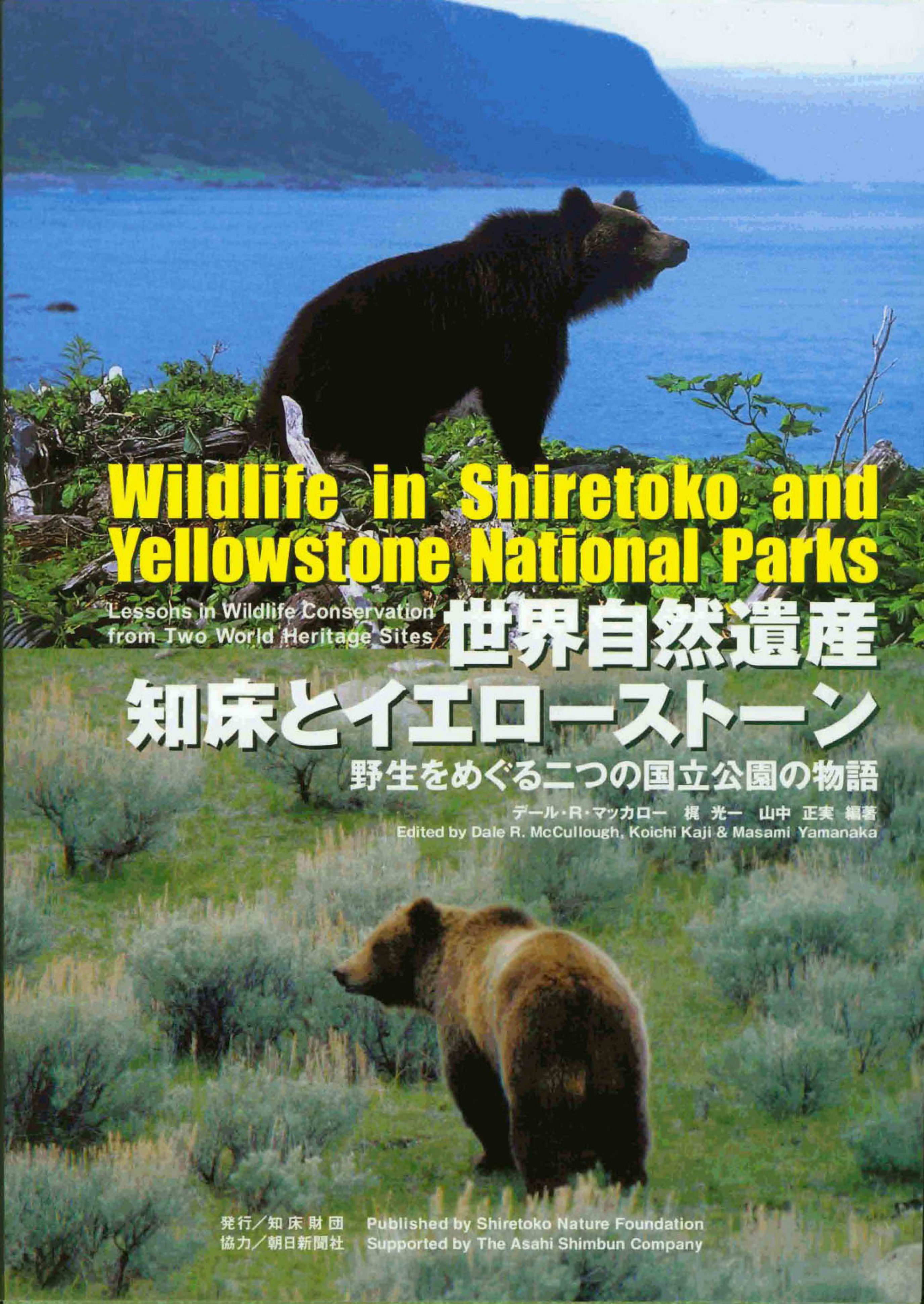

Wildlife in Shiretoko and Yellowstone National Parks

Lessons in Wildlife Conservation from Two World Heritage Sites

世界自然遺産 知床とイエローストーン

野生をめぐる二つの国立公園の物語

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5. Grizzly Bear Management in Yellowstone National Park

The Heart of Recovery in the Yellowstone Ecosystem

Charles C. Schwartz, Kerry Gunther

Abstract

Grizzly bear (*Ursus arctos*) management in the Greater Yellowstone Ecosystem (GYE) in the past quarter century has resulted in more than doubling of the population from around 200 to more than 500, expansion of range back into habitats where the bear was extirpated more than a century ago, and a move toward removal from the U.S. Endangered Species list. At the center of this success story are the management programs in Yellowstone National Park (YNP). Regula-

tions that restrict human activity, camping, and food storage, elimination of human food and garbage as attractants, and ranger attendance of roadside bears have all resulted in the population of grizzlies in YNP approaching carrying capacity. Recent studies suggest however, that YNP alone is too small to support the current population, making management beyond the park boundary important and necessary to the demographics of the population as a whole. Demographic analyses suggest a source-sink dynamic exists within the GYE, with YNP and lands outside the park within the Grizzly Bear Recovery Zone (RZ) representing source habitats, whereas lands beyond the RZ constitute sinks. The source-sink demography in the GYE is indicative of carnivore conservation issues worldwide where many national parks or preserves designed to protect our natural resources are inadequate in size or shape to provide all necessary life history requirements for these wide-ranging species. Additionally, wide-ranging behavior and long-distance dispersal seem inherent to large carnivores, so mortality around the edges is virtually inevitable, and conservation in the GYE is inextricably linked to management regimes not only within YNP, but within the GYE as a whole. We discuss those needs here.

1. Introduction

Bear management in YNP has evolved over the past 133 years since the park was established on March 1, 1872 (Figure 2-5-1). Gunther (1994) provides an excellent review of the early history which we summarize here. For nearly 60 years, both grizzly and black bears (*U. americanus*) were treated as a novelty and a form of entertainment for the visiting public. Roadside bears were common and panhandling by black bears accepted (Shullery 1992; Gunther 1994). Grizzly bears commonly fed on park garbage at the dumps much to the delight of the viewing public. As park visitation increased so did bear-human conflicts. From 1931 to 1959, 48 people per year were injured (Cole 1976; Meagher and Phillips 1983; Schullery 1992; Gunther 1994). Additionally, during the same period, 98 incidents of property damage per year occurred. As bear-human conflicts amplified, so did the removal of problem bears by YNP staff.

Outside the park, grizzly bears were suffering the consequences of European colonization of the American West. A recent review contrasts the evolution of human attitudes toward large carnivores in Europe and North America (Schwartz et al. 2003b). Three salient quotes aptly capture the pervasive attitudes of the time. Historian and trapper Stanley Young (Young 1946: 27) wrote: "There was sort of an unwritten law of the range that no cow man would knowingly pass by a carcass of any kind without inserting in it a goodly dose of strychnine sulfate, in the hope of killing one more wolf." Second, U.S. Biological Society E. A. Goldman wrote, "Large predatory animals destructive of livestock and game, no longer have a place in our advancing civilization" (Dunlap 1988: 51). Third, in 1756, John Adams described North American as "the whole continent was one continuing dismal wilderness, the haunt of wolves and bears and more savage men. Now the forests are removed, the land covered with fields of corn, orchards bending with fruit and the magnificent habitations of rational and civilized people" (Kellert 1996: 104). The European colonizers declared war on carnivores.

The history of grizzly bears in the GYE is typical for the species in the conterminous United States south of Canada. At the time of the Lewis and Clark expedition in 1805, grizzly bears inhabited most of the western United States and extended out into the Great Plains (Servheen 1999). Grizzly bears enjoyed a wide distribution (Rausch 1963; Martinka 1976; Servheen 1999; Schwartz et al. 2003a). With settlement and conquest of western North America, grizzlies were eliminated from 98% of historic range during a 100-year period (Mattson et al. 1995). Of 37 grizzly extent populations in 1922, 31 were extirpated by 1975 (Servheen 1999).

In 1959, when Craighead et al. (1995) began pioneering work on grizzly bears in YNP, the population had been reduced to a fraction of its former size and was relegated largely to the park and surrounding environs. The grizzly bear population in YNP represented one of the last remnants of a historically larger population.

In 1960, a National Park Service bear management program was implemented (National Park Service 1960) in an effort to reduce human injury and property damage. A major emphasis of the program was to reestablish bears in a natural state. According to Gunther (1994), the program included (1) expanded education, (2) prompt removal of garbage, (3) enforcement of no feeding regulations, (4) improvement of garbage containers, and (5) removal of problem bears.

By 1970, YNP initiated a new, more intensive bear management program (Leopold et al. 1969) aimed at eliminating human foods from the diets of bears. The goal was to have both black and grizzly bear populations subsist on natural foods. This dictated closure of garbage dumps within and adjacent to YNP. As a result of diminishing garbage, grizzly bear conflicts and subsequent removals amplified (McCullough this volume). During the period 1967 to 1972, 229 grizzly bears were removed from the GYE. This high grizzly bear mortality (National Academy of Sciences 1974) and uncertainty about population status prompted the USFWS to list the species as threatened south of Canada under the Endangered Species Act in 1975 (U.S. Fish and Wildlife Service 1982, 1993).

From 1973 through 1982 the park continued to manage bears under the 1970s program. Bear numbers continued to decline after listing both inside and outside YNP, and early research (Knight and Eberhardt 1984) suggested that the balance between a stable population and one in decline might be determined by the fate of as few as two adult females (Knight and Eberhardt 1987). Such estimates were premised on a 1980 estimate of about 30 adult females in the population (Knight and Eberhardt 1984). Adult female survival was identified as the most important vital rate influencing population trend (Eberhardt 1977). Knight and Eberhardt (1985) identified low adult female survival as the critical parameter causing a decline in the Yellowstone population prior to the mid-1980s, and strategies were implemented to improve female survival.

In 1983, YNP implemented a modified bear management program (National Park Service 1983). This plan was similar to the 1970s plan (Gunther 1994) but put more emphasis on habitat protection which led to the creation of Bear Management Areas (BMA). BMAs were designated areas closed to humans either seasonally or annually with the goal of minimizing displacement of bears from prime feeding areas and to reduce bear-human conflicts and human injuries. Approximately 21% of YNP was designated as part of 15 BMAs.

At the same time, agencies working with grizzly bear in the conterminous United States formed a working group called the Interagency Grizzly Bear Committee (IGBC). The IGBC also recognized the need for focused management and made recommendations aimed at curbing the continued population decline in the GYE. Their focus centered on management actions (Interagency Grizzly Bear Committee 1986; Knight et al. 1999; U.S. Fish and Wildlife Service 2002) to improve grizzly bear survival inside the designated grizzly bear RZ, especially on federal lands beyond the boundary of YNP. These included policy changes regarding removal versus relocation of problem bears, food storage and garbage disposal restrictions on all federal land within the RZ, elimination or transfer of sheep allotments on public lands outside YNP, and increased law enforcement activities (Interagency Grizzly Bear Committee 1986; Knight et al. 1999). Actions began in 1983 and were incorporated in the 1993 Grizzly Bear Recovery Plan (U.S. Fish and Wildlife Service 1993).

2. Impact of Yellowstone National Park's Bear Management Program on Grizzly Demographics

YNP led the way in the development of bear management policies in the GYE. These programs arguably had a positive and significant impact that reduced conflicts with humans, injuries to humans, and removals of incorrigible individuals (Gunther 1994). Both grizzly and black bear populations benefited in YNP. Histograms comparing property damage, human injury, and subsequent bear removals clearly show management programs were successful (Figures 2-5-2, 3, 4, 5). Property damage and human injuries declined dramatically over the decades (Figures 2-5-2, 3). Removal of problem bears peaked during the decade of the 1970s following dump closure, but has declined substantially since that time (Figures 2-5-4, 5).

It is difficult to determine which objectives in the bear management program were most effective and likely all were operating in concert. Clearly, efforts to manage garbage within YNP have worked. Annually, YNP spends in excess of $1 million (2004 estimate) to collect and haul garbage. Trash containers are designed to be bear-proof, user-friendly, and efficient to empty and maintain. Trash is collected daily to prevent accumulation and to reduce smells associated with spoilage. Closure of the dumps was very disruptive to food-conditioned bears, especially grizzlies. This was reflected in the spike in conflicts and removal of grizzly bears following dump closure. However, not all the grizzly bears in YNP were reliant on garbage and there was a component that utilized natural foods (Cole 1972, 1976).

The creation of BMAs to provided security for bears in prime foraging locations also worked. Although no formal analysis of the impact of the BMAs was published, an internal analysis by the Interagency Grizzly Bear Study Team suggests higher use of BMAs both seasonally and annually by radio-marked grizzly bears when compared to areas not within BMAs. Observations of females with cubs also suggest higher usage of BMAs by grizzly bears when compared to areas outside them. Certainly, closing areas to human use ended bear human conflicts, encounters, and potential human injuries in these areas.

3. Impact of the IGBC Bear Management Policies on Grizzly Demographics

YNP led the way in establishing bear management programs that helped improve bear survival and minimized human-bear conflicts and injuries within the confines of YNP. During the decade following listing, these policies likely affected the majority of the GYE grizzly bear population because most bears at that time lived within YNP (Basile 1982). However, YNP was insufficient in size to maintain a biologically viable population of grizzly bears in the GYE. Consequently, actions by the IGBC back in 1983 that were aimed at improving bear survival outside YNP in the grizzly bear RZ were also necessary.

A recent analysis of demographic trends in the GYE (Schwartz et al. 2005c) combining reproductive rates (Schwartz et al. 2005a), survival of dependent young (Schwartz et al. 2005b) and survival of adults (Haroldson et al. 2005) into estimates of lambda (Harris et al. 2005) confirm information from other studies (Eberhardt et al. 1994; Eberhardt 1995; Boyce et al. 2001) that the GYE bear population has grown at a rate of 4 to 7% per year since the early 1980s around the time that the IGBC implemented its management actions, and YNP modified its Park Management Plan. In the most recent analysis Schwartz et al. (2005c) evaluated both reproduction and survival in a spatial context. They created three residency zones and attributed the proportion of time a bear spent in each. These three zones were (1) inside YNP, (2) outside YNP but inside the RZ, and (3) outside the RZ.

Although spatial analysis does not prove cause and effect, results strongly supported the hypothesis that IGBC management efforts reduced mortality and improved the population's growth rate (Figure 2-5-6). Using conservative estimates of independent female survival rates, hypothetical populations living entirely in YNP or outside YNP but inside the RZ showed population growth as measured by lambda (λ) >1 where IGBC management actions were applied. However outside the RZ where they were not applied, λ was <1 (Harris et al. 2005; Schwartz et al. 2005d). Of the three zones studied, YNP has the strictest controls on human activities that directly or indirectly influenced bear survival. These restrictions included strict gun control, highly regulated front- and back-country camping, garbage management, no livestock grazing, and regulated access to vehicles and hikers. Within the RZ outside YNP, access management was less restrictive and hunting was permitted, but controls existed over anthropogenic foods (garbage management, back-country food storage) and nearly all sheep grazing had been eliminated. None of these restrictions apply outside the RZ.

These conclusions were further supported by the finding that changes in abundance of whitebark pine (*Pinus albicaulis*), one of the most important fall foods, had the least impact on bears living inside YNP. Blanchard and Knight (1991, 1995) and Mattson et al. (1992) concluded that during years of poor whitebark seed (WBP) production, bears made greater use of areas near humans and came into conflict more often with humans. As a result, bear-human conflicts and the number of management-trapped bears increased. The annual number of recorded grizzly bear deaths from 1976 to 1992 was strongly related to whitebark pine seed use (Mattson 1998). Recorded mortalities were 1.8 to 3.3 times greater during years when pine seeds were not intensively used. Nearly all bears in their analysis lived within the RZ. These early works did not incorporate a spatial component into analyses. Results of Schwartz et al. (2005d) support their findings, but indicate that the decline in λ during good versus poor WBP years was -0.018, for inside YNP, -0.022, outside YNP but inside the RZ, but -0.050 outside the RZ, respectively. Further studies by Harris et al. (2005) clearly demonstrated that survival of independent females contributed 73% of the elasticity associated with changes in λ. Reductions in survival of independent females (Haroldson et al. 2005) from good (WBP = 29) to bad (WBP = 0) cone crops were 2.0, 2.5, and 6.3% when residency was set to inside YNP, outside YNP but inside the RZ, and outside the RZ, respectively.

Ecosystem-wide, survival of independent female grizzly bears has increased since 1983 (Haroldson et al. 2005) (Figure 2-5-7). This improved survival coupled with an increasing population size resulted in grizzly bears expanding their range over the past two decades (Basile 1982; Blanchard et al. 1992; Schwartz et al. 2002) (Figure 2-5-8). Comparisons of occupied habitats (Schwartz et al. 2002) indicate a 48% expansion in range from the 1970s through the 1990s. Expansion of occupied habitats has nearly doubled at approximately 20-year intervals in the southern portion of the ecosystem (Pyare et al. 2004).

Finally an assessment of bear-human conflicts in the GYE by Gunther et al. (2004) showed that from 1992 to 2000, of 995 grizzly bear-human conflicts reported, 53% occurred outside the RZ. During this period, approximately 34% of the known bear distribution was outside the RZ (Schwartz et al. 2002). A more recent analysis (Schwartz et al. 2006) however suggests that although >30% of the known distribution of grizzlies is outside the RZ, bear density in this area is low, constituting <10 to 14% of the total population. This pattern of high conflicts, occurring in an area where only a small proportion of the bears reside, is reflective of a source-sink dynamic in the GYE.

4. A Source-Sink Dynamic

Changes in survival and reproduction among the three defined zones of residency were principally influenced by three factors: humans killing bears, changes in food abundance, and density-dependent factors affecting reproduction and survival of dependent young. Humans were responsible for >85% of documented mortalities of adult bears (Haroldson et al. 2005) and about one third of recorded deaths of cubs and yearlings (Schwartz et al. 2005b). These results demonstrate that humans are the single greatest cause of grizzly bear deaths in the GYE. Efforts to minimize conflicts between people and bears represent a major component of any management program directed at the long-term conservation of the GYE grizzlies. Actions taken inside YNP through the IGBC in the RZ have clearly improved bear survival and population health in YNP and the RZ. Without such efforts, the proportion of problem bears in the GYE would, no doubt, have been greater.

Source-sink theory was formalized by Pulliam (1988), although the concept was introduced by Levene (1953). A source population is one in which births exceed deaths and emigration exceeds immigration. In sink populations, deaths exceed births and immigration exceeds emigration (Pulliam 1988). Experimental (Gates and Gysel 1978; Gundersen et al. 2001) and simulation (Pulliam 1996) studies of source-sink dynamics have primarily focused on plants, birds, or small mammals where individuals reside year round either in a source or a sink habitat, but not both. Most simulations addressing larger mammals assume individuals move from one state to another as a result of emigration and immigration, so that individuals reside exclusively in source or sink habitats. The assumption that individuals reside exclusively in either source or sink habitats is unrealistic for animals with large home ranges living in spatially and temporally heterogeneous environments. Grizzly bears, for example, may include both source and sink habitats within their annual or life range (Knight et al. 1988). Bears are attracted to sinks in a maladaptive way because of the presence of anthropogenic foods.

The GYE is effectively an island with one bear population. Models presented by Schwartz et al. (2005d) suggest that survival for grizzly bears beyond the RZ is low, with most mortality on or near private lands: for bears outside the RZ, $\lambda = 0.878$; elsewhere within the GYE $\lambda > 1$. This source-sink pattern is expected and consistent with findings on extinction rates and reserve sizes for large carnivores (Woodroffe and Ginsberg 1998). Areas outside reserves are population sinks because large carnivores are often limited by humans killing them, and most deaths occur beyond reserve boundaries. High mortality is expected when large carnivores expand beyond boundaries of protected habitat or where the reserve is small relative to an individual's home range. Where reserves are large relative to home ranges, many individuals can live entirely within the protected area and are buffered from human killing. When reserves are small relative to home ranges, animals cannot live entirely within the reserve boundary and must use habitats that are less secure outside of reserves, which can result in reduction or even extinction of the population. This is particularly true where human killing represents the greatest threat to demographic stability. When this occurs, the survival of individuals, and ultimately of the population, is determined by the ratio of secure to nonsecure habitat within individual home ranges, the relative amount of time individuals spend in each, and their cumulative effect on survival. The critical element of this dynamic is to ensure that, on average, recruitment equals or exceeds mortality for the population as a whole, recognizing that high human-caused mortality beyond suitable and secure habitats is expected and may exceed recruitment in some years. Maintaining a balance between recruitment and mortality is the crux of large carnivore conservation generally (Woodroffe and Ginsberg 1998) and grizzly bear management in the GYE specifically.

To ensure a self-sustaining population, reserves must be of adequate shape and size, and fecundity must be high enough so that recruitment equals or exceeds mortality, including mortality beyond the protected area (Woodroffe and Ginsberg 1998). Conservation and management then become a balancing act directed at minimizing, or at least managing, mortality for the population, recognizing that the majority of deaths for independent-aged bears will occur at the interface between bear habitat and humans. This dynamic has significant ramifications for future management of the GYE grizzly bears. How humans choose to live and behave at the interface between developed areas and secure grizzly bear habitat will determine the extent to which bears expand beyond the existing RZ. Actions taken by YNP and the IGBC in the early 1980s seemingly improved grizzly bear survival inside the RZ. As bears expand beyond this zone (Schwartz et al. 2002), and as the states of Wyoming, Idaho, and Montana identify additional lands deemed socially acceptable and biologically suitable for grizzly bear occupancy (USFWS 2002), measures must be taken to ensure that mortality, particularly that associated with sink habitat, does not result in a population decline in source habitat.

Because over 98% of lands are publicly owned within the RZ (U.S. Fish and Wildlife Service 2002), IGBC management actions implemented in the 1980s affected virtually all available grizzly bear habitats within the RZ. However, management of attractants on private lands is a continuing problem. Within the RZ, 20% (26 of 127) of all known and probable human-caused grizzly bear deaths during 1983 to 2002 occurred on private land (IGBST, unpublished data). In contrast, outside the RZ, 62% (28 of 45) occurred on private lands. Private land outside the RZ constitutes 23% of the total current grizzly bear distribution. Managing human-caused mortality on private lands will be more difficult than on public lands. If the public can learn to live compatibly with bears and to minimize food conditioning and resulting bear–human conflict, then losses of bears on private land can be accommodated by bear production within secure habitats. However, human behavior along the edge must be continuously managed to prevent excessive bear mortality if continued expansion of bears into suitable habitats outside the RZ is to occur. Management agencies, therefore, must focus their activities toward improving human coexistence with and acceptance of grizzly bears at this interface. How agencies respond to bear–human conflicts will affect population health and will determine how far bears expand their range outside the RZ. Agencies must focus not only on removing problem bears but also on developing and implementing ways to manage bear–human conflicts. And although "it's easier to destroy a bear than to manage sources of bear–human conflict" (Eberhardt and Knight 1996: 420), both are necessary to maintain public acceptance of grizzlies and ensure long-term persistence of the species. Consequently, actions and impacts of private land development and agency responsiveness in and adjacent to grizzly bear habitats to address bear–human conflicts on private lands will, to a large degree, determine continuing success of the recovery process.

Development pressure in the GYE will almost certainly increase (Clark et al. 1999; Hansen et al. 2002), and some private lands currently dedicated to ranching and agriculture will be converted to rural residential development (Hernandez 2004). New development will increase sources of human foods and attractants that will potentially amplify grizzly bear–human conflicts and, ultimately, bear mortality. Additionally, many people moving into these new developments are immigrants from other regions of the United States (Riebsame et al. 1997) who often lack the knowledge and skills necessary to live compatibly with grizzly bears, making continuous outreach efforts even more necessary.

Human acceptance of grizzly bears will strongly influence their long-term persistence. Although we lack a nationwide study addressing human attitudes toward grizzly bears in the GYE, Wyoming Game and Fish contracted a public attitude survey toward grizzly bear management in Wyoming (Kruckenberg 2001). Results showed that a large majority (74%) of Wyoming residents feel that grizzly bears benefit Wyoming and are an important component of the ecosystem that they occupy. Opinions on efforts to increase bear numbers in Wyoming were about equally divided between those who favored (42%) and opposed (39%) such efforts. Those in favor felt grizzly bears hold an important place in the ecosystem (40%) and should be protected from extinction (31%). Those opposed felt grizzly bears were dangerous to humans (36%) and livestock (18%). Support for efforts to increase bear numbers improved from 42 to 61% when coupled with the idea that wildlife managers would be stationed locally to track bears, inform and educate people, and resolve conflicts.

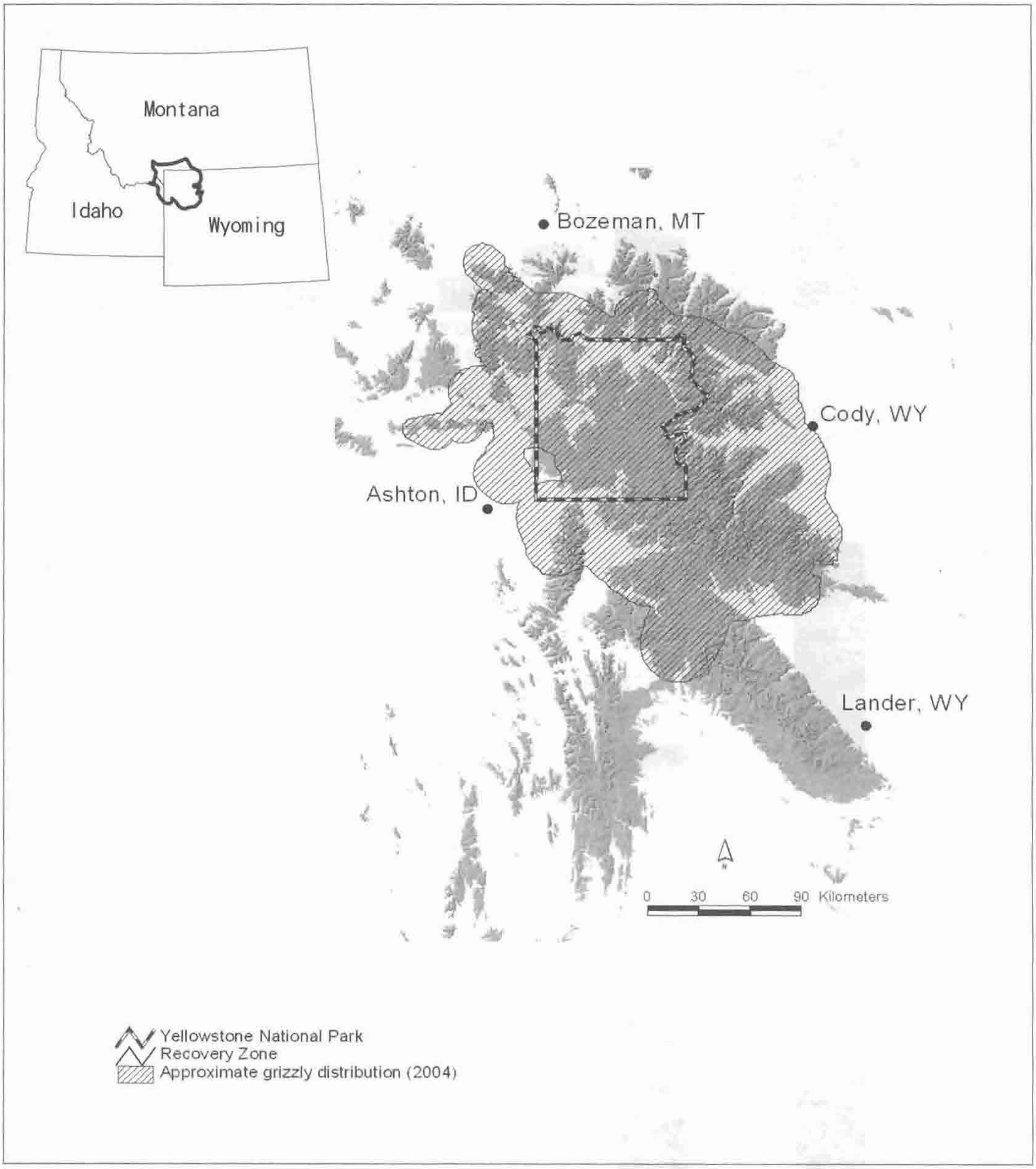


図 2-5-1 広域イエローストーン生態系とアメリカ魚類・野生生物局のグリズリー回復区域は、モンタナ州、アイダホ州、ワイオミング州にまたがっている。右側の詳細図はイエローストーン国立公園の輪郭、2004年現在のグリズリー分布概略(Schwartz et al., 2006)、そして広域イエローストーン生態系での高標高域（2,350 m 以上）を表す。

Figure 2-5-1 The Greater Yellowstone Ecosystem and the U.S. Fish and Wildlife Service Grizzly Bear Recovery Zone occur in the states of Montana, Idaho, and Wyoming. The detail on the right shows outline of Yellowstone National Park, the approximate distribution of the grizzly bear as of 2004 (Schwartz et al. 2006), and the higher elevation terrain (≥ 2,350 m) in the GYE.

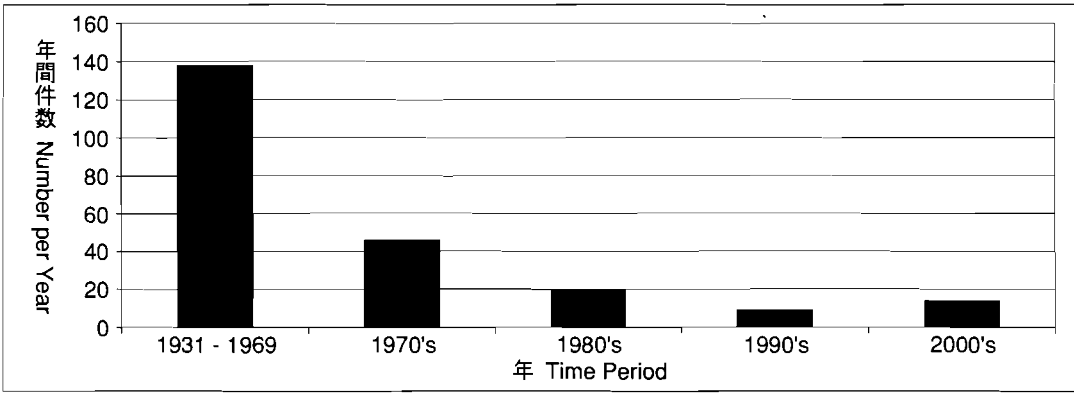


図2-5-2　イエローストーン国立公園におけるクマによる器物損壊（1931～2004）（Gunther, 1994を今回更新）
Figure 2-5-2 Bear-caused property damages in Yellowstone National Park, 1931–2004. Original data presented by Gunther (1994) and updated here.

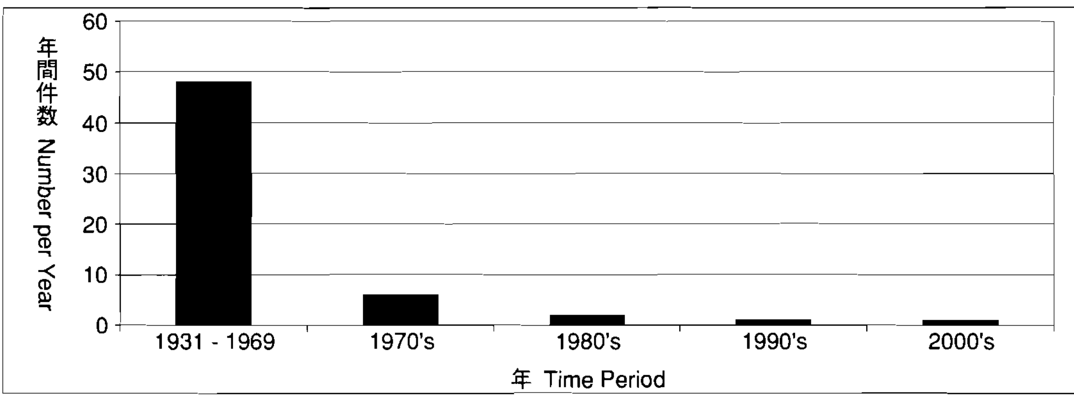


図2-5-3　イエローストーン国立公園におけるクマによる人身事故（1931～2004）（Gunther, 1994を今回更新）
Figure 2-5-3 Bear inflicted human injuries in Yellowstone National Park, 1931–2004. Original data presented by Gunther (1994) and updated here.

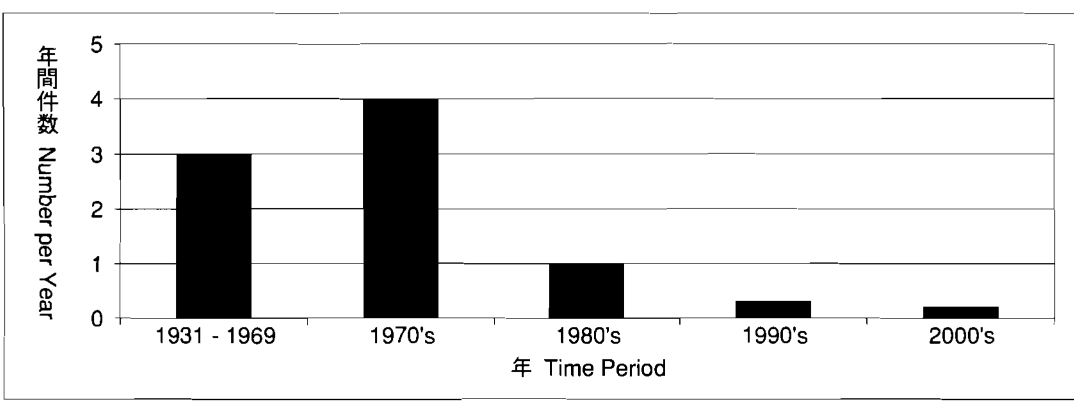


図2-5-4　イエローストーン国立公園内におけるグリズリー駆除数（1931～2004）（Gunther, 1994を今回更新）
Figure 2-5-4 Grizzly bear removals within Yellowstone National Park, 1931–2004. Original data presented by Gunther (1994) and updated here.

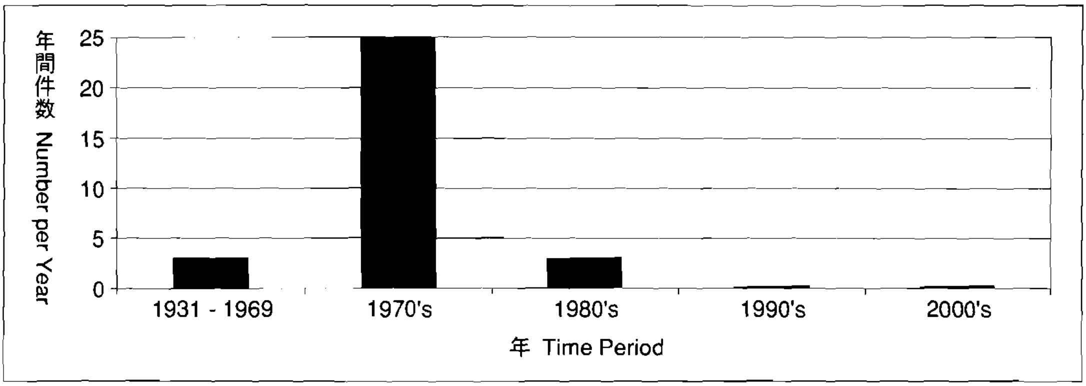


図 2-5-5 イエローストーン国立公園内におけるアメリカクロクマの駆除数（1931～2004）（Gunther, 1994 を今回更新）
Figure 2-5-5 Black bear removals within Yellowstone National Park, 1931–2004. Original data presented by Gunther (1994) and updated here.

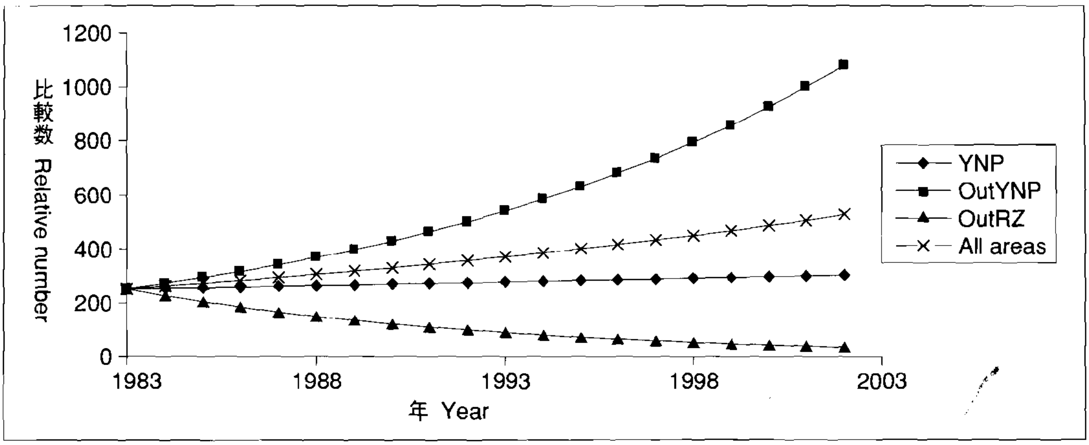


図 2-5-6 広域イエローストーン生態系の 3 区域における個体数変化の論理的試算。区域はお互いに排他的で (1) イエローストーン国立公園 (YNP) 内、(2) イエローストーン国立公園外だがグリズリー回復区域内である部分 (OutYNP)、そして (3) グリズリー回復区域外 (Out RZ)、そして全区域の推定された平均成長率 (Schwartz et al., 2005d より)。
Figure 2-5-6 Theoretical estimates of population change in 3 residency zones in the Greater Yellowstone Ecosystem. Zones are mutually exclusive and include lands (1) inside Yellowstone National Park (YNP), (2) lands outside YNP but within the U.S. Fish and Wildlife Service Grizzly Bear Recovery Zone (OutYNP), and (3) lands outside the Recovery Zone (Out RZ). The average estimated growth rate is also presented (All areas). Data are from Schwartz et al. (2005d).

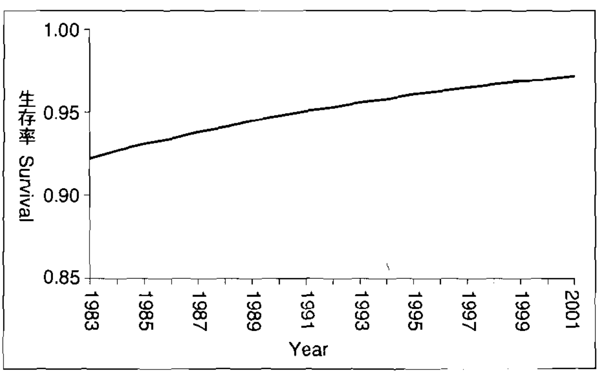
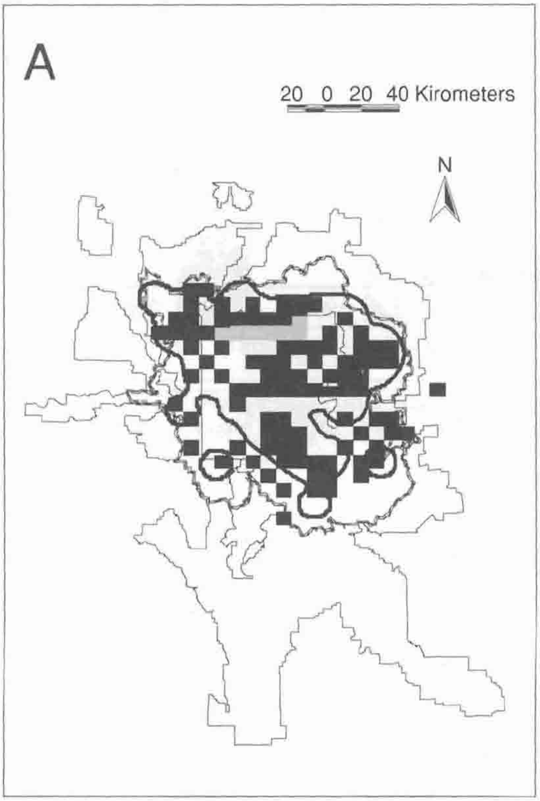
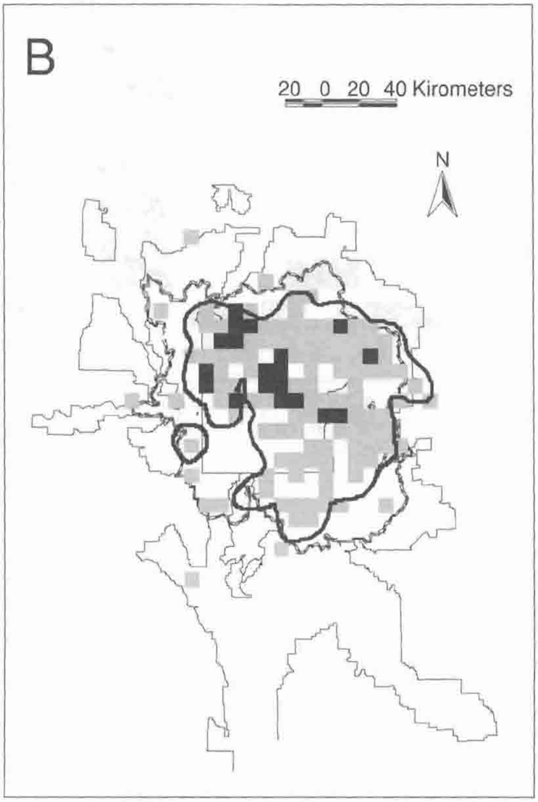


図 2-5-7 グリズリーのメス成獣の平均生存率の変化（1983～2001）（データは Haroldson et al. (2005, 表 14 posterior model 2) より、ベータ係数は同文献表 16 提供を使用）
Figure 2-5-7 Changes in mean survival rates of independent female grizzly bears from 1983–2001. Data are from Haroldson et al. (2005, Table 14, posterior model 2) using beta coefficients provided in Haroldson et al. (2005, Table 16).





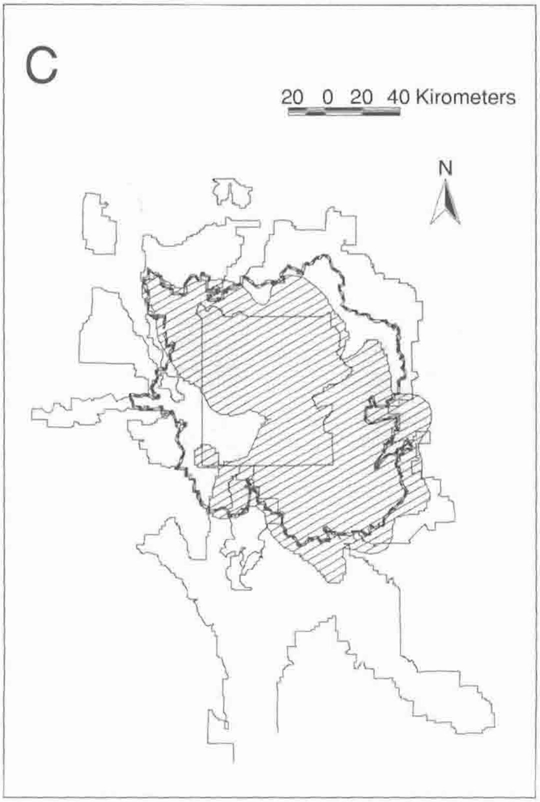


図 2-5-8　1970 年代からの広域イエローストーン生態系でのグリズリー分布の変化（1970 年代（A）、1980 年代（B）、1990 年年代（C））（Schwartz et al., 2002 より）

Figure 2-5-8 Change in distribution of grizzly bears in the Greater Yellowstone Ecosystem from the decade of the 1970 s (A) to the 1980 s (B), and1990s (C). Original data from Schwartz et al. (2002).