food, which could compromise their overwinter survival. On the other hand, if bears chosen for transplant are fat and healthy there is less concern about overwinter survival, and bears that den shortly after release may be more inclined to stay in the release area upon den emergence (Clark et al. 2002). Release in fall would be more experimental then release in spring or summer.

Regardless of when bears are moved, we recommend they be transported in an enclosed and climate-controlled vehicle so temperatures can be kept within a bear's thermoneutral zone and external stimuli such as human activity, noise, smell, and light can be minimized. We also recommend providing high quality food, such as ungulate carcasses, at the release site to encourage bears to stay in the area, and to compensate for any nutritional stress associated with release.

Grizzly Bear Release

Release Method

Past bear reintroductions have used either a hard release, where bears were captured, transported, and released without an acclimation period, or a soft release, where release was preceded by an acclimation period (Clark et al. 2002). Four recent reintroductions of grizzly bears have used a hard release, which we recommend for North Cascades population augmentation. As mentioned above, we recommend providing high quality food at the release site to encourage bears to stay in the area, and to compensate for any nutritional stress.

One significant obstacle to successful bear reintroductions has been the homing behavior of released bears; bears have returned hundreds of kilometers to their original capture site (Miller and Ballard 1982; Blanchard and Knight 1995; Clark et al. 2002). Clark et al. (2002) suggested the main factors that influence homing in bears include age, sex, presence of cubs, food availability, translocation distance, and geographic barriers. The selection of candidate bears based on sex, age, reproductive status, and natural food availability were reviewed above.

A number of studies have identified an inverse relationship between the distance American black bears were translocated and their probability of return to the point of capture (reviewed in Clark et al. 2002). A variety of transport distances have been recommended for grizzly bears to reduce homing. Blanchard and Knight (1995) recommended > 100 km, Thier and Sizemore ([1981] in Blanchard and Knight 1995) recommended > 120 km, and Miller and Ballard (1982) recommended > 258 km. Our two recommended source areas of grizzly bears, Wells Gray and Tweedsmuir South, are located approximately 355 and 535 km straight line distance, respectively, from potential release areas. These are relatively long distances compared to the distances that translocated nuisance bears are typically moved, and are comparable to the distances that bears have been moved during previous reintroductions.

Ironically, human-made obstacles such as roads and developments that are barriers to natural immigration of bears may also prevent homing (Clark et al. 2002). The North Cascades is relatively isolated from the nearest grizzly bear population in the Stein-Nahatlatch grizzly bear population unit by a railway, a major highway, the Fraser River, and associated human development along the river itself (NCGBRT 2004; Singleton et al. 2002). The Coquihalla Highway, which has been fenced for much of its length, is also at least a partial barrier to grizzly bear movement (NCGBRT 2004). The Okanagan Valley east and northeast of the North Cascades grizzly bear population unit is a major fracture zone for grizzly bear movement (Singleton et al. 2002). The southern portion of the North Cascades grizzly bear population unit and the proposed augmentation area is bisected by Highway 3, which is at least a partial barrier to movement (Singleton et al. 2002; MacHutchon, unpublished data).

Release Areas

Given conditions on the release of grizzly bears, we reviewed the following factors associated with potential release areas in the North Cascades grizzly bear population unit:

- habitat quality and quantity
- habitat security
- potential for interaction and conflict between released bears and humans
- potential for interaction and conflict between released and resident bears
- potential for movement of released bears out of the North Cascades

Habitat Quality and Quantity

Gyug (2003) created a unified map of grizzly bear habitat suitability (RIC 1999) for the North Cascades grizzly bear population unit. He then derived habitat effectiveness ratings based on road density and zones of human influence. We used these maps to evaluate habitat quality and quantity within potential release areas. In general, we found the availability of moderate to high value spring foraging habitat, particularly not affected by human activity, was a significant limitation of most release areas.

Abundant meat resources positively affect body size, reproductive success, and population density of grizzly bears; therefore, they have a positive influence on habitat quality (Hilderbrand et al. 1999). Mammals, such as mule deer, hoary marmots, and Columbian ground squirrels, are likely the highest quality food in the North Cascades, but their relative availability and ease of capture vary among seasons and locations. There are no large populations of wintering ungulates in the North Cascades so Gyug (2003) felt scavenging of winter-killed ungulates was likely to contribute little to overall foraging suitability in spring.

Habitat Security

A few different measures of grizzly bear habitat security exist, but the NCGBRT (2004) defined it as ‘core area’, which was any area > 10 ha in size and > 500 m from a open motorized route, including open roads, four-wheel drive roads, and ATV-accessible old roads. There is no known minimum threshold for the proportion of a landscape that should be secure habitat for grizzly bears, but targets range from 55 to 68% (Mattson 1993; IGBC 1998; Gibeau 2000). Differences in proportions are related to habitat quality, land management designation, or bear density (NCGBRT 2004). NCGBRT (2004) proposed strategies to minimize both the loss of core area and the increase in high open road density in the North Cascades. Nevertheless, about 500 km of new road were built between 1999 and 2002 (Gyug 2003). Most of the release areas we evaluated were within protected areas, which have the highest proportion of secure habitat and the least likelihood of human-caused mortality of bears; however, because protected areas may not be ideal release areas for other reasons, e.g., habitat quality, we also evaluated some areas outside of protected areas.

Bear–Human Interaction

Survival of reintroduced bears is often lower than for non-translocated bears for several months to a year following release, largely because their wide-ranging movements increase the likelihood of interaction with humans, and because vehicle-related mortality increases (Clark et al. 2002). There are many human activities inside and outside of protected areas in the North Cascades, so proactive management will be important to minimize the likelihood of bear-human conflict and bear mortality following release.

Bears released in the North Cascades will not be human food-conditioned so there is no reason to suspect they will actively interact with humans; however, if they encounter easily obtained human food or garbage, they may consider the benefits of the attractants outweigh the costs of obtaining them. Food conditioning in bears has significant negative impact on bears and humans, therefore, it is essential to proactively manage non-natural attractants and avoid situations that may lead to food conditioning.

Bears have low reproductive rates, therefore mortality, especially of adult females, is the major factor limiting grizzly bear population growth (Knight and Eberhardt 1985; Knight et al. 1988). McCrory (2001, 2002) identified several potential sources of human-caused mortality in the North Cascades that could slow grizzly bear recovery, including management control kills, illegal kills (poaching), traffic mortality, conflicts with livestock grazing, and defence-of-life and mistaken identity kills by sport hunters. Minimizing encounters between bears and humans and bear habituation to humans are the best options for minimizing mortality risk (Mattson and Knight 1991; Gibeau et al. 1996; Benn and Herrero 2002). This can be achieved by managing non-natural attractants and human access, minimizing direct bear-human interaction, and reducing incidental killing of bears by hunters through safety education (McCrory 2001). In addition, frequent monitoring and management intervention when necessary will help reduce mortality of released bears.

Bear–Bear Interaction

Grizzly bear recovery will be positively influenced by successful breeding between transplanted and resident bears. On the other hand, grizzly bear survival, growth, and reproduction can be negatively affected by competition among bears for available resources. It is difficult to assess the amount of competition likely among grizzly bears in the North Cascades because very little is known about the size and distribution of the resident population; however, we assumed if seasonally important habitats were limited in release areas known to have resident bears, then the likelihood of intraspecific competition was higher. Sightings data indicated where some grizzly bears were present, but we used the data cautiously because they likely were biased. Sightings do not occur randomly, so they may only reflect where people were active and not the actual distribution of bears. In addition, bears in open habitats are seen more often than bears in forest or thick shrub cover, so sightings may only reflect the distribution of bears when in open habitat.

Movement Out of the North Cascades

If a released bear wanders widely, it could move out of the North Cascades grizzly bear population unit within Canada or if released in the vicinity of the Canada/U.S. border, it could move into the North Cascades Ecosystem of Washington. Movement of a bear into human-developed areas is undesirable because of higher mortality risk; however, movement of a bear into wilderness areas of the North Cascades Ecosystem of Washington is consistent with recovery efforts on both sides of the border. There is abundant habitat to support grizzly bears in the North Cascades Ecosystem (Almack et al. 1993; Gaines et al. 1994; Singleton et al. 2002), and since there are some bears remaining in Washington (Almack et al. 1993), breeding and reproduction is possible. Most people living in or near the North Cascades Ecosystem of Washington support grizzly bear recovery (Gaines et al. 2001; Davis and Morgan 2003), so movement of a bear into the ecosystem should not require drastic management intervention, such as moving the bear back to Canada; however, there has been some vocal political and public opposition to bears moving into Washington from B.C., so political and social concerns will have to be weighed against the biological advantages in the final selection of release areas, particularly for those near the international border.

Grizzly Bear Release Mitigation

The NCGBRT (2004) outlined a number of strategies to maintain habitat suitability and effectiveness, limit human access, maintain population linkage, educate the public, facilitate interagency cooperation, and minimize bear-human conflict and mortality of bears in the North Cascades. McCrory (2002) outlined specific measures aimed at management of visitor use and park facilities in three protected areas within the augmentation area. Implementation of mitigation strategies in both reports will be important to the success of population augmentation efforts. We believe that mitigation measures are best applied adaptively because of information and data uncertainties. If ongoing monitoring indicates lack of success of a particular method, it should be reassessed and modified.

Response to Bear-Human Interaction

A released bear that moves close to areas of human activity or development may need to be taught appropriate boundaries over which its presence will not be accepted by using aversive conditioning. Aversive conditioning uses a variety of bear deterrents to teach bears, through negative experience, to avoid humans and areas of human activity (Gilbert 1989; Ciarniello 1997; McMullen 2002; Sowka 2003). Judging when it is necessary to use aversive conditioning requires frequent monitoring of a bear's activity and assessment of public tolerance of a bear's presence.

Response to Bear Movement

If a bear leaves its area of release, it should be monitored closely, but not necessarily recaptured. The decision to recapture a bear or not should take into account various factors that are unique to each situation, such as a bear's association with areas of human activity, the bear's rate and direction of travel, the bear's exploitation of local habitats, and the likelihood that the bear will return to the release area versus continuing on elsewhere. Monitoring the movement and habitat use of released bears will provide an opportunity to learn what works and does not work for the bears.

Public Information and Education

Public information and education includes efforts to get public support, particularly local support, for augmentation efforts (Clark et al. 2002), and to provide information directed toward minimizing bear-human conflict and grizzly bear mortality (McCrory 2002). The biological issues associated with grizzly bear population augmentation are complex, but they likely can be more easily overcome than some of the social and political issues. Servheen et al. (1995) found public support for augmentation efforts was critical and proved to be the main factor limiting use of the technique. They suggested that significant effort be initiated to develop and maintain public understanding and support for bear conservation as part of any transplant effort. Negative public attitudes toward population augmentation are partially associated with the perception that reintroduction will result in land use restrictions and partially associated with the potential danger to humans and the destruction of livestock or other property (Clark et al. 2002; NCGBRT 2002). Programs that simply provide information about bears with the assumption that such knowledge will result in a shift in attitudes are rarely successful because knowledge is only one of several factors influencing attitude (Clark et al. 2002).

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