RELATIONSHIPS BETWEEN HUMAN INDUSTRIAL ACTIVITY AND GRIZZLY BEARS[1]

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Abstract: Most grizzly bears (*Ursus arctos*) live outside parks and reserves and often have to contend with, among other things, resource extraction industries. These activities can affect individual bears and therefore populations by: 1) causing strong, energetically expensive reactions by bears that disrupt their normal behaviour, 2) displacing bears from areas of human use, 3) altering habitats in which bears live, 4) disrupting the bears' social system, and 5) industrial personnel killing bears or increasing mortality rates indirectly by improving access for hunters, poachers, other resource users, and settlers. Grizzly bears are able to adapt to many habitat changes and a temporary increase of human presence. In most cases, increased motorized access that results in a long term increase of human activity and/or settlement with consequent increase in bears being shot is the most significant aspect of industrial developments. If an industrial activity is conducted with adequate guidelines to maintain important habitats, properly locate camps, incinerate garbage, restrict use of firearms, and close motorized access after the job is complete, the bear population probably will be maintained at a satisfactory level. Although many bears may be alive when an industry has completed its work, if access remains intact, the grizzly population is placed in a precarious position and may decrease in size and eventually be extirpated. Closing access after job completion is often physically and politically difficult. Industry personnel and government managers must take leading roles in planning, advertising, and implementing road closures.

Cumulative effects models have been built to predict the impact of human activities on bear populations. These models are in early stages and require data to support the coefficients used and the relationships between coefficients. Then they should be tested. One significant variable the models lack is the potential for a specific activity to be the seed for blooming additional and perhaps more harmful developments.

Int. Conf. Bear Res. and Manage. 8:57–64

To maintain our accustomed standard of living, North Americans require products that use vast quantities of natural resources such as timber, minerals, hydrocarbons, water, range, and soil. As increasing densities of human settlement radiated across the continent and gradually northward during the last century, most ecosystems were greatly altered by people using these resources. To maintain some areas in a relatively pristine condition, parks and reserves were established and within these, industrial activities and human settlement were strictly regulated or disallowed. Today, most of the continent has been severely altered by various resource extraction activities and large tracts of relatively undisturbed places are limited to parks and mountainous portions of the west and the north.

Most individuals of each North American bear species – black (*Ursus americanus*), grizzly/brown (*Ursus arctos*), and polar (*Ursus maritimus*) – do not live in parks or reserves and many co-exist with various human activities. Because the spread of industrial development and human settlement continues into remaining remote areas, other bears will be forced to deal with increasing numbers of people.

The rise of human numbers on the continent has not affected all bear species to the same extent. Black bears have undoubtedly been influenced by urbanization, expanses of vegetative mono-cultures, and local overharvest (Manville 1983) but they have survived the spread of humanity relatively well; in some locations they may have benefited, at least over the short term (Manville 1983, Lindzey et al. 1986, Young and Beecham 1986, Garner and Vaughan 1987).

Polar bears are confined to portions of the continent that are inhospitable to most people and, as a consequence, the increasing human population has so far had a minimal effect on their distribution. With increasing interest in oil and minerals in the north, polar bears are now facing more temporary human residences.

Of the North American bear species, the numbers and distribution of grizzlies have suffered most from the expanding human population; they currently occupy less than half their historic range and their status is tenuous south of Canada (Martinka and Kendall 1986) where these bears are classified as threatened. The grizzly bear remains vulnerable to many threats, the greatest of which are human-caused mortality and habitat modification or loss by logging, geothermal, mineral and hydrocarbon developments, water impoundments, and livestock grazing (LeFranc et al. 1987).

The most secure situation for grizzly bears is a large tract of land set aside as wilderness or where wilderness has been regained by reducing human use. This management option, however, is rare and we will be forced to manage bears and people together over most of the remaining grizzly bear range. Because grizzly bear movements are extensive, to prevent further fragmentation of their range, bears and their habitat must be managed on a landscape scale often exceeding thousands of square kilometres (Schoen 1990). How the land between reserves is managed will be most important in determining the distribution and perhaps continued existence of grizzlies over the long term. Given the history of grizzly-human co-existence, this will be a difficult challenge.

[1] Invited paper

People can affect bear populations in 5 general ways: 1) we can stimulate strong, energetically expensive reactions by bears that disrupt their normal behaviour, 2) bears can be displaced from areas of human use, resulting in the loss of habitats available, 3) people can alter the dynamics of plant and animal communities, or habitats, that bears live and depend on, 4) man can disrupt bears' social systems by forcing more bears into limited seasonal habitats perhaps causing increased intraspecific conflict, mortality and dispersal, and 5) man can cause direct mortality by legal harvest, poaching, legal and illegal nuisance bear killing or bear removal, self-defense, and research and management accidents. These 5 categories of potential impacts are often interrelated. Cumulative effects models have been built to estimate the total effects of a human activity by summing some of these potential impacts.

In this paper I review the relationship between grizzly bears and human resource extraction industries by investigating the 5 main ways industries can affect grizzly bear behaviour and population trends. Some of the ideas and concepts presented are supported by very limited empirical data and should be considered only as hypotheses. They have been presented to stimulate discussion and direct future research. Solutions to the most significant problems are proposed.

I thank F. Bunnell and R. Archibald for suggesting the topic and inviting me to present this review. A. Hamilton, J. Nagy, and D. Shackleton reviewed an early draft and made helpful suggestions. I would like to acknowledge R. Demarchi for permitting the use of his access maps and his continued support. Financial support for this review came from the National Fish and Wildlife Foundation, Shell Canada, B.C. Southern Guides and Outfitters, and the East Kootenay Fish and Wildlife Association.

IMMEDIATE REACTIONS

How a bear reacts to people will depend on many variables, including the type of human activity, where the interaction occurs, the distance between person and bear, the amount of cover, the individual bear's past experiences, inherited tolerance, and age/sex class. Grizzly bears are capable of at least partially habituating to human activities (K.L. Jope pers. commun.) provided the activities are frequent enough and innocuous. In portions of Glacier National Park where hiking is popular, some grizzlies have habituated to people on foot (Jope 1985) whereas in the adjacent Flathead drainage where hikers are rare and almost all carry guns (hunters), bears show stronger reactions to people on foot than to any other form of human activity (McLellan and Shackleton 1989*a*). In the Flathead, however, some bears have at least partially habituated to vehicles but not to the degree that bears in Denali National Park have (Tracy 1977, Singer and Beatte 1986).

Similarly, radio-collared bears that were not immobilized from a helicopter but were frequently relocated from low flying aircraft can become accustomed to aircraft and may not even look up as they are circled (Blanchard 1983, McLellan and Shackleton 1989*a*). Due to habituation, we should expect to find bears' strongest reactions to most innocuous activities at the onset of an industrial development and their reactions to decrease with time. We should also expect bears to react less to the most common, innocuous human behaviours.

Individual bears may show different responses to the same stimuli occurring in different locations. People hiking or driving where they often do will elicit milder reactions in bears than the same activity where it rarely occurs (Tracy 1977, Jope 1985, McLellan and Shackleton 1989*a*). The extraction phases of industries such as oil and gas, timber, and mining that result in people behaving predictably may result in fewer extreme reactions of bears than the more extensive and unpredictable seismic, mineral exploration or even timber cruising phases of development.

Cover also affects a bear's reaction to people. In the Flathead, bears in timber were never known to flee from vehicles but a bear in the open almost always ran away from the vehicle to the closest timber (McLellan and Shackleton 1989*a*). In Denali Park, which is generally more open than southern Rocky Mountain areas, reaction to vehicles that stopped was stronger when the bears were partially screened by vegetation than when they were in the open. It was suggested that reduced security was because bears could not see clearly what the people were doing (Singer and Beatte 1986). The ability of cover to reduce bear responses to people is the basis for many fundamental habitat management prescriptions (Blanchard 1983, Zager et al. 1983, Young and Beecham 1986).

In the Flathead, independent yearlings and some subadult grizzlies reacted less to people and vehicles than other age classes, however, little information was available for adult males because they were rarely located or observed near a road (McLellan and Shackleton 1988). In other areas, the age/sex class of the bear was not an important variable in predicting a reaction to humans (Tracy 1977) except for certain cases in Glacier National Park where females with young were more apt to charge at hikers (Jope 1985).

If conditions are right, bears show very strong re-

sponses to people. On several occasions I have observed a grizzly bear run up more than 700 m vertically in less than 15 minutes and continue running until it was out of view. Fortunately, such reactions occur only when extreme cases of each variable that influences bears' reactions happen at once. In the Flathead drainage, I have only observed extreme reactions when the grizzly encountered a person on foot in a sparsely timbered area where people rarely go. Important questions include how frequently are individual bears startled into strong responses and what effect does this have on its survival and reproduction.

The frequency of strong reactions by bears to people depends on the history and characteristics of the area plus the amount and unpredictability of the human activities. Excluding intentional harassment, highest frequencies of extreme reactions would be expected where there is little cover, the bears have only experienced negatively reinforced conditioning (hunting), human numbers rapidly increase, and people are conducting unpredictable activities. These conditions are likely more prevalent in northern, sparsely timbered locations than in southern ranges.

I am unaware of data describing how frequently bears respond to people in a location ideal for generating strong reactions. In the Flathead, however, I monitored movements and reactions of radio-collared grizzly bears before, during, and after an intensive helicopter-supported seismic program that was conducted over 3 years directly across a sparsely timbered area where bears concentrate to feed on huckleberries (*Vaccinium globulare*). Besides the helicopter pilot intentionally chasing 1 unmarked grizzly from where a crew was working, there were no strong reactions noticed or reported (McLellan and Shackleton 1989*b*).

This study missed being ideal for estimating maximum frequencies of strong reactions by bears due to industrial activity because there was some timber to provide cover and the radio-collared bears had been relocated from fixed-wing aircraft before and were likely habituated. Strong reactions may be more common elsewhere. Although I cannot estimate how often the most frequently harassed bears are forced into an extreme reaction, it likely rarely occurs due to habituation, cover, and because most human activities are predictable.

In most cases, strong responses by grizzly bears to human activities likely have minimal effects on the bear's probability of surviving and reproducing. The bears in the Flathead that had seismic work conducted across their range for 3 summers all lived and were very productive (McLellan and Shackleton 1989*b*). I have been told of grizzly bears being chased for over an hour by helicopter before being darted, immobilized and handled, greatly exceeding any reaction due to industry, and still there was no indication of increased mortality or impaired reproduction. Similarly, Ramsay and Stirling (1986) concluded that the effects of helicopter capture and handling of polar bears which, when compared to most industrial activity is extreme harassment, were acceptably small.

DISPLACEMENT

Human activities rarely cause extreme reactions by bears because people are usually predictable. Bears simply avoid locations where human activities are common, such as roads and active industrial sites, by enough distance that they won't be disturbed by a passing vehicle or an additional machine starting up (Tracy 1977, Harding and Nagy 1980, Aune et al. 1984, Archibald et al. 1987, Mattson et al. 1987, McLellan and Shackleton 1988 and 1989*b*). The distance that bears are displaced from a human activity is likely dependent on some of the same variables that influence a bear's immediate reaction to people (see above).

A bear's past experience with humans is important because habituation and conditioning affect the bear's sense of security, particularly with predictable events such as vehicles on roads or industrial sites. Due to habituation, the displacement of bears from an innocuous activity such as vehicles decreases with the duration of the activity (Singer and Beatte 1986). Habituation may also reduce the effect of intensity, such as the number of vehicles. We would expect that many vehicles would be more disturbing and result in greater displacement than fewer; however, frequently passing vehicles may also increase the rate and degree of habituation.

Because bears in open habitats almost always fled from vehicles except when in cover, it appears that cover reduces the amount of displacement (McLellan and Shackleton 1989*a*). Similarly, grizzly bears used areas near roads (McLellan and Shackleton 1988) and campgrounds (Nadeau 1987) more often at night than day, perhaps using darkness as cover.

The relative quality of habitats near and far from human activity areas and how limiting these habitats are may also be important in influencing displacement. In an area where the bear population is below carrying capacity or during a season of plentiful foods, I expect most bears to be far from high human use areas even if people are only a minor disturbance because there would be no benefit to the bear by approaching closer. If, however, the bear population is at carrying capacity creating competition for limited seasonal resources, there would be a

benefit of moving closer to areas of high human use, and I would expect less displacement. When the best foraging sites are close to human activity centres, such as garbage dumps and even seeded roadsides, many bears are not displaced but attracted.

Pearson (1975) and Russell et al. (1979) found female grizzly bears with young segregated from adult males by elevation. In other study areas, age-sex classes may segregate by distance from human use areas. In both Yellowstone National Park and the Flathead, adult males used areas far from roads most often whereas adult females with cubs and some younger bears used areas near roads and developments more frequently (Mattson et al. 1987, McLellan and Shackleton 1988).

Because numerous variables influence displacement, I expect variation among study areas. By monitoring radio-collared bears before and during intensive mineral exploration, Simpson et al. (1985) did not detect displacement by nonhabituated grizzly bears. Similarly, McLellan and Shackleton (1989*b*) found little displacement by grizzly bears from active logging, road maintenance, or seismic exploration. Archibald et al. (1987) determined that 2 radio-collared bears were displaced from habitat within 150 m of a logging road when log hauling was in progress, but they were not displaced when hauling ceased. The amount that these bears were displaced has since decreased due to habituation (A. Hamilton pers. commun.). Schoen and Beier (1988) reported that all 11 radio-collared bears being monitored remained in the vicinity of intensive road building adjacent to a salmon spawning stream. These bears moved away from the construction when people were active but returned during the evening. Mace and Jonkel (1980) suggested that 4 radio-collared grizzly bears were not relocated in a drainage that was within their home ranges because of the logging that was occurring there.

Reductions in expected grizzly bear daytime use of areas within 250 m of roads in the Flathead and up to 500 m in Yellowstone Park have been reported (McLellan and Shackleton 1988, Mattson et al. 1987). A 0.7 km/km^2 road density in the core Flathead study area resulted in a daytime habitat loss equivalence of 8.7%. Daytime habitat use in Yellowstone Park was 15.7% less than would be expected without roads and developments. In the Kimsquit drainage, log hauling alienated an average of 7% of the 2 female grizzly bears' seasonal home ranges for 14 hours a day (Archibald et al. 1987). Because bears cannot use all areas at the same time, shifting their use towards roads at night and disproportionate use by subordinate and more security-conscious individuals would reduce the habitat loss equivalence. In areas where human use is predictable, displacement of grizzly bears from industrial activities and roads is apparently a more significant impact than bears' immediate reactions to humans.

ALTERED HABITATS

Most resource industries, timber harvest in particular, alter the populations of plants and animals plus physical characteristics that together make bear habitat. Through plant succession, further habitat change occurs for many years. Industrial habitat alterations may harm or benefit bear populations during various periods of succession (Lindzey et al. 1986, Brody and Stone 1987).

Of the variables influencing the effect of habitat alterations, the quantity, quality and duration of bear foods produced in modified habitats are most important. Removing trees that produce important foods such as white-bark pine (*Pinus albicaulis*) will likely have a negative impact on bears. Removing other species of trees could cause an increase in density and berry production of understory shrubs (Martin 1983, Zager et al. 1983, Bratkovich 1986), spring foods such as grasses and horsetails (*Equisetum* spp.) (Zager et al. 1983, Young and Beecham 1986, Bratkovich 1986, Simpson 1987), or ungulates (Thomas et al. 1979) for varying lengths of time.

To be of added value to the bear population, the coverage of bear food on the site must not only increase from what it was, but must increase to where it is used by bears. If the bears are below carrying capacity due to heavy hunting pressure, bear foraging opportunities in the altered habitat may have to be among the best in the bears' home ranges before being used. If the bear population is at or near carrying capacity, subadults or security-conscious females with cubs may use less productive sites (Pearson 1975, Russell et al. 1979, McLellan and Shackleton 1988) and the altered habitats may not have to be the most productive to be used. Timber harvest used as a habitat enhancement tool is potentially valuable only if it produces a bear food that is of limited supply elsewhere in the bears' ranges.

Because crown closure of second-growth conifer stands may reduce food production for most of the timber rotation, the period that foods are produced in an altered area is important to the long term effect of habitat changes. It is possible that, in some areas, a long term forest management plan could ensure a varied forest age structure with at least some sites producing bear foods at any one time.

The abundance and proximity of security cover is also an important variable influencing the effect of habitat

alterations on bear populations. Given equal foraging opportunities in cover and in the open, I expect bears will feed in cover. The distance from cover that bears will go to forage is likely an interaction between how much better the foraging opportunities are in the open than in cover and the amount of human activity in the area.

Thermal cover may also be important in very hot periods and perhaps where rainfall is very heavy (A. Hamilton pers. commun.). During seasons or time of day when weather conditions are extreme, bears may shorten their foraging bouts in open habitats, which would limit how far they go from cover.

The general lack of documented use of clear-cuts by bears (Zager et al. 1983, Young and Beecham 1986, Schoen and Beier 1988, McLellan 1989) even though bear food production often increases after logging (Martin 1983, Zager et al. 1983, Bratkovich 1986) is likely because: 1) the clear-cuts still did not become better foraging sites than other habitats available to bears, 2) there are usually open roads entering clear-cuts, and 3) these bear populations may be below carrying capacity due to historically heavy hunting and security-conscious individuals are not displaced into suboptimal foraging areas.

Because grizzly bears are found in very diverse ecological zones, making general conclusions or recommendations regarding the quantity and quality of bear foods produced and the duration of production in altered habitats is not only difficult but perhaps dangerous. For example, based on research in the Flathead drainage in Montana, Zager and Jonkel (1983) recommended minimal scarification after logging to reduce impact on shrub rhizomes. Less than 100 km north of their study area, most grizzly bear feeding in cutting units is for *Hedysarum sulphurescens*, which grows abundantly in scarified units (McLellan, unpubl. data). Recommendations should be based on ecological knowledge for specific habitat types and preferably specific sites. Often however, detailed ecological knowledge is unavailable.

Currently, input from biologists on forest plans in bear habitat is often directed at ungulate or fisheries management. Reducing cutting unit size, creating irregular edges, leaving cover between cutting units and roads, and protecting snowchutes for cervids and riparian habitats for cervids and fish have greatly reduced the impact of timber harvest on bear habitat.

Some industries, such as hydroelectric power, can be extensive, eliminate important riparian habitats, and change bear movements (Miller 1987, Simpson 1987). Open pit mines and tailings also destroy bear habitat although not as extensively as reservoirs. Other industries, such as logging, may have significant impacts in some ecosystems if conducted without guidelines.

SOCIAL DISRUPTION

Bears that are displaced from human activities, large cutting units, or hydro reservoirs leave familiar places to move to less known locations. If the population is below carrying capacity, there may be vacant habitat that displaced bears can learn to exploit efficiently. If bear numbers are near carrying capacity, bears will be "packed" into remaining habitats in unnaturally high numbers. Although bear social behaviour has the plasticity to adapt gradually to bear concentrations at very productive food sources such as garbage dumps and salmon streams, it is unlikely to have the same stability elsewhere.

I am unaware of data reflecting increases in intraspecific wounding, deaths, and cannibalism due to forced concentrations of displaced bears. However, if bears become concentrated, an increased encounter rate among individuals would be expected. These interactions would not only be more common, but also be often among unrelated and unfamiliar bears and, consequently, aggression should be more common.

DIRECT MORTALITY AND ACCESS

Within the last century, bears, and particularly grizzlies, were intentionally eradicated from much of their historic range by the ranching industry, leaving large tracts of suitable but vacant grizzly bear habitat (Brown 1985). But one does not have to read history books to hear of bears being killed by resource industry personnel. I have heard numerous stories of bears, often many bears, being attracted to camps by poor management of food and garbage and subsequently shot. Employee attitudes and company policies have only recently begun to change; garbage incinerators and rules limiting firearms in camps are now common. Some small, marginally viable operations, however, cannot afford proper garbage management and remain mortality sinks.

Mortalities directly caused by industry are now relatively low. Of 66 known or suspected deaths of marked grizzly bears in 6 study areas in British Columbia, Alberta, Montana, and Idaho where resource industry occurs, none have been directly due to resource extraction industries, except ranching (Table 1). Cattle are grazed in only 1 of these study areas and there the most common cause of grizzly mortality after legal harvest was control killing due to livestock depredation (24%; Aune and Brannon 1987).

Most resource extraction operations depend on a net-

Table 1. Marked bears killed by various causes in Montana, British Columbia, and Alberta study areas with industrial resource activities.

Study	Industries[a]	Number marked	Years record	Mortality factors							
				Hunt	Illegal	Livestock depred.	Industry	Problem	Natural	Research	Total
McLellan (1989)	TO	65	8	6	7	0	0	0	1	1	15
Simpson (pers. commun.)	TH	13	5	2	2	0	0	0	2	0	6
Hamilton (pers. commun.)	T	21	6	2[b]	0	0	0	1	2	1	6
Aune & Brannon 1987	OL	40	11	7	4	4	0	0	1	1	17
Nagy et al. 1988	TO	38	5	11	0	0	0	0	2	5	18
Knick and Kasworm 1989	TM	19	5	0[b]	4	0	0	0	0	0	4
Total		196	40	28	17	4	0	1	8	8	66
% of total				42	26	6	0	2	12	12	100

[a] T = timber; O = oil and gas; H = Hydroelectric; L = Livestock; M = Mining
[b] Hunting was closed in this study area

work of roads for exploration and moving products to market. Once roads are built, improved access may make other industries economically viable, settlement more practical, and recreation more available, thus increasing human density (Fig. 1). The amount and predictable pattern of vehicular use by industrial personnel and others may reduce displacement and strong reactions by bears due to habituation, but this makes them more susceptible to being shot. Attracting bears to productive cutting units, or seeding landings and roadsides with grasses and clover while leaving road access intact, can also make bears vulnerable to hunters and poachers and collisions with traffic (Simpson 1987). Of the 66 mortalities of marked grizzlies in the previously mentioned studies, 42% were due to legal harvest, 26% were due to illegal harvest, and only 12% were natural. Not all these bears had active radio-collars when killed, and consequently there are biases in these data. Because of compulsory reporting, all legally killed bears were likely reported whereas there were probably more illegally killed bears with both functional and nonfunctional radios than reported. In 3 of the 6 studies, there were as many or more illegal than legal mortalities.

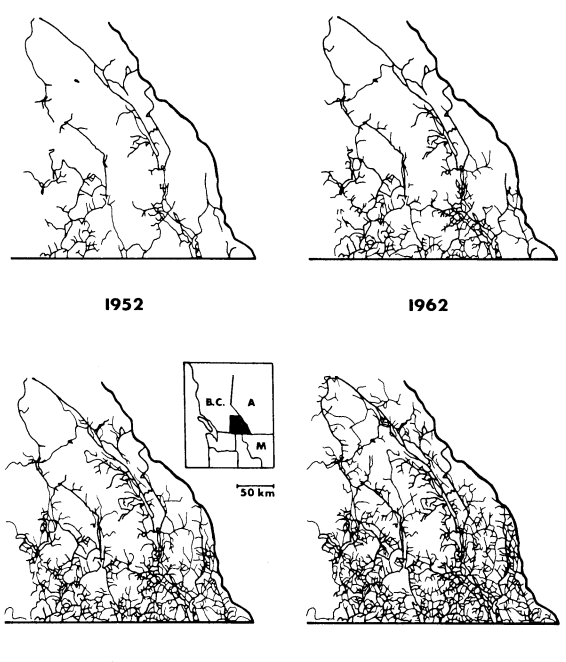

Fig. 1. Maps of 2 wheel drive access road development in the Kootenay Region of British Columbia between 1952 and 1986. Dead-end roads entering cutting units or residences are not included.

If wildlife managers consider the mortality rate of bears to be excessive, they can quite easily reduce the number of legal kills. Once an area is accessed to where illegal and control killing alone are excessive, it becomes extremely difficult and expensive to reduce the number of human-induced mortalities. This may be the predicament now facing the grizzly bears in Yellowstone National Park and adjacent areas (Knight and Eberhardt 1984).

RECOMMENDATIONS

Road construction in remote areas appears to be the major long term impact of resource extraction industries and the most significant problem facing grizzly bears in most locations. Open roads are an influence in all 5 ways that people affect bears. Vehicles on roads can harass bears, displace them from quality habitats, and cause reduced bear use of altered habitats, such as cutting units. Bears that are displaced from roads may cause social disruption in areas away from roads. Finally, roads permit access for many people and some of these will shoot bears.

Cumulative effects models, which incorporate dis-

placement, habitat change, and risk of mortality to predict the effects of an industrial development on grizzly bears, are being developed in the United States (Weaver et al. 1986). Although these models address the immediate influence of roads, they do not specifically address what may be the most critical aspect of roads: opening an area not only to hunters and recreationists, but squatters, permanent settlers, ranchers, and other resource extraction industries. The initial construction of a road is very important because most people want road access to wild country, and are unaware that the road may eventually eliminate the wilderness they seek. The cumulative effects analysis should incorporate the probability that a specific activity will eventually spawn additional pursuits. For example, a logging operation in an inhospitable, high elevation basin of good bear habitat that was accessed by a temporary road would be of much less concern than clear-cutting, even poor bear habitat, but where grasses would quickly respond and ranchers would lobby for grazing permits, permanent camps, and deeded land.

Long term access management plans that may include reducing existing access to regain wilderness are required to maintain viable grizzly bear populations across large landscapes of habitat. Such plans will be unpopular with some administrators and citizens who want to continue to "settle the west". Agencies, industry, and other user groups must co-operate in educating the public and advertise the value of long term access plans.

Although harassment, displacement, and most importantly, increased bear mortality rates caused by improved access are major concerns in most of the remaining grizzly bear range, the other influences of industry can also be important. In areas such as the far north where there is little cover, bears have had little opportunity for habituation, and industrial activities, such as those supported with aircraft, are often unpredictable, so harassment may be significant. Educating pilots and other personnel of potential impacts of repeated harassment and enforcing existing or developing new legislation may be necessary.

In most areas, altered habitats by timber management also have a significant impact on bears. On the northwest coast, merchantable timber is not only extensive, but old-growth forests are exceptional bear habitat whereas second-growth is poor and may remain so for over a century (Schoen et al. 1988). Long term forest and access management plans will be required in these areas to ensure the continued existence of adequate seasonal foraging sites with adjacent cover.

In the interior, ecosystems are generally more dynamic and a mosaic of seral stages occurs naturally. Here, habitat changes by timber management may not be as imminent as access and settlement, but it remains important. Fortunately, many recommendations regarding silvicultural practices, strategic retention of cover, and timing of industrial activity in these areas have been presented elsewhere (Blanchard 1983, Zager et al. 1983, Young and Beecham 1986, Contreras and Evans 1986, Simpson 1987).

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