Appendix 9

Literature Review of Factors Affecting Nuisance Bear Activity

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Table of Contents

Introduction

Many members of the public perceive that there has been an increase in the amount of nuisance bear activity in Ontario since the cancellation of the Spring black bear hunt in 1999. However, there is a great deal of controversy over whether this perceived increase is real, and over what the causes of any increase in nuisance activity might be.

Analysing historical records of nuisance complaints in Ontario may enable us to determine whether there has been an actual increase in the number of complaints about bears being nuisances. As a first step, a review of the literature may provide insights into the factors that affect nuisance bear activity.

A detailed review was conducted of published scientific literature, unpublished theses from Canadian and U.S. universities, unpublished literature from agencies in Canada and the United States, and information available on web sites of various agencies in Canada and the United States.

The following report summarises causes of changes in nuisance activity by black bears based on a review of published and unpublished literature. The review focuses first on factors that may affect the reporting rate for nuisance bear activity, then on causes of variation in nuisance activity itself.

1.1 Variation in rate of reporting of nuisance bears.

An increase in the number of complaints may not necessarily reflect increased nuisance bear activity. Rather, a change in the reporting rate may be responsible (i.e., some factor makes it more likely that members of the public will contact a government office to complain about the presence of a bear). There are several factors that may cause a change in the reporting rate for nuisance bear activity. For example, human-bear problems in Virginia have increased with

growing populations of both bears and humans (Virginia Dept. Game and Inland Fisheries 2001). Virginia's black bear population has increased during the past 25 years (Virginia Dept. Game and Inland Fisheries 2002), and from 1991-2000 harvest of black bears in Virginia increased at an annual rate of 6.3% from about 500 animals to about 900 animals. Nevertheless, despite increasing human and black bear populations and steadily increasing harvest levels, the reporting rate of black bear nuisance activity varied greatly from year to year (Virginia Dept. Game and Inland Fisheries 2002). Similarly, Pennsylvania's black bear population has recovered from historic lows caused by high mortality and widespread deforestation (Ternent et al. 2001). Pennsylvania's black bear population has tripled since 1980 and range expansion is continuing (Ternent et al. 2001). As a result, bears and people are coming into contact more than ever before as development is encroaching into or occupying bear habitat (Pennsylvania Game Commission 2002).

Heightened public awareness of black bear issues can also lead to an increase in reporting rate. Wisse (2000) referred to a rash of "bear-mania" in the U.S. following the widely publicised mauling death of a woman in Tennessee in May 2000. In Ontario, increased reporting after 1999 may have been a reaction by Ontario residents who were adversely affected by the cancellation of the spring hunt, or were convinced that the bear population was growing rapidly because of reduced harvest levels and so posed a risk to human safety. Due to the intense controversy over the Spring bear hunt in Ontario from 1995-98, the cancellation of the Spring bear hunt in 1999, the fatal attack by a black bear on a young woman in Quebec in July 2000, and the fatal attack by a black bear on a man in Quebec in fall 2001 public awareness of black bear issues has been high in Ontario in recent years. Such increased awareness alone can cause nuisance complaints to increase. In cases such as this, positive feedback likely exists through media coverage of bear

issues (i.e., heightened awareness leads to more complaints and additional media coverage, which further heighten awareness).

Increased reporting can be due to the lack of prior experience with bears of many people living or pursuing recreational activities in bear country for the first time. More and more people who are relatively unfamiliar with bears are living and recreating in bear habitat. This includes retirees, eco-tourists, canoeists, climbers, hikers, mountain bikers, and cottagers from urban areas. In south-central Ontario along the edge of the Canadian Shield, bear range may be expanding into areas where residents are unfamiliar with them, due to vegetation succession in habitats that were deforested by logging or cleared for agriculture in recent history (de Almeida and Obbard 2001). The lack of prior experience that such people have with bears means that they are inexperienced in preventing bear conflicts (Waters et al. 2001). People lacking experience with bears are likely predisposed to report most encounters, even if the bears are behaving normally, and pose little threat to human life or property (Landriault 1998). In cottage country (Haliburton and the Muskokas in Ontario), seasonal residents are responsible for most reports of nuisance bear activity, likely due to lack of knowledge of the aspects of their own behaviour that lead to conflicts with bears (Landriault 1998). Fear of bears is a major reason for complaints from those who are inexperienced with bears and not knowledgeable about bear behaviour (Decker and O'Pezio1989, Garshelis1989, Ternent et al. 2001). Conversely, landowners with more knowledge of, and contact with bears tend to be more accepting of bears, despite nuisance and damage problems (Decker and O'Pezio 1989, Jonker et al. 1998, Garshelis et al. 1999, Virginia Dept. Game and Inland Fisheries 2002). The Florida Fish & Wildlife Conservation Commission lists a lack of familiarity with bears and increased reporting among causes of a recent increase in bear complaints (Florida Fish & Wildlife Conservation

Commission 2001). In Pennsylvania, residents in bear country are often unwilling modify their behaviour (by removing attractants) since they consider trapping and relocation to be a viable solution to the problem (Ternent et al. 2001). In north-eastern Pennsylvania, a surge in the number of people moving from urban areas where there are no or few bears into bear-occupied habitat has occurred, and these people are often unprepared to either tolerate bears or to deter them from becoming nuisances. Many people feed bears and other wildlife worsening the problems (Ternent et al. 2001).

1.2 Increased nuisance activity by bears

1.2.1 Characteristics of bears responsible for nuisance problems

Prior to the use of firearms, natural selection likely favoured bears that avoided humans. When indiscriminate killing reduced the numbers of bears in North America during the late 19th and early 20th century, aggressive bears may have been selected against and timid bears may have been favoured (Herrero 1989). Although specific exceptions do exist, such as if a person is caught between a female and cubs, or the bear has no perceived avenue of escape, the natural response of most wild, free-ranging American black bears to humans is avoidance (Herrero 1985). The root cause of nuisance activity by bears is positive interactions with humans and their property, in the form of access to food (Gilbert 1989, Warburton and Maddrey 1994, Ternent et al. 2001, Virginia Dept. of Game and Inland Fisheries 2002,). A thorough understanding of the factors affecting changes in nuisance activity over time requires an understanding of the behaviour of bears who gain access to human food sources.

Bears have the highest brain to body-mass ratio of all carnivores (Gittleman 1986). Their behaviour is heavily influenced by learning (Eagar and Pelton 1978, Gilbert 1989), and the transmission of learned behaviour to offspring (Herrero 1985, Gilbert 1989, Gralenski 2001,

Ternent et al. 2001). Learned responses of bears to humans depends on the history of interactions between humans and bears. Interactions between bears and humans may be categorised as negative, neutral, or positive (Gilbert 1989). Negative interactions involve pain or discomfort on the part of the bear; they can lead to avoidance of an area, of people, or increased aggression when confronted (Gilbert 1989). If a bear's initial interactions with humans are negative ones, future conflicts may never occur. Neutral interactions do not severely affect behaviour, but can cause bears to lose their fear of humans (Gilbert 1989), a condition known as habituation. Habituation can occur even when no food rewards are involved if bears frequently encounter humans without consequence (Aumiller and Matt 1994). Positive interactions involve successful foraging on human foods. They inevitably lead to aggressive food seeking and use of developed areas (Gilbert 1989). Bears that aggressively seek out human foods are referred to as food conditioned.

Habituated and food-conditioned bears are responsible for most attacks on people (Herrero 1989, Herrero and Fleck 1990), and are often responsible for increased nuisance problems (Will 1980, Warburton and Maddrey 1994). Such bears tend to become bolder the longer they are allowed to exploit human food sources without negative consequences (Kelly 2001, Ternent et al. 2001). One or a few food conditioned bears can create the impression of many bears entering a developed area, by establishing foraging routes within and around the area (Ternent and Garshelis 1999, Gralenski 2001, Kelly 2001). Food conditioned bears anticipate similar rewards in similar situations (Gilbert 1989, Ternent et al. 2001). If intentionally fed by one person, they are likely to approach other people; if successful in attempts to forage near homes, they will approach other homes (Ternent et al. 2001).

There is evidence to indicate that, once food conditioned, black bears rarely revert to "wild" behaviour (i.e., exhibiting fear of humans and avoidance of developed areas), and that only infrequent rewards may be necessary to perpetuate food conditioning (McCullough 1982). Bears that become accustomed to approaching houses and people often become chronic nuisances, and end up being relocated or destroyed (Falker and Brittingham 1998, Kelly 2001). Keay and Webb (1989) documented nuisance activity by food conditioned bears at campsites, even after installation and mandatory use of bear-proof dumpsters and food storage containers. The bears in question exhibited "more sophisticated behaviour that permitted access to human foods", rather than switching to natural food items (Keay and Webb 1989). In Shenandoah National Park, nuisance problems continued for several years after management to prevent bear access to human foods. Removal of known problem bears was necessary to realise a reduction in incidents (Garner and Vaughan 1989). Extensive and varied aversive conditioning of three bear cubs to the presence of humans that had become habituated in captivity failed to instil fear of humans in the bears (Ratajczak et al. 2001). The cubs learned to avoid the sources of discomfort (hose, dogs, charger prods, pepper spray), but would still approach people when none of these were present (Ratajczak et al. 2001).

In cases where nuisance bears were relocated, the majority returned to within a few kilometers of the location of capture (McArthur 1981, Massopust and Anderson 1984, Rogers 1984, Inglis 1990, Landriault 1998, Pastuck 2001), and some continued nuisance activity (Beeman and Pelton 1976, Alt et al. 1977, Massopust and Anderson 1984, Inglis 1990, Shull et al. 1994). Bears that have been relocated and successfully homed are likely to return home if relocated again (Beeman and Pelton 1976, Inglis 1990, Landriault 1998). Subadults are less likely to home than adult bears, but may be likely to become engaged in nuisance activity after

release (Shull et al. 1994). Yearling and subadult males are less likely to home after being relocated than any other age class of bears (Inglis 1990, Landriault 1998).

Capture and on-site release has also been used in attempts to deter problem bears from using developed areas (Brady and Maehr 1982, Wooding et al. 1988, Clark et al. 2002). Researchers noted that bears tended to avoid capture locations after immobilisation and handling for the collection of biological data (Amstrup and Beecham 1976, Chi et al. 1998). Others noted that bears trapped and released on-site after raiding apiaries rarely returned (Brady and Maehr 1982, Wooding et al. 1988). In Arkansas, 12 of 15 bears did not repeat nuisance activity at the capture site after handling and release (Shull 1994). In Great Smoky Mountains National Park in Tennessee, 40% of bears released on-site were later observed at the release location, 37% required further management action, and 27% eventually had to be relocated (Clark et al. 2002). It is not known whether the bears handled during the course of the above studies continued nuisance activity in other areas. Clark et al. (2002) found that the behaviour of the bear when captured (shy/passive *vs*. aggressive/conditioned) was a significant correlate with the success of capture and on-site release as a deterrent of nuisance activity by individual black bears. Bears captured and released near picnic areas and campgrounds did not avoid the area in future (Clark et al. 2002). It seems likely that bears caught near these potential sources of human food had already received positive reinforcement associated with the area, and may have been food-conditioned and/or habituated to humans. Bears exhibiting nuisance activity in the daytime were more likely to cause problems after capture and release than bears causing problems at night, and this was attributed to the bears' increased level of habituation and conditioning (Clark et al. 2002).

Forbes et al. (1994) compared the frequency of problem bears in two national parks in New Brunswick of about equal size and with similar garbage management programs. Despite there being more visitors in Fundy National Park (FNP) the number of encounters with black bears averaged 8.6/yr, less than one-third the rate of Kouchibouguac National Park (KNP) (32.3/yr). Forbes et al. (1994) attributed the much lower encounter rate in FNP to higher harvest levels in the adjacent area (24/yr) than in the area adjacent to KNP (15/yr). The authors suggested that the higher harvest level around FNP sensitised FNP bears to humans explaining why there are fewer problem bear incidents. The authors did not explain how unharvested bears would learn to be wary of humans.

Males are consistently over-represented in samples of nuisance bears relative to their representation in the population (Piekielek and Burton 1975, Rogers et al. 1976, Garshelis 1989, Inglis 1990, McLean and Pelton 1990, Clark et al. 2002). The greater mobility of male bears, their encountering of unfamiliar areas as they disperse from natal areas, and possibly their fearlessness contribute to this overrepresentation (Rogers 1987, Garshelis 1989). Young males in particular are frequent offenders (Rogers et al. 1976, Garshelis 1989, Inglis 1990). Young males may become involved in nuisance activity as they disperse and explore unfamiliar areas (Garshelis 1989), or because they are excluded from habitat far from humans by larger males (Garshelis 1994). The fact that fewer old males cause problems may reflect the fact that there are fewer large males in the population, due to selection for them by hunters (Rogers 1976). It may also be the case that large male bears secure habitat distant from humans (Garshelis 1994).

Nutritionally stressed bears become bolder when attempting to obtain sources of food, and so are more likely to approach humans and developed areas while foraging (Hygnstrom and Craven 1996). Increases in nuisance activity have been correlated with natural food shortages

(Piekielek and Burton 1975, Rogers 1976, Garshelis 1989). Human food and garbage may be high quality forage for bears, particularly at times when high quality natural foods are scarce, such as in early spring, or in years of mast failure (Rogers 1989, McLean and Pelton 1990).

1.2.2. Attractants

Bears are opportunistic feeders, and have an excellent sense of smell. A wide variety of human foods and waste products can attract bears into an area. Improperly stored garbage is the most common cause of human-bear conflicts in residential areas and campgrounds (Garshelis 1989, Hygnstrom and Hauge 1989, Gniadek and Kendall 1998, Plaxico and Bonney 2001, Ternent et al. 2001, Waters et al. 2001). Other common attractants associated with residential areas include food left out for pets or other species, and dirty picnic tables and barbecues. Birdfeeders in particular have been reported to attract bears into residential areas, with garbage and compost being exploited only after bears are more habituated to people (Calvert 2001, New York State Dept. Environmental Conservation 2001).

Intentional feeding of black bears quickly leads to habituation and food conditioning (Keay and Webb 1989, McLean and Pelton 1990, Falker and Brittingham 1998, Ternent et al. 2001), and often results in high bear densities near the food source, whether it be a home or roadside (Kelly 2001, Ternent et al. 2001).

Agricultural crops are often used by black bears (Jonker et al. 1998, Garshelis et al. 1999). Apiaries are particularly susceptible to bear damage (Garshelis 1989, Ontario Ministry of Agriculture and Food 2002), but significant damage to corn, oats, and other field crops also occurs (Jonker et al. 1998). Occasionally, livestock are taken by predatory black bears (Ontario Ministry of Agriculture and Food 2002).

Aggregations of black bears are common at garbage dumps in bear country. Female black bears that forage at dumps or otherwise obtain human food gain a fitness advantage in the form of more rapid growth, and enhanced reproductive output (Rogers et al. 1976, Stringham 1989, McLean and Pelton 1990). Use of dumps by certain age and sex classes of black bears is not consistent, with most age and sex classes making some use of dumps (Stringham 1989). Increased vulnerability to hunters can result in higher mortality rates for bears that feed at dumps (Stringham 1989), though it is illegal to harvest bears within 400m of a dump in Ontario (Ontario Ministry of Natural Resources 2002). Conspecific killing has resulted in higher mortality rates for grizzly bear cubs whose mothers feed at dumps, but the ability of black bears to climb trees, and the tendency of female black bears to leave their cubs at the periphery when feeding at dumps, should help to minimise conspecific killing of cubs at dumps (Stringham 1989). It seems logical to assume that bears that feed at dumps become habituated and food conditioned, and this is many managers' impression of "dump bears" (Stringham 1989). However, Rogers (1989) observed low nuisance activity in the vicinity of dumps and suggested that properly situated dumps may serve as buffers against nuisance activity. Neither use of dumps, nor human scent on garbage were thought to lead to habituation and food conditioning where dumps were small with few human visitors; however, at large dumps frequently visited by people bears did become habituated to people (Rogers 1989). Park managers have found it necessary to remove problem bears from populations following dump closures in order to abate nuisance bear problems (Craighead 1979, Garner and Vaughan 1989). It was not clear whether continued nuisance activity was a result of habituation and food conditioning, or nutritional stress associated with the loss of a food source.

1.2.3 The importance of annual variation in food supply on black bear reproduction, movement, and encounters with humans.

During summer and fall, bears preferentially forage on wild berries (soft mast) and nuts (hard mast). Common summer foods in boreal mixedwoods include strawberries, raspberries, pin cherries, serviceberries, sarsaparilla (Brown et al. 1999), and later in the summer bearberries, blueberries, and beaked hazel nuts become important food sources (Brown et al. 1999). Soft mast producing species are also abundant in clear-cuts, and blueberry barrens. Soft mast also makes up the majority of black bear diets in the fall where hard mast is rare or unavailable (Brown et al. 1999). Where hard mast producing species occur (hazel, oak, beech), nuts and acorns are heavily used (Beeman and Pelton 1980, Garshelis and Pelton 1981, Eagle and Pelton 1983, McLaughlin et al. 1986, Schooley et al. 1994).

Diversity and productivity of soft mast producing species used by bears tends to be higher in deciduous than coniferous forests (Jonkel and Cowan 1971, Beck 1991, Clark et al. 1994). Oak, beech, and feral apple trees can provide high-energy fall foods in the Great Lakes–St. Lawrence Forest region, and along its transition zone with the boreal forest (Brown et al. 1999). Effects of annual variation in climate on food supply may therefore be more pronounced in the boreal forest, where bears rely heavily on a few species. In the Great Lakes–St. Lawrence Forest Region, bears can switch to alternate mast producing species in the event of failure of a soft mast crop such as blueberry (McLaughlin et al. 1986, Brown et al. 1999).

The productivity of mast crops can vary widely from year to year, with changes in temperature and precipitation (Arimond 1979, McLaughlin et al. 1986, Garshelis 1989, Strickland 1989, 1990, 1991, 1992, Schooley et al. 1994, McLaughlin et al. 1994, McLaren 1999, 2000, 2001, 2002,). Primary productivity in boreal forests is sensitive to climatic

variability (Arain et al. 2002). Two species of the genus *Vaccinium* were found to undergo regular fluctuations in seed production (Van der Kloet and Cabilio 1996, Selas, 2000). However, no relationships were observed between annual precipitation, maximum monthly temperatures, or minimum monthly temperatures and seed production in *V. corymbosum L.* (Van der Kloet and Cabilio 1996). Selas (2000) investigated relationships between climatic variables at times when flower bud formation and berry ripening occur. High temperatures during flower-bud formation in autumn, high temperatures in winter with thin snow cover, low temperatures in spring, and low or high amounts of precipitation during summer ripening depressed seed production relative to the underlying regular pattern (Selas 2000).

Variation in black bear recruitment rates, including litter production rate, litter size, and cub survival is dependent on the weight of adult females at the end of the foraging period (Bunnel and Tait 1981, Beecham 1983, Rogers 1987, Eiler et al. 1989, Elowe and Dodge 1989, Kolenosky 1990, Miller 1990a, Costello et al. 2001). Body mass of adult females in turn is dependent on the availability and productivity of natural bear foods (Beecham 1980, LeCount 1982, Rogers 1987, Miller 1994, Costello et al. 2001). Female bears that are nutritionally stressed resorb embryos thereby passing up a breeding opportunity (Erickson 1964), or may produce smaller litters (Rogers 1987, Kolenosky 1990), negatively affecting their lifetime fitness. The incentive for bears to maximise their energy intake in order to meet their nutritional requirements, even in years of natural food shortage, is therefore very strong and is based on their evolved life history strategy. For black bears in temperate environments, most weight gain occurs near the end of bears' active season, as hard and soft mast becomes available (Beeman and Pelton 1980, Clark et al. 1994).

Black bears typically produce litters every two years, and do not breed if accompanied by cubs (Kolenosky 1990). If the majority of females fail to produce litters following a mast failure, they will all be available to breed the following year, as will females that were encumbered with cubs during the mast failure. This can lead to synchronised reproduction and a large year class of cubs two years after the mast failure (McLaughlin et al. 1994). As individuals in the large year class mature and attempt to establish home ranges of their own, increases in encounters with humans and their property may occur.

Most bear-human encounters and nuisance activity occur when natural foods are in short supply, as nutritionally stressed black bears range farther (Hirsch et al. 1999, Igo 2001), and venture closer to humans and developed areas in search of food (Garshelis 1989, Hygnstrom and Craven 1996, Igo 2001, Stokes et al. 2001). Nuisance activity (Rogers 1976, Garshelis 1989), hunter success (McDonald et al. 1994, Noyce and Garshelis 1997), and bait station population indices (McLaren et al. 1999, Van Manen et al. 2001, McLaren and Obbard 2002), vary considerably from year to year. This is at least partially an effect of variation in the availability of natural foods (Garshelis 1989, Van Manen et al. 2001, McLaren and Obbard 2002). Noyce and Garshelis (1997) demonstrated that size of the black bear harvest depends more on food availability in that year than on bear abundance, and Garshelis (1989) found the same relationship for summer nuisance activity.

The potential for changes in weather conditions to influence nutritional stress, movements, and behaviour of black bears translates into the potential for drastic fluctuations in nuisance activity, without any change in bear numbers or population structure.

1.2.4 Factors affecting temporal variability in levels of nuisance bear activity.

Factors affecting temporal variability in nuisance activity may be placed in two groups:

1) Those that result in temporal variation in food supply (and therefore in carrying capacity). Type 1 causes can further be grouped (according to the temporal scale of the effect) into seasonal differences, annual differences, and those leading to more long-term changes in food supply.
2) Those that increase the probabilities of interactions between bears and humans (and their property). Type 2 causes involve changes in the density of people, and/or the density of bears in an area.

1.2.4.1 Effects of temporal variation in food supply

Seasonal variation

During the spring in north-eastern North America, natural bear foods are generally of low nutritional quality. The spring diet of black bears in eastern North America consists largely of green vegetation including flowers, clover, grasses, sedges, forbs, catkins and new leaves and shoots of woody plants including aspens and birch (Hugie 1982, McLaughlin et al. 1986, Unsworth et al. 1989, Romain 1996, Brown et al. 1999). Bears lack the ability to digest cellulose (Rogers 1976), and therefore, to derive large amounts of energy from green vegetation (Brown et al. 1999, Partridge et al. 2001). Carrion, neonate ungulates, spawning white suckers, and colonial insects (ants, bumble bees, wasps) are used to supplement this otherwise low-protein diet (Beeman and Pelton 1980, McLaughlin et al. 1986, Ballard 1992, Romain 1996). Although controversy exists over whether bears continue to lose weight after emergence from their dens in the spring (Noyce and Garshelis 1998), spring may be a period of nutritional stress and poor physiological condition for black bears (Jonkel and Cowan 1971, Rogers 1976). Black bears may therefore be more likely to attempt to exploit human foods in the spring and early summer,

before more high-energy foods (soft mast) become available. In areas of western North America where spring berries occur, damage to conifers is low compared to areas where natural foods consisted primarily of new green vegetation (Noble and Meslow 1998). Damage to conifers has been reduced by supplemental feeding of black bears in the spring (Partridge et al. 2001).

Seasonal movement patterns of black bears increase the chances of certain age classes of bears encountering humans and their property during the spring and early summer. The breeding season for black bears peaks in early to mid summer, during which time the daily movements of adult male black bears is at a maximum (Hirsch et al. 1999). Adult females also travel extensively in the spring and early summer, seeking to expand their territories, and encounter adult males (Rogers 1987). Late spring and early summer is also the time when family groups of females and yearlings break up, then the adult females become receptive and ready to mate again (Rogers 1987, Kolenosky 1990). Yearling females tend to establish home ranges that overlap with their mothers' range, but young males disperse, travelling up to 200 km to find a new home range (Rogers 1987, Garshelis 1994). When young males disperse they often encounter human habitations and development (Beeman and Pelton 1980).

Nutritional stress and high mobility of certain portions of black bear populations combine to make late spring and early summer a problematic time for nuisance bear complaints across much of their range (Alt et al. 1977, Garshelis 1989). Some studies of seasonal trends in nuisance activity showed that late spring nuisance activity was generally high, and less variable between years than summer and fall nuisance activity (Garshelis 1989, Plaxico and Bonney 2001).

Seasonal distributions of nuisance activity in different parts of Ontario apparently differ (Inglis 1990, Landriault 1998). Nuisance captures and kills in Algonquin Park between 1973 and

1990 were more common in July and August than May or June (Inglis 1990). This seasonal pattern was fairly consistent from year to year, and coincided with the peak visitation rate by people (Inglis 1990). In Chapleau district in 1983 and 1984, nearly all nuisance bear captures occurred in June and July; in Parry Sound between 1983 and 1995, most nuisance captures occurred in July and August; in Sudbury, the seasonal distribution was bimodal, with peaks in June and September (Landriault 1998). In Chapleau and Parry Sound, seasonal peaks in nuisance activity correlated with influxes of seasonal visitors and residents (Landriault 1998).

Other seasonal peaks in nuisance activity may occur coincident with high availability of human foods. Bear visitation to campgrounds in Minnesota was positively related to human use (Garshelis 1989). Nuisance activity and foraging in agricultural areas peaks when crops ripen in the late summer and fall (Garshelis 1989, Jonker et al. 1998, Garshelis et al. 1999). Overall nuisance activity tends to decline during late summer and fall, unless conditions for hard mast production are poor (Garshelis 1989, Inglis 1990). Summer and fall nuisance activity is more variable from year to year than spring and early summer nuisance activity, and accounts for most annual variation in nuisance activity (Garshelis 1989).

Annual variation

Several studies have reported that annual fluctuations in nuisance activity correlate well with natural food availability and poorly with bear population size (Shorger 1946, Piekielek and Burton 1975, Rogers 1976, Rogers 1987, Garshelis 1989, Garshelis and Noyce 2001). In addition to reducing nutritional stress, abundant soft or hard mast may lead to decreased bear movements, resulting in lower encounter rates and nuisance activity (Igo 2001). Weather conditions and their effect on natural food supply, or natural food supply itself, are frequently cited as probable causes of high levels of nuisance bear activity (Table 1).

Table 1. Reported causes of high levels of nuisance bear activity in certain years.

Cause of increased activity	Source and Location
Berry crop failure	de Almeida and Obbard 2001. Ontario
Delay in berry crop	de Almeida and Obbard 2001. Ontario
Natural food crop failures	Inglis 1990. Ontario
Low snow depth → Lack of spring foods	Garshelis 1989. Minnesota
Low abundance of soft mast	Garshelis 1989. Minnesota
Scarcity of natural foods	MNDNR 2002. Minnesota
Late frost, cold temperatures, and drought	Pastuck 2001. Manitoba
Dry winter → Lack of spring foods	NY Bureau of Wildlife 1999. New York
Poor hard mast production	Adams 2001. New Hampshire
Poor nut and berry crops	Hygnstrom and Craven 1996. Wisconsin
Natural food shortage	Hygnstrom and Hauge 1989. Wisconsin
Poor mast year	Waters et al. 2001. Georgia
Low availability of natural foods	Vaughan pers. comm. 2002. Virginia
Drought → Food shortage	Doan-Crider 2001. Arizona
Drought → Food shortage	Andelt 2002. Colorado

Garshelis (1989) found significant relationships between numbers of nuisance complaints in different seasons and specific environmental variables. Annual variation in nuisance bear activity during spring and early summer was explained by an inverse relationship with snow depth, and late summer and fall nuisance activity was dependent on abundance of soft mast (Garshelis 1989). Suggested mechanisms for the observed relationship between snow depth and spring/summer nuisance activity all involved nutritional stress, and included early emergence, the availability of winter-killed deer, and the availability of ants (Garshelis 1989). Within the study area, the areas exhibiting the most complaints, and the highest annual variation in complaints, were those areas with high annual variation in wild fruit production (Garshelis 1989). Results of this study may be particularly relevant to questions about causes of increased nuisance activity in Ontario, since many of the same wild fruit producers (blueberry, juneberry, raspberry, cherry, hazelnut, mountain ash) are common in Minnesota and Ontario (Arimond 1979, Garshelis 1989, Usui et al. 1994, Romain 1996, Brown et al. 1999).

Effects of annual food shortages on nuisance activity may be observed for years following the event. Mechanisms behind increases in nuisance bear activity 1-3 years following years of food shortage may include poor nutritional condition the spring following the year of food shortage (Garshelis 1989), food conditioning that occurred during the food shortage (Garshelis 1989, Ternent et al. 2001), or synchronised reproduction the year after the event leading to large numbers of subadults present in the population in subsequent years and to uneven age distributions in the population (McLaughlin et al. 1994). For example, a wide food shortage across central Ontario in 1995 apparently synchronised black bear reproduction in 1996 (M. Obbard, unpublished data). The subsequent large year class produced in 1997 would have been dispersing subadults between 1999 and 2001, potentially contributing to an increase in nuisance activity. There is evidence from age analysis of the Ontario harvest data that large year classes were born in 1997, 1999 and 2001 (L. Dix-Gibson, personal communication, 2003), suggesting that reproduction in the central Ontario population has remained synchronised throughout three reproductive bouts. During a severe drought affecting central Ontario in July and August, 2001 large numbers of females with cubs of the year were sighted, and starting in late August many orphaned cubs were reported (M. Obbard, unpublished data).

Long-term change

When the food producing capacity and therefore, carrying capacity, of bear habitat changes, bear population responses in the form of changes in bear numbers and density are likely to be preceded by changes in nuisance activity levels. Reductions in carrying capacity should lead to increased nuisance activity in the short term, since the natural habitat can no longer support the density of bears occurring there. Over time, nuisance activity should decrease as density responses and/or destruction of problem bears reduces the population to a size the natural

habitat can support. Increases in food producing capacity of the habitat should reduce nuisance activity in the short term during the seasons when food production is high (at least for bears that are not highly human habituated and food-conditioned), by enabling bears to meet their nutritional needs without venturing close to humans. The following discusses observed and potential effects of the loss of historical sources of supplemental human foods and habitat change on nuisance activity levels.

Loss of historical sources of supplemental foods

Two potentially significant sources of supplemental foods for black bears are dumps and bait piles maintained by hunters and outfitters.

a) Dump closures

Garbage dumps may provide high quality food for bears (Rogers et al. 1976, Rogers 1987, 1989). Generally, bears that feed at dumps exhibit faster growth, earlier maturity, and higher reproductive output compared to bears that rely solely on natural foods (Rogers et al. 1976, Rogers 1987, 1989). Bear usage of dumps increases in years when natural foods are scarce (Rogers 1989). Rogers (1989) further suggests that nuisance activity is inversely related to distance from an accessible dump. This is based on the idea that bears will forage wherever foraging is most efficient, i.e., in the forest when natural foods are abundant, at a dump when they are scarce, and at campgrounds or developed areas when natural foods are scarce and no dumps are available (Rogers 1989).

Dump closures have led to dramatic increases in nuisance activity at least in the short-term (Craighead 1979, Garner and Vaughan 1989). The impact of a dump closure will depend on the proportion of a population of bears that uses the dump, and the abruptness of the closure (Stringham 1989). Previous closures of dumps for the purpose of reducing bear/human conflict

were effective only after many years, and the translocation or killing of several problem bears (Garner and Vaughan 1989, Keay and Webb 1989). It is unclear whether increased nuisance activity following dump closures is attributable to conditioning of the bears that had fed at the dumps, or simply a reduction in food supply and carrying capacity, leading to temporary high levels of nutritional stress within the population.

b) Loss of supplemental food

The most popular technique for hunting black bears in Ontario in the spring was still-hunting over bait (de Almeida and Obbard 2001). When Spring hunting was legal, many tourist outfitters maintained piles of presumed high-calorie human food at still-hunting locations starting in late April or early May, shortly after bears emerged from dens (McLaren and Obbard 2002). With closure of the Spring hunt in 1999, this potentially significant supplemental source of food was no longer available; however, the effect of this loss of food is unknown.

Proponents of supplemental feeding suggest that it can reduce nuisance problems (Virginia Dept. of Game and Inland Fisheries 2002). In one area of Virginia, 139 individual hunters provided nearly two metric tonnes of supplemental food in one year (Gray and Vaughan 2001). The authors warned that regulating supplemental feeding could adversely affect bear reproduction, survival, population size, and nuisance activity (Gray and Vaughan 2001). If supplemental foods are consistently provided over time, individual bears may become dependent on them, and the local habitat may support a higher density of bears than would be supported by the carrying capacity of the natural environment (Graber and White 1983). Bears with access to supplemental human food show faster growth in body size and higher reproductive rates (McLean and Pelton 1990). Supplemental food can have a positive effect on body growth, reproductive output and even local density of bears. However, this pattern was not consistently

shown in all studies. For example, bears fed supplemental food in spring in Washington showed short-term gains in body mass relative to bears without access to supplemental food (Partridge et al. 2001). Yet, once supplemental feeding stopped in late June and natural foods became abundant, bears that did not have access to supplemental food were able to compensate and differences in body mass between the two groups disappeared. Partridge et al. (2001) concluded that supplemental feeding in spring helped to reduce damage to conifer trees, but there was no long-lasting effect on bear condition or productivity.

This suggests that supplemental feeding may reduce nutritional stress, but the effect on bear populations is not predictable.

Habitat change

In Ontario, bears are widely distributed (Pelton et al. 1994, de Almeida and Obbard 2001) occupying both the Great Lakes–St. Lawrence Lowland Forest and Boreal Forest Regions (Rowe 1972). Timber harvest is a significant factor affecting forest stand types in both forest regions, resulting in a mosaic of stands of different ages and compositions across the province. Timber harvest can degrade or improve bear habitat, or render it unavailable to bears (Mattson 1990, Brown et al. 1999). The effect of timber harvest on the production of bear foods in Ontario depends on the forest type affected and the specific forestry activities that take place. Thinning (Mattson 1990, Brown et al. 1999), and selective timber harvest (Brody and Stone 1987, Noyce and Coy 1990, Costello and Sage 1994) in hardwood forests create canopy gaps resulting in better soft mast production relative to even-aged or closed-canopy stands (Arimond 1979).

Loss of boreal mixedwood forests or their conversion to clearcuts or monoculture conifer stands is likely to result in the loss of spring foods (Peters and McLaughlin 2001). In the boreal forest, clear cutting of conifer stands is common, and thought to emulate the natural fire regime.

Broadcast burning following clearcutting increases similarity with a natural fire regime (Mattson 1990, Brown et al. 1999). Clear-cuts in boreal forests create early successional communities and provide good summer foraging habitat for black bears, due to increased production of soft mast especially blueberries (Manville 1983, Brown et al. 1999). Use of clearcut blocks less than ten years old is high relative to their representation on the landscape, indicating selection for these habitats (Obbard and Kolenosky 1994, Usui 1994). After ten years, shading by regenerating jack pine limits the production of berry producing shrubs (Usui 1994). Herbicide applications for conifer release damage blueberry crops, reducing or eliminating the similarities between clearcuts and forest fires (Peters and McLaughlin, 2001). Herbicide application qualitatively changes the effect of clearcutting on production of bear food species, from a positive to negative effect (Moola et al. 1998). In general, timber management practices intended to accelerate crown closure and eliminate competing vegetation will have a negative effect on habitat for black bears (Mattson 1990).

In the Great Lakes–St. Lawrence Lowlands Forest ecoregion of central Ontario, clear-cutting is unlikely to improve bear food production. In hardwood stands, selective cutting (Hugie 1982, Peters and McLaughlin 2001) and thinning (Mattson 1990) are more beneficial to bears than clear-cutting.

Natural succession in abandoned agricultural and previously deforested lands near the southern edge of the Canadian Shield could allow southward range expansion by black bears. Such early successional communities will provide abundant food species for black bears. Any range expansion could result in increased bear-human conflicts if people living in the area have no prior experience with black bears (Ternent et al. 2001).

1.2.4.2 Changes in human population size/density

With more people living, working, and recreating in bear habitat in the future, interactions between people and bears will increase without any change in bear numbers or behaviour (Mattson 1990, Ternent et al. 2001). Some of these interactions could involve nuisance behaviour, especially when bear attractants are improperly stored or disposed of.

In north-eastern Pennsylvania, bear numbers are stable, but the human population has increased by about 50% in 10 years. Nuisance complaints have increased over that time to high levels suggesting that the social carrying capacity for black bears may have been exceeded without any increase in the bear population (Ternent 2001). Similarly, Calvert (2001) cites an increasing human population in bear country as the cause of increased residential nuisance complaints in New Hampshire despite a stable bear population. Conflicts in Minnesota have also increased as more people build homes and cabins and use the forested northern portion of the state for recreation (Minnesota Department of Natural Resources 2002). In both Yosemite and Shenandoah National Parks, human-bear encounter rates vary not with bear numbers or activity levels, but with visitor density and with park management practices such as closing of dumps or installing bear-proof garbage containers and food lockers (Keay and Wagtendonk 1983, Garner and Vaughan 1989). Observations of increased bear mortality with increased human access to bear habitat, generally associated with building of roads, (Brody and Stone 1989, Schoen 1990, Rossel and Litvaitis 1994) is further evidence that human encroachment into and use of bear habitat results in increased encounter rates. When human encroachment results in the conversion of bear habitat to cultural ecotypes, short-term increases in nuisance complaints are even more likely, as displaced bears disperse, or attempt to forage in their historical home range (Ternent et al., 2001). If increased nuisance bear activity parallels human population growth and

encroachment into bear habitat, it will be a continuing challenge in the future for our society to learn to co-exist with bears.

1.2.4.3 Changes in bear population size/density

Black bears are difficult to enumerate, complicating analyses of the effects of changes in bear numbers on nuisance complaints. Increases in nuisance complaints can be interpreted to reflect an increase in the number of bears, but this relationship is poorly supported by data (Garshelis 1989), even when reliable indicators of population numbers or growth trend are available. Garshelis (1989) and Garshelis and Noyce (2001) discounted changes in population size and structure as the cause of annual variation in nuisance complaints, and attributed much of the variation in complaints to year-to-year variation in natural food supply. It is logical however, that as bear populations increase, human-bear problems increase as bears encounter humans more frequently (Virginia Dept. of Game and Inland Fisheries 2001, 2002). Several jurisdictions cite growing or expanding bear populations among causes of increases in encounter rates or nuisance activity (Hygnstrom and Craven 1996, Bittner 2001, Cardoza 2001, Ionescu 2001, Ternent et al. 2001, Waters et al. 2001). Some of these cite increasing bear populations as the main cause (Bittner 2001, Cardoza 2001, Ionescu 2001). Cardoza (2001) further suggests that the increase in nuisance activity is roughly proportional to the increase in the bear populations, but presents no data (and see Garshelis [1989]). When growth in the bear population is accompanied by range expansion, nuisance complaints are likely to rise because of the greater probability of encounter, and because the people encountering bears are unfamiliar with them (Ternent et al. 2001, Waters et al. 2001).

The overwhelming influence of annual variation in food supply on bear movements and behaviour means that sightings (Gniadek and Kendall 1998), harvest data (Garshelis 1990,

Noyce and Garshelis 1997, McLaren and Obbard 2002), and nuisance activity (Garshelis and Noyce 2001) are poor indicators of the growth trend of black bear populations. Garshelis and Noyce (2001) observed no direct relationship between bear numbers and nuisance complaints during a tripling of the bear population in Minnesota in the last two decades. However, peaks in nuisance complaints corresponded with bad food years and the peaks in nuisance activity have increased as the bear population increased (Garshelis and Noyce 2001).

Black bears have slow reproductive rates (Jonkel and Cowan 1971, Young and Ruff 1982, Kolenosky 1990, Miller 1990b), precluding rapid population growth. Short-term changes in black bear population size are thought to result from random changes in food supply, through their effect on reproduction (Beecham 1983, LeCount 1982, Rogers 1987, Garshelis 1994). Dramatic changes in number of adults in bear populations from year to year generally do not occur (Miller 1990b).

Hunter harvest to reduce bear density is the most common management technique used in the range of the black bear. Hunted populations usually are of lower density than non-harvested populations (Lindzey and Meslow 1977, Powell et al. 1996, Doan-Crider and Hewitt 2001, Obbard unpublished data). Regulated hunting has the potential to reduce human-bear problems, but does not always achieve the desired effect. For example, hunting to control bear population levels has been used successfully to reduce damage to commercial forests (Peolker and Parsons 1980), agricultural damage (Garshelis 1989), and nuisance activity (Garner and Vaughan 1989, Hygnstrom and Hague 1989). Similarly, F orbes et al. (1994) reported lower problem bear rates in Fundy National Park (FNP) compared to another similar national park, and attributed that lower rate to higher harvest adjacent to FNP. However, increasing quotas was ineffective at reducing nuisance activity in Alberta (Pelchat 1982), and agricultural areas of

Minnesota (Konito et al. 1998). For effective management of nuisance activity by sport harvest, hunting seasons should coincide with periods of high nuisance activity (Hygnstrom and Hague 1989), and quotas should be higher in areas where complaints are concentrated (Hygnstrom and Hague 1989, Garshelis, 1989, Konito et al. 1998). Hunting to reduce nuisance activity may not be feasible near urban areas (Ternent 2001, Virginia Dept. of Game and Inland Fisheries 2002), and may be ineffective near large sanctuaries (Ternent et al. 2001, Virginia Dept. of Game and Inland Fisheries 2002).

General Conclusions from the Literature Review

1. Rates of interaction between humans and black bears, including sightings, nuisance activity, and harvest rates, are dependent on the amount of food available to bears within their habitat. When natural foods are scarce, or historical sources of supplemental food are removed, higher levels of nuisance activity will occur.
2. Annual variation in nuisance activity is most strongly influenced by annual variation in the availability of natural foods.
3. The root cause of nuisance activity by black bears is attraction to sources of human food or waste that is easily accessible by bears.
4. In residential areas improperly stored garbage is the dominant attractant, although other attractants such as bird feeders, composters, pet food stored outside, fruit trees, and intentional feeding are also important.
5. Black bears exploit agricultural products (corn, oats, beehives, and orchards).
6. Spatially focused hunting, targeted at nuisance individuals, can reduce nuisance activity associated with agricultural attractants.
7. Regulated hunting has the potential to reduce human-bear problems, but does not always achieve the desired effect. Results of several studies are contradictory.
8. Temporary increases in nuisance activity have been associated with loss of historical sources of supplemental foods (e.g., dump closures).
9. Habituated and food-conditioned black bears rarely revert to wild behaviour: once persistent nuisance behaviour is learned, animals usually have to be relocated long distances to remote areas, or destroyed.

10. Spring nuisance activity varies less from year to year than summer and early fall nuisance activity. This is because most high-quality natural foods do not become available until mid-summer. Before these foods ripen, bears are in a similar nutritional predicament each year when they feed on lower-energy natural foods, which have low variation from year to year.
11. Range expansion by bears and encroachment into bear habitat by humans tend to cause increases in nuisance activity, more so than a simple increase in the number or density of bears within an area.
12. Non-permanent and new residents in bear country are more likely to report bear activity as nuisance activity than long-term residents. They are also less likely to modify their behaviour to reduce human-bear conflicts. However, as people gain more experience with wildlife and become better educated about causes of human-bear conflicts they generally become more tolerant.
13. When public awareness of bear issues is high, nuisance complaints increase (positive feedback effect: so-called "bear-mania").

The above general conclusions are represented in diagrammatic form in Figure 1. Based on the literature review, we identified the major factors affecting reporting of nuisance activity by black bears. In this hypothesis of effects diagram, both direct effects and indirect effects are identified, as is the nature of each effect (positive or negative) on nuisance activity and reporting of nuisance activity.

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Fig. 1. Hypothesis of effects diagram for nuisance black bear activity in Ontario showing the direction of the effect of the variable, and the nature of the effect (positive or negative). Numbers relate to General Conclusions section.