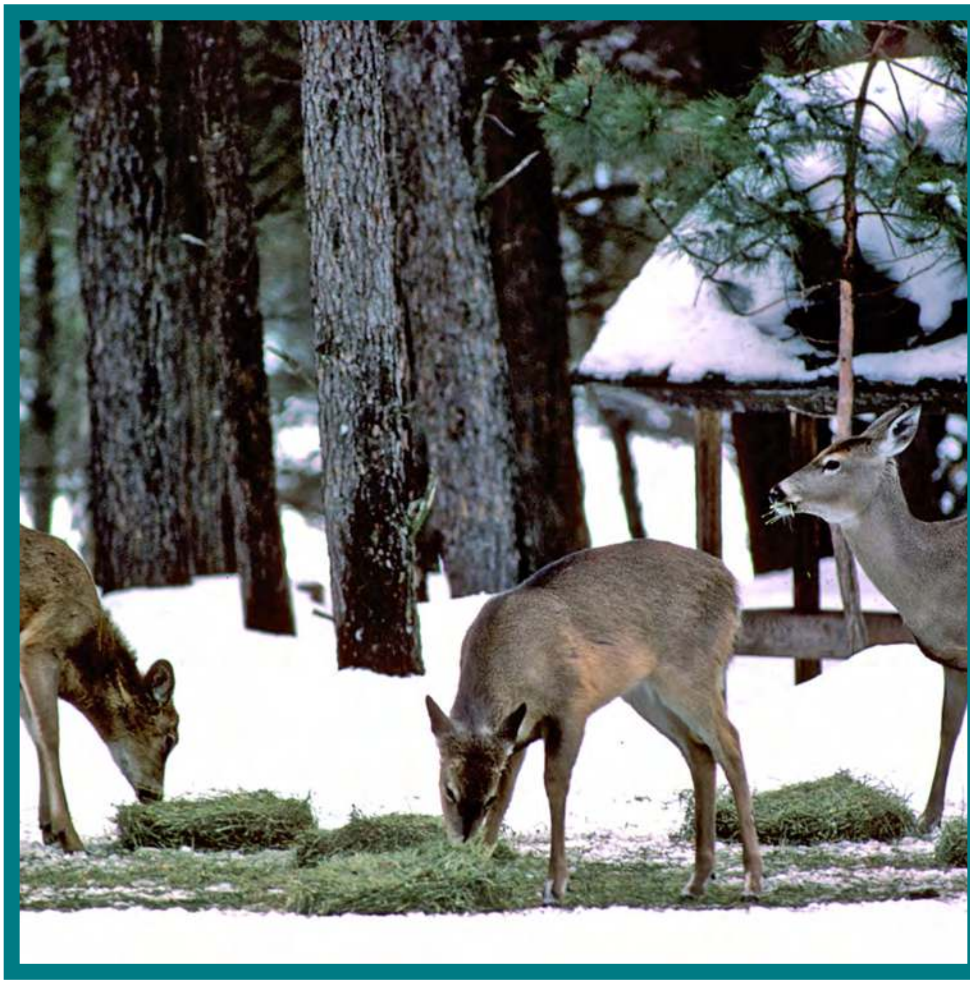
The Wildlife Society



Baiting and Supplemental Feeding of Game Wildlife Species

Technical Review 06-1
December 2006

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Foreword

Presidents of The Wildlife Society occasionally appoint ad hoc committees to study and report on select conservation issues. The reports ordinarily appear as either a technical review or a position statement. Review papers present technical information and the views of the appointed committee members, but not necessarily the views of their employers. Position statements are based on the review papers, and the preliminary versions are published in The Wildlifer for comment by Society members. Following the comment period, revision, and Council's approval, the statements are published as official positions of The Wildlife Society.

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Acknowledgments

In December 2003, The Wildlife Society (TWS) President Daniel Decker appointed a 6-member committee to review and summarize available scientific information relative to the impacts of baiting and supplemental feeding of wildlife. A sincere thank you is extended to each member of the committee for their active participation, commitment of time, and significant contributions in the successful preparation of this technical review. The respective employers are also thanked for their cooperation in allowing the committee members to work on this project. We thank The Wildlife Management Institute for its financial support in sponsoring monthly conference calls. The committee appreciates the efforts of the many individuals who reviewed, commented on, and provided advice and guidance on various sections of the report. These include Tom Franklin, Robert Brown, Paul Krausman, and Thomas Ryder for reviewing the first draft; Randy Davidson and Matt Knox for reviewing the section on wild ungulates; David Ley for reviewing the write-up on migratory game bird diseases; and Joseph Clark and Michael Vaughan for reviewing the section on bears. Finally, the committee is thankful to TWS Council for the opportunity to begin what is hoped will be a continuing, in-depth, and extensive effort to investigate and monitor the full spectrum of all wildlife species impacted by baiting and supplemental feeding.

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Synopsis

Baiting and supplemental feeding of wildlife are complex and controversial issues. Like other activities, when practiced at low prevalence and intensity, and when conducted properly by knowledgeable agency personnel, professionals, or responsible hunters, they can, in appropriate situations, provide beneficial effects. However, human nature, coupled with a lack of understanding of the potential risks and impacts, can quickly compromise limited benefits and create long-term negative impacts to species and ecological processes.

Several significant threats arising as a direct result of baiting and feeding are disease outbreaks, habitat degradation, habituation to humans, and alteration of wildlife behavioral patterns. The significant costs and implications of diseases, such as bovine tuberculosis (TB) and brucellosis, have dramatically and adversely affected ecosystems and society. Additionally, continuing political pressure stimulated by potential economic benefits has raised the issue to become a ballot initiative in some state elections. Baiting and feeding wildlife has become so popular — by deer and bear hunters, by professionals to rehabilitate elk populations, or recreationally for songbirds — that it has created negative ecological impacts and political questions.

The present debate has prompted this review of current knowledge and understanding of baiting and supplemental feeding activities. We explore the impacts these activities have on species behavior, physiology, and genetics and the issues they raise with respect to diseases, ecological integrity, economics, human health, and wildlife management on black bear (*Ursus americanus*), wild ungulates, and migratory and upland game birds.

Ultimately, the effects of supplemental feeding and baiting on public trust doctrine and fair chase bring baiting and feeding into the public arena where wildlife managers must make well-informed and educated decisions about its use. Unfortunately, there are no simple solutions to the issue of baiting and feeding wildlife regarding where it can be done, by whom, and at what scale. Some situations require flexibility for its use, while others require immediate and drastic measures for its elimination. Managers and policy makers must consider all facets of these practices, improve their understanding of the activities, appreciate potential threats and risks, and weigh these against the benefits that the practices may offer prior to passing judgment.

Introduction

Baiting and supplemental feeding of wildlife are practices ingrained in human culture, likely since prehistoric man first learned that putting food out for wildlife enhanced one's ability to harvest animals for food, fur, and other animal products. However, pioneers in the field of game management recognized pitfalls of baiting and supplemental feeding. Aldo Leopold (1933) writes of the need to regulate baiting whereas Durward Allen (1954) discusses the problems associated with "artificial" feeding, which he describes as " … management at the 'retail' level, that is dealing with individuals rather than populations." Nevertheless, baiting and supplemental feeding of wildlife are common practices throughout many areas of North America today, utilized by wildlife professionals, hunters, trappers, wildlife watchers, and people from all walks of life interested in attracting or potentially helping wildlife for a myriad of reasons, some sound and reasonable, others of questionable value.

Baiting and supplemental feeding of wildlife can have positive and negative impacts on both target and non-target wildlife species as well as on the people who engage in the practice. Awareness of the controversy over baiting and supplemental feeding was heightened in the 1990s with the discovery in Michigan that baiting and feeding of white-tailed deer (*Odocoileus virginianus)* significantly increased the spread of bovine tuberculosis in both deer and domestic cattle. The eastward movement of chronic wasting disease in deer and elk, a potentially long-term and devastating disease to wild and captive populations alike, has further heightened the debate over supplemental feeding. Likewise, the practice and ethics of baiting has become a politically and professionally charged issue in many states, discussed in legislative sessions and appearing on ballots and referendums. While many are scrambling to take actions designed to regulate baiting and supplemental feeding, other interests are equally opposed to legalizing, regulating, or eliminating these practices. Baiting and feeding of wildlife present major biological, ecological, legal, and regulatory issues, as well as social and ethical concerns, political and economic implications, professional wildlife debates, and challenges to the very core of human values. The issues are many, the stakes are high, and the solutions are not clear-cut, easy to address, or well understood by the public.

In response to the increasing concern and controversy over baiting and the supplemental feeding of wildlife, a technical review committee was appointed by TWS President Dan Decker to:

> "...review past and current research and scientific information related to baiting and artificial and supplemental feeding of game species. This review will summarize [in a paper] available information relating to the positive and negative effects of baiting and feeding of game wildlife on: 1. physical health of game animal individuals and populations (e.g., disease transmission); 2. animal behavior and wildness; 3. ecological integrity and habitat health; 4. human health and safety; 5. social implications; 6. non-target species; and, 7. ethics and issues of fair chase."

The committee's charge was limited to key game species because of the magnitude and complexity of trying to effectively address all wildlife species. Even then, the committee was forced to drop entire sections pertaining to alligators, raccoons, and beaver and no doubt missed many other game species. There was also a question about whether or not various habitat management practices such as food plot establishment, creation and management of wildlife openings, and unharvested agricultural crops or agricultural residue left in fields should be considered as form of baiting and supplemental feeding. Baiting and supplemental feeding as addressed in this report does not include or imply habitat management or agricultural practices.

For the purposes of this technical review, the committee adopted the following definitions based on the intentional placement of food for wildlife, one's intent to attract wildlife, and the duration of the action (i.e., baiting is short-term and supplemental feeding is long term).

Definitions

Supplemental feeding is the act of intentionally placing any food for use by wildlife on an annual, seasonal, or emergency basis with the intent of:

a) Improving the condition of individual animals (e.g. body mass, growth rates, antler size) or population performance (e.g. survival, fecundity, restoration, growth).

b) Providing additional food resources to wildlife in emergency situations when natural foods become unavailable or severely restricted due to natural or man-induced perturbations (e.g. periods of severe drought or winters, wildfire).

c) Attracting or luring wildlife to alternate locations to reduce damage to agricultural crops, livestock, and timber stands, or to reduce threats to human health and safety and;

d) Artificially attracting or concentrating wildlife to enhance recreational opportunities (e.g. hunter harvest, wildlife viewing, photography).

Baiting is the act of intentionally placing food attractants to manipulate the behavior of wild species for the purpose of:

a) Attracting wildlife to a specific location to enhance hunter harvest, trapping, or viewing opportunities;

b) Capturing and treating animals for control of infectious and non-infectious diseases;

c) Reducing or controlling overabundant native or exotic wildlife populations, invasive species, or problem wildlife that pose a threat to human health or safety, domestic animals, or private property;

d) Capturing wildlife for relocation or population augmentation and restoration and;

e) Capturing wildlife for implementation of research and management programs.

Biological Issues and Impacts

Wild Ungulates

History

Ungulate feeding in North America has been primarily directed toward white-tailed deer, mule deer (*Odocoileus hemionus)*, and elk (*Cervus elaphus*). In theory, providing supplements to ungulates should mitigate the effects of seasonal nutritional deficiencies. However, supplemental feeding has not prevented starvation of mule deer, elk, mountain sheep (*Ovis canadensis),* and pronghorn (*Antilocapra americana)* (Hunter and Yeager 1949) and in some situations, has increased it (Bartlett 1938, Gerstell 1942, Carhart 1943, Doman and Rasmussen 1944, Smith 1952, Keiss and Smith 1966). Poorly planned emergency feeding programs resulted in unsuitable food being fed to malnourished animals (Schoonveld et al. 1974, Wobeser and Runge 1975, Woolfe 1977, Mautz 1978, Robbins 1983, DelGiudice et al. 1990), which ultimately led to a general rejection of emergency feeding as a wildlife management tool.

In contrast to this conclusion, studies with captive deer demonstrated that these animals could be fed a diversity of supplements without causing nutritional or digestive problems (Nicol 1938, Davenport 1939) if what, when, and how they were fed was altered (Dean 1976, Ouellet et al. 2001). As knowledge of wild ungulate nutrition increased (Mould and Robbins 1982, Baker and Hobbs 1987, Spalinger et al. 1988, Hoffman 1989), supplements for deer (Ullrey et al. 1971, Baker and Hobbs 1985), elk (Robbins 1973), moose (*Alces alces*) (Schwartz et al. 1985) and other wild ruminants (Baker et al. 1998) became available for use by government agencies and private individuals.

Supplemental winter feeding of elk became entrenched in western North America in 1911 when Wyoming and the United States Congress began the first government-subsidized feeding program at the National Elk Refuge (NER) in Jackson Hole, Wyoming. Once restored, elk from NER were used to restock depleted ranges throughout western North America. Public and political pressure continues to promote the feeding of approximately 31,000 elk during most winters in Wyoming, Idaho, Oregon, Utah, and Washington. Elk are fed in winter to increase the nutritional carrying capacity of the habitat, to enhance hunting and viewing opportunities, to mitigate elk mortality during severe winters, and to alleviate damage to fences, crops, and motorist (Robbins et al. 1982, Smith 2001).

Behavioral Impacts

Few controlled investigations have been conducted to evaluate effects of supplemental feeding on the behavior of wild ungulates. Limited evidence suggest that an animal's behavioral response to food supplementation varies depending on objectives of the feeding program, level and duration of feeding, spatial distribution of supplements, and season of year food is offered.

Feed grounds create unnatural crowding and the potential for negative interactions (e.g. adult-fawn competition) (Boutin 1990, Easton 1993, Tarr and Perkins 2002). Social tolerance of supplementally fed deer was greatest during winter and spring and least during parturition. As herd density and crowding increased in fed populations, excessive neonatal mortality occurred among 2- and 3-year-old females (Ozoga and Verme1982). An important variable influencing social interactions on feed grounds is the quantity and spatial distribution of supplements offered. When provided in unlimited amounts to reasonably well-nourished animals, competition for food is minimal. Conversely, when limited amounts of food are provided in a patchy distribution to starving animals, adult males generally dominate all other deer, and mature does dominate yearlings and fawns (Dahlberg and Guettinger 1956, Ozoga 1972, Ozoga and Verme 1982, Barrette and Vandal 1986, Schmitz 1990, Grenier et. al. 1999).

The migratory behavior of deer appears to be minimally affected by supplemental feeding. There were no differences in timing of spring migration, home range size, or seasonal movements of free-ranging white-tailed deer when *ad libitum* quantities of supplement were offered year-round (Ozoga and Verme 1982). During emergency winter feeding in Colorado, mule deer voluntarily switched from *ad limitum* levels of supplemental feed to native forages as they became available in spring (Carpenter et al. 1984).

The social and migratory behaviors of elk are affected in a similar way to those reported for deer. Aggressive behavior of elk on feed grounds was minimal when *ad libitum* amounts of supplements were distributed over a large area. In contrast, restricted feeding resulted in dominance by adult males over females and all adults over calves (Boyce 1989). Elk easily habituate to feed grounds and feeding reinforces fidelity to these wintering areas. However, once feeding is suspended and natural forage becomes available, elk, like deer, resume normal migrations to intermediate and summer ranges (Smith and Robbins 1994).

Physiological Impacts

Wild ungulates in northern latitudes experience deep snow and cold temperatures that reduce food availability and increase energy expenditures during winter (Moen 1976, Hobbs 1989). These conditions coupled with sub-maintenance diets for extended periods can jeopardize survival. Population and habitat management offer a long-term solution to this problem (Gilbert et al. 1970), however, during severe winter weather, high mortality is frequently unrelated to population density (Wallmo and Gill 1971, Bartmann and Bowden 1984) and high levels of mortality can occur even on the best managed winter ranges (Crowe and Strickland 1984).

Supplemental feeding improved body condition and increased over-winter survival of free-ranging mule deer and pronghorn when fed at *ad libitum* levels during severe winters (Carpenter et al. 1984, Baker and Hobbs 1985, Lewis and Rongstad 1998, Bishop and White 2004) but had little effect during moderate winters (Lewis and Rongstad 1998). The magnitude of these responses was proportional to the duration and severity of winter and quality and quantity of available native forages (Mautz 1978, Hobbs 1989). However, when supplements were unpalatable, fed in limited amounts, or provided after deer had become malnourished, effects were minimally beneficial, absent, or detrimental (Anderson et al. 1975, Woolf and Harder 1979).

Captive deer consuming high levels of nutrients on a daily basis showed improved growth rates and body condition, increased fecundity rates, advanced dates of breeding and fawning, and lower post-partum fawn mortality rates (Verme 1963, 1965, 1969, Robinette et al. 1973, Ullrey et al. 1975, Sadleir 1980, Verme and Ozoga 1980, Ozoga and Verme 1982, Ozoga 1987). For captive male deer, supplements decreased the time to sexual maturity, increased antler mass, and prolonged antler retention time (Long et al. 1959, Robinette et al. 1973, Ozoga 1988). However, to our knowledge, similar investigations with free-ranging male deer and elk have not been conducted. We speculate that the high levels of nutrient intake of captive animals could not be achieved by free-ranging deer consuming native forages and therefore extrapolation of results is not valid.

Physiological responses of captive and free-ranging elk were similar to deer when consuming supplemental feeds that meet seasonal nutritional requirements. Supplemental feeding improved fecundity rates (Sadlier 1969, Mitchell et al. 1976, Oldemeyer et al. 1993), lactational performance (Arman et al. 1974, Loudon, et al. 1983, 1984), fetal growth rates, growth and development of calves (Thorne et al. 1976, Milne et al. 1987, Smith et al.1997, Smith and Anderson 1998), adult survival (Smith 2001), and enhanced sexual development and maturation of captive males (Suttie 1980, Wairimu et al. 1992, Kozak et al. 1994). However, birth weights of elk were not improved when elk were supplemented on summer ranges (Hudson and Adamczewski 1990, Smith et al. 1997), when ranges were overstocked, or when elk were fed supplements in limited quantities (Bailey 1999, Kimball and Wolfe 1979, Smith 2001).

Diseases and Parasites Associated with Baiting and Feeding

Supplemental feeding and baiting of wild ungulates alter epidemiologic risk factors associated with disease prevalence. The number and density of animals in a group and the frequency of contact between susceptible and infected animals strongly affect rates of spreading of infectious disease in a population. Transmission of infectious agents occurs through physical contact between infected and susceptible individuals, exposure to bodily secretions and aerosol droplets, and contact with contaminated surfaces (e.g. soil, feeders, or foods) (Martin et al. 1987, Thrusfield 1997). Feeding and baiting alter ungulate behavior and increase infectious disease risk by encouraging higher densities and repeated and prolonged animal presence at feeding sites. When an adequately infectious agent is introduced among susceptible animals at a particular threshold density, high contact rates facilitate disease transmission. Managing wildlife diseases involves understanding and controlling multiple interacting factors, often with limited understanding of disease etiology, detectability of diseased wildlife, and public understanding of disease management (Wobeser 1994). The examples below illustrate specific disease challenges relating to supplemental feeding and baiting of ungulates. In each case, feeding or baiting alters risk factors contributing to the maintenance and spread of disease. Because baiting and supplemental feeding alter epidemiologic risk factors applicable to transmission of a wide variety of pathogens, additional wildlife health issues stemming from these practices are conceivable.

Bovine brucellosis in wild ruminants is a zoonotic disease caused by the bacterium *Brucella abortus,* likely introduced to North America via domestic cattle (Meagher and Meyer 1994, Cheville et al. 1998, Thorne 2001). Clinical signs include lameness, abortion, and neonatal death. It is probably transmitted through ingestion of contaminated feed, oral contact with infected fetuses, placentas, fetal fluids, or vaginal exudates. *Brucella* can persist for months under cold conditions (Crawford et. al 1990, Thorne 2001). The United States Department of Agriculture (USDA) spent about $3.5 billion between 1934 and 1997 to eradicate the disease in livestock (Frye and Hillman 1997), resulting in only two states, Wyoming and Texas, not currently certified as brucellosis-free (Dean et al. 2004).

Brucellosis currently occurs in wild elk and bison in the Greater Yellowstone area (GYA) of Wyoming, Idaho, and Montana (Lanka et al.1992, Thorne 2001, Dean et al. 2004) and has strong epidemiologic links to supplemental winter feeding (Thorne et al. 1978, Thorne 1993, Smith 2001). Feed ground elk have an average seroprevalence rate of about 30% whereas elk wintering on native range have little or no brucellosis (Thorne 2001, Dean et al. 2004). It is generally believed that brucellosis is not self-sustaining in elk herds that are not concentrated on winter feed grounds (Cheville et al. 1998, Thorne 2001).

Brucellosis in elk and bison in the GYA may be transmissible to cattle (Lanka et al.1992, Cheville et al. 1998, Thorne 2001, Dean et al. 2004). Wyoming lost its brucellosis-free status in 2004 after the disease was detected in cattle that were likely infected by winter-fed elk (Dean et al. 2004, Wyoming Brucellosis Coordination Team 2005). In response, Wyoming established the Governor's Brucellosis Coordination Team to develop recommendations for ending transmission between cattle and wildlife, eliminating brucellosis in wildlife, and addressing the problems associated with feed grounds (Dean et al. 2004). Brucellosis control in GYA elk and bison is complex, costly, and controversial and may involve vaccination, population reduction, test and slaughter, and removal of feed grounds (Cheville et al. 1998, Wyoming Brucellosis Coordination Team 2005).

Bovine Tuberculosis (TB) is caused by the bacterium *Mycobacterium bovis* and has a wide host range, including humans, deer, many other mammals, and birds (Gale 1971, Winkler and Gale 1971, Clifton-Hadley et al. 2001). *M. bovis* is transmitted through respiration or ingestion of bacteria shed in bodily excretions (Palmer et al. 2001, Clifton-Hadley et al. 2001, Palmer et al. 2004). The persistence of *M. bovis* outside mammalian hosts is variable (Duffield and Young 1985, Jackson et al. 1995, Tanner and Michel 1999) but the bacteria can live up to 16 weeks on frozen deer bait/food (Whipple, unpublished data cited in Palmer et al. 2004).

Before 1994, TB was reported in fewer than 10 free-ranging cervids in the United States and infected cattle were thought to have been the source of the disease. TB was also documented and apparently eliminated in a population of elk, bison, and moose in Alberta in the 1950s (Corner and Conell 1958; Schmitt et al. 1997;

Clifton-Hadley et al. 2001). In 1994 TB was discovered in wild white-tailed deer in Michigan, the first known occurrence of a self-sustaining infection in free-ranging wildlife in the United States (Schmitt et al. 1997; O'Brien et al. 2002). Factors contributing to the outbreak likely included: 1) many TB infected cattle in the late 1950s, 2) a growing deer population, and 3) long-term feeding and baiting of deer (Schmitt et al. 1997, O'Brien et al. 2002, Miller et al. 2003, Palmer et al. 2001, 2004). Recent studies indicate that feed sharing and concentrating deer at feeding and baiting sites enhance spread of TB (Palmer et al. 2001, 2004, Miller et al. 2003).

TB has become a serious problem in Michigan. By late 2004 more than 126,430 free-ranging white-tails were examined for TB with 482 testing positive (J.S. Fierke, Michigan Department of Natural Resources, personal communication). Since 1994, TB confirmation in at least 33 cattle herds caused Michigan's "accredited-free of TB" status to be revoked in 2000 (Michigan Department of Agriculture 2004). Deer are the presumed source of infection for many if not all of these herds (O'Brien et al. 2002). Since 1995, TB has been confirmed in coyote (*Canis latrans*), raccoon (*Procyon Lotor*), black bear (*Ursus americanus*), red fox (*Vulpes vulpes*), bobcat (L*ynx rufus*) and opossum (*Didelphus virginiana*). The source of these infections is probably white-tailed deer (Bruning-Fann et al. 2001, State of Michigan 2004).

A second locus of TB infection exists in wild elk in the Riding Mountain region of Manitoba. The disease is likely perpetuated where animals congregate, particularly at hay storage, supplemental feeding, illegal baiting, and intercept feeding sites (Pastuck et al. 2002). Between 1991 and early 2003, TB was found in 11 nearby cattle herds. Surveillance of 3,273 ungulates between 1992 and 2002 confirmed TB in 10 elk and one white-tailed deer (Lees et. al 2003). Planned control measures include hay protection fencing to reduce cervid congregation and cervid-cattle contact, and stricter regulations on baiting and feeding cervids (Pastuck et al. 2002).

Chronic Wasting Disease (CWD) is a fatal, transmissible spongiform encephalopathy of cervids. White-tailed deer, mule deer, Rocky Mountain elk, and moose are the only species known to be naturally susceptible to CWD, although their subspecies may also be susceptible (Williams et al. 2001; Williams et al. 2002). CWD was first described in captive mule deer in Colorado in the late 1960s (Williams and Young 1992) and has since been diagnosed in captive cervid populations in 10 states and two Canadian provinces. CWD was documented in free-ranging elk in Colorado in 1981 (Spraker et al. 1997) and has now been diagnosed in free-ranging cervids in 11 states and two Canadian provinces. Epidemiologic data indicate that translocated cervids are the known or most likely source of infection in "new" geographic locations; however, other potential sources cannot be ruled out (Williams et al. 2001; Bollinger et al. 2004.).

Although details of its transmission are unknown, CWD seems to be transmitted directly between animals and indirectly via contaminated excreta, soil, or carcasses (Miller et al. 1998, Miller at al. 2000, Miller et al. 2004, Bollinger et al. 2004). During the course of the disease, CWD prions become progressively more abundant in the nervous system and gut-associated lymph tissues (Sigurdson et al. 1999, Spraker et al. 2002), suggesting that prions may be shed in saliva and feces. These excreta and infected carcasses may be an important source of infection (Williams et al. 2002; Miller and Williams 2003, Miller et al. 2004). In paddock studies mule deer contracted CWD when exposed to infected deer or areas where infected deer had lived or decomposed in previous years (Miller et al. 2004). Because CWD is readily transmitted among captive deer and elk, it is thought that CWD transmission may be facilitated among free-ranging cervids by concentrating animals through baiting and feeding (Williams et al. 2001; Bollinger et al. 2004).

Controlling CWD in free-ranging populations is a considerable challenge. There is no treatment or vaccine. Control is rendered difficult by the long incubation period, subtle early symptoms, persistence of the disease agent in the environment, incomplete understanding of transmission, and lack of a logistically feasible live animal test (Williams et al. 2002). Suggested management strategies include: surveillance for CWD in wild cervids and game farms, prevention of transmission between free-living and captive cervids, controlling cervid populations to achieve disease management objectives, regulating animal translocations, and avoiding concentrating animals by baiting and feeding (Williams et al. 2001; Bollinger et al. 2004).

Non-infectious Disease occurs when foods are contaminated with a toxin or incompatible with an animal's physiological state. Feeding and baiting alter disease risk factors related to feed type, quantity, and quality. Spoiled or moldy feeds may contain aflatoxins produced by fungi (genus *Aspergillus)*. Aflatoxins are immunosuppressive, hepatotoxic, and carcinogenic and can cause disease or death in wildlife, domestic animals, and humans (O'Hara 1996; Quist et al. 1997). Aflatoxins occur in grain products used and/or sold as wildlife feeds. Fischer et al. (1995) found that about 50 percent of the shelled corn samples collected from deer bait piles in the southeastern US contained up to 750 ppb aflatoxin. In samples of bagged, shelled corn purchased from Texas retailers, 44 percent exceeded 20 ppb aflatoxin, 20 percent contained levels ≥100 ppb and 8 percent of samples exceeded 300 ppb (Texas Parks and Wildlife 1998). These levels exceed maximums established for certain livestock feeds (FDA 1989). Aflatoxin concentrations may increase over time during storage and in wildlife feeders (Thompson & Henke 2000; Oberhau & Dabbert 2001).

Rumenal acidosis (rumenitis) may occur when ruminants eat large quantities of high-carbohydrate foods (e.g. corn, wheat, barley, sugar beets, and apples). In deer, diet change from high-fiber woody browse to low-fiber, high-carbohydrate foods may initiate significant changes in rumen micro flora and reduce rumen mobility which, in turn, causes indigestion, dehydration, diarrhea, toxemia, ataxia, and death. Recumbancy, staggering, or diminished activity may occur within 24 hours and in some cases death within 24 to 72 hours (Wobeser and Runge 1975; Woolf and Kradel 1977; Michigan Department of Natural Resources 2004).

Like rumenal acidosis, enterotoxaemia may occur when ruminants consume large quantities of high-carbohydrate feed. Increases in undigested carbohydrates in the lower digestive tract allow excessive growth of the bacterium *Clostridium perfringens* and the subsequent production and absorption of several potent toxins. Death may occur within 24 hours of grain consumption. There is no effective treatment for either rumenal acidosis or enterotoxaemia in free-ranging deer and elk because of the acute nature of illness and because the disease often goes unnoticed until animals are found dead (Michigan Department of Natural Resources 2004).

Genetics

Research addressing the impact of supplemental feeding on genetics of wild ungulates is lacking. The popular conjecture is that supplemental feeding lowers population quality by enabling less fit individuals to avoid selective, natural culling during severe winters. Since there is no empirical evidence either way, the conjecture cannot be supported or refuted. Clearly, research is needed to elucidate these effects, but the difficulty in defining and then measuring meaningful characteristics of population quality and fitness relative to supplemental feeding is a formidable research challenge.

Effects on Wildlife Management

Successful wildlife management often requires deciding when humans should intervene in natural ecosystem processes. One area of debate is whether wildlife managers and/or private individuals should offer food supplements to wild ungulates. While providing additional food may prevent starvation, enhance population performance, reduce property damage, and enhance recreational opportunities such as wildlife viewing and hunting, it may also lead to long-term habitat destruction, increased disease risk, and agricultural and property damage, as well as ultimately diminish the "natural" value of wildlife and wildlife-related recreation.

Use of baits or supplemental feeding to temporarily attract, concentrate, or alter movements of wild ungulates is a common tool used by wildlife management agencies. Ungulate management and research practices that incorporate baiting or feeding include trapping, administering vaccines or markers, assessing population parameters, and localized population reduction. Supplemental feeding of ungulates during periods of nutritional stress, intercept feeding to reduce agricultural damage, and feeding for wildlife viewing purposes are conducted or allowed by regulatory agencies in some states and provinces. There are disparate opinions among wildlife managers, scientists, and policy-makers as to the need for these practices, but given the complexity of management issues and regional differences a "one-size-fits-all" approach is not likely or practical.

Harvest of ungulates over bait as a public hunting method is practiced in 25 states (Michigan Department of Natural Resources 2005). Though difficult to quantify, the amount of bait placed for hunting purposes is estimated to be quite high in some regions. A 1999 survey indicated that about 400,000 Michigan deer hunters used bait (Frawley 2000). In Wisconsin, various conservative estimates include 4 million kg of bait placed by bowhunters in a given season (McCaffery 2000); 2 million kg of bait each day placed by an estimated 138,800 gun hunters in 2000 (Toso 2001); and 15 million liters of bait during the 2001 deer season in northern Wisconsin (Wisconsin Department of Natural Resources 2005). Fall bait sites in Michigan have been reported to contain about 45 kg of feed, whereas winter feeding sites ranged from about 900 - 18,000 kg of feed (Garner 2001).

Data from several states indicate considerable variation in hunter success rates when using bait. Surveys from Wisconsin and Michigan suggest a negative or relatively neutral relationship between hunting over bait and overall efficiency of harvesting deer, particularly among gun hunters (Langenau et al. 1985, Petchenik 1993, Michigan Dept Natural Resources 1999b., Bull et al. 2004, Wisconsin Department of Natural Resources 2005). In South Carolina, total deer harvest rates, female harvest rates, and doe-to-buck harvest ratios were higher, and hunter effort per deer and per capita deer-vehicle collisions were less in jurisdictions where baiting was prohibited (Ruth and Shipes 2004). In contrast, there is evidence of increased harvest success with baiting, especially among bow hunters (Langenau et al. 1985, Winterstein 1992, Bull et al. 2004, Wisconsin Department of Natural Resources 2005). In Texas, baiting increased success rates, reduced kill distance, increased crippling rates, increased deer observations when range and deer body condition were poor, and reduced the time required to harvest a deer (Synatzske 1981). In some areas, hunter success rate when using bait was dependent on the timing and duration of baiting, with earlier and longer baiting improving the chances of harvesting a deer with a firearm (Wisconsin Department of Natural Resources 2005).

Providing supplemental foods to wild ungulates for the purpose of increasing survival and improving body condition and/or reproductive performance is an agricultural management paradigm. It removes a given species from the context of the ecological community in which it occurs, and buffers the animal from normal ecological processes. Supplemental feeding of free-ranging, male wild ungulates to enhance trophy characteristics focuses on individual animals and is perceived by many to be a management tool for achieving maximum body mass and antler growth. To our knowledge, this perception is unfounded and has not been documented in the scientific literature. Emergency feeding of ungulates because of inadequate seasonal ranges may promote the erroneous idea that wildlife can be stockpiled beyond the carrying capacity of the range. If winter or summer range is insufficient, increasing survival by offering supplemental feed exacerbates the problem. Furthermore, supplemental feeding programs may contribute to a public perception that mortality of ungulates during winter or periods of drought is unacceptable or unnatural. Management agencies that commit to emergency winter feeding of ungulates may generate a public expectation that feeding will and should continue (Smith 2001). For this reason, "guidelines to define what constitutes an emergency, such as those developed in Colorado that specify when feeding is necessary … must exist before emergencies are declared" (Smith 2001).

Wildlife Viewing is a rapidly expanding outdoor recreational pursuit (Manfredo and Larson 1993, Dwyer 1994) that can be enhanced by using baiting or supplemental feeding to facilitate predictable viewing opportunities (Gill 2002).This growing contingency of wildlife enthusiasts have political clout that should not be underestimated by wildlife managers. In Wisconsin, stakeholders interested in recreational deer feeding used political pressure to overturn a statewide ban on supplemental feeding even though the ban was placed to reduce the spread of CWD. The stakeholders and legislature decided that recreational benefits of feeding deer outweighed the potential risk of increasing the transmission of CWD, particularly in areas where the prevalence of CWD was low (Heberlein 2004).

Supplementally fed wildlife can become habituated to feed and visitors. For example, elk on the NER feed grounds routinely allow visitors to approach within 10 to 15 meters without altering normal behaviors. However, supplemental feeding in these circumstances artificially concentrates and redistributes animals for extended periods in areas where they might not naturally occur, and at densities that natural habitats cannot support. Wild ungulates that are concentrated for viewing purposes may promote public interest in wildlife but also give the false impression that a particular species is plentiful throughout its range or that adequate range exists, and that food is the primary requirement for sustaining healthy populations. In addition, feeding that is condoned and practiced by management agencies may encourage private individuals to apply this practice as well.

Wildlife Damage: Use of intercept feeding to reduce agricultural damage by elk is practiced by the U.S. Fish and Wildlife Service at the NER and in several western states and Canadian provinces. Loss of elk winter range due to human land use patterns and subsequent reduced biological and cultural carrying capacity is one of the underlying reasons for feeding in some locations (Smith 2001).

Wildlife Habituation: Supplemental feeding alters normal avoidance behavior of wild ungulates toward humans and human activities. Food provisioning, together with human reinforcing behaviors that are consistent, repetitious, and either neutral or positive, can lead to habituation, loss of "wildness," and greater dependence on humans for survival. In some cases, the duration of habituation is short-term, lasting only during the period of winter feeding (Lyon and Ward 1982, Carpenter et al. 1984, Boyce 1989). In other settings, however, feeding by government agencies or private citizens deliberately or unintentionally can lead to long-term habituation and loss of wild behaviors valued by society (Peek 1984, Thompson and Henderson 1998).

Deer and elk habituate to using supplemental food sources and will readily use feeders, troughs, bait piles, and hay stacks (Ozoga and Verme 1982, Kozicky 1997, Smith 2001). Henke (1997) demonstrated that deer will visit feed sites when they hear the sound of a mechanical feeder in operation, and winter-fed elk in Jackson, Wyoming follow feed trucks as winter feed is distributed. Ungulates that are habituated to feeding sites become dependent on those sites, particularly during severe winter weather.

Urban and suburban deer problems testify to the ability of deer to adapt to human activity. The Colorado Division of Wildlife (2001b.) cite numerous cases of elk, moose, and deer attacks on humans which were caused by habituation. Suburban deer problems can be reduced by eliminating feeding, which in turn would reduce habituation (DeNicola et al. 2000). Not all feeding or baiting activities result in habituation to humans, and the degree of habituation is influenced by activities around the feed or bait site. Garner (2001) reported that baited white-tailed deer were quite wary and likely to switch to feeding only at night. Increased hunting pressure at bait sites also caused deer feeding activity to become more nocturnal (Synatzke 1981). Ozoga and Verme (1982) noted that deer remained cautious when they approached feeders though they frequented year-round feeding sites.

Ecological Integrity/Stewardship

Some advocates of supplemental feeding suggest that providing high quality supplements in times of nutritional stress will reduce an animal's dependence on native forages (Vallentine 1990). The fundamental premise is that animals will maximize nutrient intake by consuming highly nutritious and readily available supplemental diets, thereby reducing foraging impacts on less nutritious native plants (Stephens and Krebs 1986). Our review of the literature suggest otherwise. Concerns that supplemental feeding would result in long-term declines in habitat quality and quantity first emerged from the winter feeding experiences of the 1930s and 1940s (Bartlett 1938, Carhart 1943, Leopold et al. 1947). Doman and Rasmussen (1944) reported "feeding serves to concentrate deer in small areas year after year where animals do serious and possibly irreparable damage to native forage species, which in turn further reduces the carrying capacity of the range and makes deer increasingly dependent upon supplements." More recent investigations provide data in support of these conclusions (Hubert et al. 1980, Ozoga and Verme 1982, Schmitz 1990, Murden and Risenhoover 1993, Hehman and Fulbright 1997, Doenier et al. 1997, Williamson 2000). Results of these studies suggest that the degree of utilization of preferred forage species is largely dependent on the duration and severity of the nutritional stress, population density, and the quantity and quality of supplement provided.

The detrimental effects of high concentrations of elk on native rangelands and pasture crops adjacent to winter feed grounds are well-documented (Murie 1951, Craighead 1952, Kay 1985, Romme et al. 1995). Elk damage woody plants and have prevented regeneration of aspen by browsing (Krebill 1972, Hart and Hart 1989, White et al. 1998). Heavy browsing by overabundant wild ungulates also affects the distribution and diversity of other animal species, and eventually impacts ecosystem processes such as energy flow and nutrient cycling (Casey and Hein 1983, DeByle 1985, Briske and Heitschmidt 1991, DeCalesta 1994).

Detrimental effects of supplemental feeding on habitat are primarily associated with the practice of feeding on an annual basis. Emergency supplemental feeding programs may be a different situation. During severe winters, snow protects all but the tallest plants on critical winter range so that damage to the total plant population is minimal. Therefore, the frequency of severe winters may impose a natural rest-rotation grazing system, suggesting that emergency winter feeding programs restricted to infrequent severe winters may not significantly degrade habitat or lower the carrying capacity of the winter range (Gill and Carpenter 1985). More research is needed to elucidate the effects of infrequent emergency winter feeding on habitat quality.

Human Health and Safety Concerns

No direct link between baiting and supplemental feeding of wild ungulates and human health and safety issues were reported in the literature. Wildlife management agencies are concerned that baiting and supplemental feeding will concentrate animals at feed sites and possibly increase the incidence of deer-automobile collisions, zoonotic diseases (e.g., lyme disease and TB), and direct attacks of habituated wildlife on humans (Williamson 2000).

Economic Issues

Much of the controversy over the issue of baiting and feeding wild ungulates is whether the benefits justify the costs. To our knowledge, few studies have been conducted to evaluate the cost/benefit ratios of government-sponsored or private citizen feeding programs. Large sums of money are expended annually or periodically for the feeding of wild ungulates to enhance recreational opportunities, alleviate damage to private property, and mitigate winter mortality. Likewise, large sums of capitol and labor have been and are currently being redirected by state and federal agencies from productive wildlife management programs to monitor and mitigate the negative economic impacts of infectious pathogenic diseases. These are examples of positive and negative economic impacts associated with the feeding of wild ungulates:

a) In Colorado, the labor, materials, and maintenance to feed deer in winter averaged $53 per deer which was similar to the cost reported for feeding deer in Utah (Musclow 1984) and Michigan (Ozoga and Verme 1982). Using this figure together with an estimate of the number of deer saved from starvation by feeding resulted in a cost of $184 per deer saved (Baker and Hobbs 1985).

b) In Texas, McBryde (1995) determined the cost of supplemental feeding of deer to be $1.34 per acre ($3.31/ha) and suggested that food plots would be more cost-effective than feeding except during drought conditions.

c) The cost of feeding 7,500 elk for an average of 79 days per winter (over a 25-year period) on NER was estimated to be $337,488 per winter or about $45 per elk. These costs do not include the capitol cost of equipment required to distribute feed to animals during winter (Smith 2001).

d) Wyoming estimates annual costs to feed 14,000 elk approaches $1,250,000. An additional $250,000 is contributed annually to control and mitigate brucellosis in elk concentrated on feed grounds (Smith 2001).

e) Cost of ongoing elk feeding programs in Idaho, Oregon, Utah, and Washington are estimated to range from $35 to $112 per elk per winter. These costs do not include administration, contracting, or monitoring of the feeding program (Smith 2001).

f) In 1988, the costs of elk management in western Wyoming, where state and federal feed grounds are located, was estimated to be approximately $2.78 million compared to license revenues of $1.84 million.

g) The cost associated with maintaining elk populations at high densities by feeding may be offset by the revenue of hunting licenses, guide and outfitting services, wildlife viewing, and photography. During 1980, it was estimated that the guide and outfitting business alone generated $4.2 million dollars in economic activity in Teton County, Wyoming (Taylor et al. 1981). In addition, during 1973-85, over 5 million people visited the NER to view and photograph elk. Approximately 185,000 of these visitors paid private contractors over $415,000 for horse-drawn sleigh rides through feed grounds at NER (Boyce 1989).

h) In 1991, hunters in Michigan spent approximately $50 million to purchase bait for hunting deer (Winterstein 1992).

i) In 1995, baiting and supplemental feeding of deer in Michigan generated approximately $15 million for farmers and two to three times this amount for retailers (Williamson 2000).

Allocation of Funds: Natural resource agencies bear costs and derive income related to supplemental feeding and baiting. For example, expenses associated with winter feeding of elk on the NER include capital costs of heavy equipment, vehicles, wagons, buildings, equipment maintenance and fuel, purchase of feed, salaries for administrative and support staff, and biological monitoring. A portion of these costs are recovered as revenue generated by sale of elk licenses (Smith 2001). When undesirable events such as disease outbreaks exacerbated by baiting and feeding occur, natural resource agencies incur substantial financial costs related to disease management. These costs include salaries for administrative and field staff, equipment, time, and expense related to depopulation, disease monitoring, control and mitigation, and legal and public relations actions. Financial and personnel resources committed to unplanned disease management activities are diverted from their original purpose of habitat or population management and conservation (Heberlein 2004).

Summary

1. Supplemental feeding can alter the normal avoidance behavior of wild ungulates toward humans. This can lead to habituation, loss of wildness, and greater dependence on humans for survival. The duration of habituation can be short-term (lasting only during the period of feeding), long-term, or permanent, as in the case of year-round feeding by private citizens.

2. Social interactions of wild ungulates on feed grounds are highly variable and are determined largely by the quantity and quality of supplemental food offered and the density and nutritional status of the animals present. Migratory behavior appears to be minimally affected by supplemental feeding.

3. Feeding a nutritionally acceptable supplemental diet to captive and free-ranging wild ungulates can improve body condition, increase survival, and enhance reproductive performance. The magnitude of the response is proportional to the severity of the nutritional stress and the quantity and quality of available native forages.

4. With the possible exception of infrequent emergency feeding, supplemental feeding on an annual basis concentrates animals in areas where preferred food resources have been heavily utilized and can lead to long-term habitat deterioration and negative community-level consequences.

5. The use of baiting and supplemental feeding to enhance hunting opportunities is an acceptable wildlife management practice in many states and Canadian provinces. However, the success rate for hunters who use bait is highly variable and is influenced by timing and duration of feeding, and method of harvest.

6. Baiting and supplemental feeding alter epidemiologic risk factors linked to the spread and maintenance of diseases in wild ungulate populations.

7. Positive and negative economic impacts are derived from feeding wild ungulates. However, to our knowledge, no economic analyses have been conducted on a local or regional scale to determine whether the costs of feeding are offset by commensurate benefits.

8. Regional differences in ungulate management needs and traditions preclude development of a uniform baiting and feeding policy for state and provincial wildlife management agencies.

Upland Gamebirds

Behavioral Impacts

Concentrated food sources may change movement and behavioral patterns among upland gamebirds. In many states, baiting is considered to be such an attractant to upland gamebirds that the use of bait for hunting purposes is illegal. Schorger (1966) notes that historically, baiting for wild turkeys (*Meleagris gallopavo*) was common and was particularly effective when corn or other grain was placed in a trench. With this method, several turkeys could often be killed with one shot.
Relatively little information exists in the literature on the effects of baiting or supplemental feeding on the movement patterns of upland gamebirds, but anecdotal reports are common. In Georgia, T. Hughes (NWTF, personal communication) observed changes in roosting patterns of wild turkeys based on locations of chufa (*Cyperus esculentus* var.) food plots. There, the turkeys changed their preferred roosts as the location of the chufa plots changed, apparently in order to remain close to this preferred food source. Similar responses to permanent food plots have been observed for bobwhite quail (*Colinus virginianus*) (B. Sanders, Wade Plantation, Sylvania, Georgia; B. Palmer, Tall Timbers Research Station, unpublished data). In Texas, Guthery et al. (2004) found that home ranges of bobwhite quail with access to feeders were half that of quail without access to feeders. Bobwhite quail in Georgia showed similar home range reductions related to feeding (Sisson et al. 2000). In contrast, Madison et al. (2000) did not find home range reductions for bobwhite quail related to the availability of food plots.

Intraspecific competition has been observed among relatively isolated wild turkey populations at cattle feeding sites in Wyoming. Here, the larger, heavier gobblers (males) were observed out-competing the hens (females) for the available food. As a result, fewer and fewer hens were observed each year, and the surviving hens had difficulty nesting, apparently due to the inordinately high number of gobblers. In some cases these isolated populations consisted almost entirely of gobblers and eventually disappeared altogether (M. Zornes, Arizona Game and Fish Department, unpublished data).

The National Wild Turkey Federation (NWTF) regularly receives reports on the lack of wildness exhibited by “wild” turkeys that have become habituated to humans, often as a result of feeding, either intentional or incidental as the turkeys find backyard bird feeders. These turkeys may become a nuisance and in some states are subject to lethal removal (B. Eriksen, NWTF, personal communication). This problem has increased in recent years as turkey populations and suburban development have increased and the wildland/urban interface has grown. Many of these reports are from the Northeast, but the same problems have been reported from the Midwest, the inter-mountain West and even the Pacific Coast, especially California.

Physiological Impacts

Supplemental feeding has positive effects on reproduction for several galliform species. In a south Georgia and north Florida study in 1999 and 2000, bobwhite quail on areas receiving supplemental food were found to produce twice as many successful nests as quail on nearby areas that did not receive the supplements (B. Palmer, Tall Timbers Research Station, unpublished data). Bobwhite quail in south Texas did not increase production due to supplemental feeding (Doerr and Silvy 2002). In Great Britain, supplemental feeding during winter and spring months resulted in significantly improved body condition for ring-necked pheasants (*Phasianus colchicus*), increasing the likelihood of successful nesting (Draycott et al. 1998). In Texas, Pattee and Beasom (1979) used a commercial poultry ration to supplement the natural diets of wild turkey hens marked with patagial tags. Compared to marked hens on nearby untreated areas the hens receiving supplemental food produced 2.7 times more poults. Treated areas also had about 2.3 times more hens with poults than untreated areas. Brood size, though variable among years, was consistently greater on the treated areas than on the untreated areas. In Minnesota, access to corn food plots apparently contributes to increased productivity for wild turkey populations near the northern limits of their range (D. Kane, St. Cloud State University, unpublished data).

Not all productivity factors associated with supplemental feeding are positive, however. In an artificial nest study in Texas, Cooper and Ginnett (2000) demonstrated increased predation correlated with proximity to deer feeders. Raccoons were especially attracted to the feeders, and have been identified as serious nest predators of gamebirds such as quail and turkeys (Davis 1959, Speake 1980, Ransom et al. 1987, Williams and Austin 1988).

In some cases, supplemental food may increase survival and reproduction. While wild turkeys are able to tolerate extremely low ambient temperatures (Oberlag et al.1990) if they have sufficient fat reserves, they are only able to maintain those reserves for about 2 weeks. During periods of deep, powdery snow, which greatly limits their mobility, wild turkeys may not be able to reach natural food sources and may starve (Austin and Degraff 1975, Wunz and Hayden 1975). For supplemental food to be effective in reducing wild turkey mortality, it must be accessible and constantly available. Wunz and Hayden (1975) determined that grain spread on hard-packed roads was generally accessible by wild turkeys even during periods of deep snow, but that for it to be effectively utilized the turkeys must have become accustomed to finding food at the feeding locations. Emergency feeding did not prevent starvation mortality. In Pennsylvania, even after periodic winter losses of up to 60 percent, wild turkey populations normally recovered in 1 to 2 years (Wunz and Hayden, 1981). Other studies of northeastern wild turkeys also minimized the importance of winter mortality when compared to summer reproductive rates (Vander Hagen et al. 1988, Roberts et al. 1995).

Corn food plots have also been demonstrated to enhance overwinter survival of wild turkeys. In Minnesota, Porter et al. (1980) found that during winters with persistent deep snows, wild turkey populations relying only on natural foods exhibited over 60 percent mortality, but turkeys with access to corn food plots sustained less than 10 percent population mortality.

In contrast to the increase in survival associated with supplemental feeding and food plots demonstrated by wild turkeys, a study of bobwhite quail mortality in Oklahoma showed no difference in survival between quail with and without access to supplemental food. Differences were found in the distribution of cause-specific bobwhite mortality, but when data were pooled over months and years, no overall difference was documented (Demaso et al. 1998). In some areas though, supplemental food may make a difference in overwinter survival for bobwhite quail. On sandy soil sites in south Texas, supplemental feeding did improve bobwhite quail survival. On clay soil sites, no improvement in survival was demonstrated, leading to the conclusion that supplemental feeding was not effective when habitat structure was inappropriate or when food was not a limiting factor. No amount of supplemental feeding of adult bobwhites will increase fall quail numbers if the population is limited by the insect availability that is vital to chick survival (Doerr and Silvy 2002).

Disease and Parasites Associated with Baiting and Feeding

Corn that is deliberately left unharvested for a wildlife food source is another source of aflatoxin (Quist et al. 2000). Stewart (1985), in a 3-year study on bobwhite quail, reported that aflatoxin levels in standing corn ranged from 42 to 1,210 μg aflatoxin/kg feed and subclinical liver damage in quail was detected.

Short-term exposure of 4-month-old wild turkey poults to aflatoxins produced a multitude of effects including decreased feed consumption and weight gains, decreased liver-to-body weight ratios, serum chemistry alterations, leukocyte alterations, and diminished cell-mediated immune function similar to those effects seen in intoxicated domestic turkey poults (Quist et al. 2000).

Mycoplasma may be a problem for wild turkey populations that feed near domestic turkeys during winter. The disease is likely to spread from domestic to wild birds. A study conducted in the Uncompahgre Plateau in Colorado found that the wild turkey populations declined dramatically concurrent with the initiation of a 10-year (1963-1973) wild turkey study which included census counts using artificial winter feeding to concentrate birds. At least 4 of 31 feeding stations were on or near ranches and farms containing domestic turkeys, chickens, and other domestic avian species (Adrian 1984). Bait stations became yearly feeding stations and were maintained by landowners, sportsmen's groups, and Division of Wildlife personnel as a means of supplementing natural winter foods (Adrian 1984).

Although evidence for the negative impact of the winter feeding stations on the wild turkey populations of the Uncompahgre Plateau is circumstantial, the close proximity of at least four of these permanent feeding stations to domestic poultry is compatible with the spread of mycoplasma. Mycoplasma is spread by direct contact, airborne in dust or droplets, and through the egg from parent to offspring (Adrian 1984).

Guthery (1986) hypothesized that quail feeders may augment the transmission of avian diseases (through digestion of diseased birds' feces while feeding) by concentrating bobwhites around quail feeders. However, DeMaso et al. (1998) reported that no northern bobwhites were found to have died of disease during a study in Oklahoma investigating cause-specific mortality on quail using feeders. It can also be noted that separate game bird populations, when brought together for supplemental feeding/baiting, could possibly transmit any disease between those populations as a result of those populations mixing.

Genetics

No information was found connecting genetics implications with supplemental feeding and baiting of upland game birds.

Effects on Wildlife Management

Wild turkeys were extirpated from many areas during early westward human expansion (Dickson 1992). Bait was used in trench traps to catch wild turkeys that would be killed and sold for market. Due to the widespread use and efficacy of using bait for market hunting wild turkeys, Pennsylvania was the first state to ban baiting in 1869 (Schorger 1966). Today, use of bait is illegal when hunting wild turkeys in almost all states.

Similarly, early white settlers caught and sold large quantities of quail for market. Pennsylvania was also the first state to pass game laws pertaining to quail (Rosene 1969).

Supplemental feeding and baiting can also increase the degree of dependency/habituation by game birds to people. There is little evidence to support dependency/habituation to people in scientific literature. However, the following are some anecdotal examples. In Cambridge, Massachusetts, a wild turkey took up residence in Kendall Square for at least three months after people started feeding it. Jim Cardoza, a wildlife biologist with the Massachusetts state Department of Fisheries, Wildlife and Environmental Law Enforcement, stated that turkeys will follow utility rights of way, rivers, and parks into urban areas. Once there, they eat bird feed, acorns, and whatever people feed them (quote from article from Alcott 2003). In New Jersey, turkeys in urban areas have become habituated to humans as a result of people feeding them (B. Arawakan, NWTF, personal communication).

Aside from other considerations concerning feeding upland gamebirds, there are questions on the efficacy of delivering food to the target species and potential effects on non-target species. According to Guthery et al. (2004), feeders are an inefficient method of delivering food to bobwhite quail. Their results provide an estimate of efficiency of only 0.4 percent based on feeder-use time by bobwhites. At this rate, for every $250 spent on food in this study area, only $1 was consumed by the target species. By inference, the rest of the food must have been consumed by non-target species, with unknown but potentially significant effects.

Ecological Integrity/Stewardship

Food plot recommendations for upland birds have appeared in scientific literature for decades. Davison (1948) provided early details on establishing food plots for bobwhite quail to augment scarce winter food supplies. Schumacher (1969) stressed the value of food plots and recommended that landowners sacrifice as much as 5 percent of their land in order to grow an association of food and cover crops that will produce increased numbers and better distribution of quail. Supplementary plantings of chufa for wild turkeys have been recommended since at least the early 20th century (Stoddard 1936).

Private landowners have long perceived value in food plots. In some areas of the Southeast, entire plantations, often consisting of thousands of acres, are managed for quail and have been for generations, with food plots established as an integral part of the management strategy.

The value and use of food plots for some upland gamebird species have been documented for decades. Robel (1969) found that bobwhite quail living within 800 meters of food plots used them as feeding areas in winter and spring and maintained better condition than quail whose ranges were over 900 meters from food plots. Bogenschutz et al. (1995) found that hen ring-necked pheasants feeding in food plots of corn and sorghum had larger lipid reserves, with increased likelihood of winter survival, than hens not feeding in food plots. Porter et al. (1980) found similar results for wild turkeys using corn food plots. In addition to actual nutritional benefits from food plots, they may provide additional survival benefits by providing emergency cover. For sharp-tailed grouse (*Tympanuchus phasianellus)* in Wisconsin, Hamerstrom (1963) found that agricultural fields and food plots provided rare open areas in a heavily forested region and that these areas were vital sources of forbes and insects to the grouse, especially the chicks. Gabbert et al. (1999) stated that pheasants in South Dakota were able to find refuge from severe winter weather and deep snow in standing corn and nearby shelter belts, combining thermal protection with proximity to food.

Many common agricultural crops are planted for the benefit of wildlife. For Canada geese (*Branta canadensis*), metabolizable energy and digestibility of chufa, corn, and milo were highest among tested crops (Petrie et al. 1998). While geese aren't upland birds, it is likely that these results can be extrapolated to other avian species. Chufa ranked very high in nutritive value and digestibility for wild turkeys when compared to other fall and winter food items (Billingsley and Arner 1970). A number of seed-producing plants commonly recommended for quail food plots have also been shown to be relatively high in nutritive value (Madison and Robel 2001). Diets of cultivated foods can benefit turkeys when compared to wild food diets. Game farm turkeys consuming cultivated foods produced significantly more eggs than did turkeys fed a wild food diet, and a much greater percentage of the eggs were fertile (Gardner and Arner 1968).

Not all research on food plots has demonstrated positive effects for gamebirds. Madison et al. (2002) found that overall survival for bobwhite quail at Ft. Riley, Oklahoma did not differ between food plot sites and sites without food plots. However, there were differences in some areas in cause-specific mortality. Hunters harvested twice as many radio marked bobwhites on food plot sites as on sites without food plots. Some predators apparently keyed in on these food plots as well, with avian predation on bobwhites significantly higher near food plots. Mammalian predation on quail did not differ between sites. Guthery (1999), after evaluating energy-based carrying capacity for quail, concluded that quail populations are not normally limited by food supply, and therefore that management strategies (such as supplemental feeding and food plots) designed to increase food supplies are unnecessary.

Beyond arguments about the necessity of planted food items for upland gamebirds, whether from agricultural crops intended primarily for other uses or from food plots, there may be other risks to upland gamebirds from the planting process itself. In Kansas, O'Leske et al. (1997) compared invertebrate biomass among fields that were prepared using traditional farming practices (which are generally highly intrusive), low-input sustainable agriculture (LISA), where much less soil disturbance is required and native, tall-grass prairie. Since invertebrates (a high-protein food source) are the primary food item for the young of all upland gamebird species (Healy 1985, Hamerstrom 1963, Rosene 1969), practices that affect invertebrate populations on a large scale are obviously important. In general, traditional agricultural practices produced much lower invertebrate populations than either LISA or native tall-grass prairie. This implies that for upland gamebird populations where fall and winter food supplies are not limiting, plantings that supplant native vegetation (with associated high invertebrate production) may be a poor exchange. In Texas, Giuliano et al. (1996) found that while quail can at least partially compensate for dietary energy deficiencies by increasing food consumption, they cannot adjust their food consumption to allow for protein deficiencies in their diet.

Human Health and Safety Concerns

The Federal Aviation Administration reported that between 1991-2004 only 32 aircraft collisions occurred with wild turkeys out of 60,581 nationwide aircraft/wildlife collisions (National Wildlife Strike Database). Exact details of the strikes were not available. Although wild turkey strikes are few compared to the total number of bird strikes, it is not clear if supplemental feeding and baiting are involved. However, habitat around airports has proven, especially for other wildlife, to be a major contributing factor for wildlife strikes. Theoretically, when wild turkeys make use of any habitat (wildlife refuge) near an airport, planes run the risk of collisions with wild turkeys more so during the take off and landing of the aircraft.

Due to the lack of detailed information, there is no data on vehicle collisions with game birds. Collision reports generally categorize deer separately and group all other wildlife together.

Wildlife exhibiting aggressive behavior toward people can pose a problem for the public's personal safety. Non-urban wildlife has been known to visit urban areas on occasion and create a nuisance of themselves. When people feed wildlife, that wildlife becomes less afraid of humans. In North Dakota, wild turkeys have been harassing three small towns. In the winter months, the turkeys move into the towns to find food and are given handouts. The turkeys do not differentiate who will or will not give them food. If they don't get it, they harass the next available person (Lisa Shea, BellaOnline Birding Editor). This is especially a problem where birds have to endure harsh winters. People who supplemental feed during the winter months set up the scenario for wildlife to stay near the easy food supply and not move on when winter is over. Similar scenarios have occurred in New Jersey where turkeys exhibited aggressive behavior after becoming habituated to people through winter feeding (B. Arawakan, NWTF, personal communication).

Avian influenza viruses (AIV) are common among wild birds worldwide, particularly waterfowl and shorebirds, however they generally do not get sick from the virus. Certain types of AIV (e.g., H5N1) can cause widespread disease and death among some species of domesticated birds (e.g., chickens, ducks, turkeys). In the United States, from 1997 to 2005, there were 16 outbreaks of low pathogenic avian influenza A viruses (H5 and H7 subtype) and one outbreak of highly pathogenic avian influenza A (H5N2) in poultry. Infected birds shed the virus in their saliva, nasal secretions, and feces. Susceptible birds become infected when they contact contaminated excretions or surfaces that are contaminated. Avian influenza viruses do not usually infect humans, but since 1997 there have been more than 100 documented cases of human infection from domestic birds, mainly in Asia. People in contact with infected birds or contaminated surfaces run the risk of becoming infected themselves (Centers for Disease Control and Prevention). To the best of our knowledge, there have been only reported cases of upland game birds carrying AIV. However, the unnatural congregation of wildlife that results from supplemental feeding increases the possibility of disease occurrence and transmission, both within wildlife and human populations.

Game birds have not been documented to pass on disease to humans. However, when people increase their exposure to wildlife through supplemental feeding and baiting, they run the risk of possibly contracting a disease. As mentioned earlier in the diseases section, aflatoxins can also affect humans by causing cancer and mutations from being exposed to contaminated feed (www.icrisat.org)

Economic Issues

Wildlife-oriented recreation is economically important in the United States. *Responsive Management* (2003), from a nationwide survey of spring turkey hunters, reported that total retail sales of turkey-related equipment and activities for 2003 were about $1.8 billion, with a total multiplier effect of about $4.4 billion. Of the total retails sales, approximately $240 million was spent on habitat improvements, most of which was probably food plot-related expenditures.

Summary

1. The availability of concentrated food sources may change movement or behavioral patterns among upland gamebirds, including changes in roosting locations, home range sizes, and intraspecific competition (Sisson et al. 2000, Guthery et al. 2004).

2. Supplemental feeding may have positive effects on reproduction and survival for some upland gamebird species (Draycott et al. 1998, Pattee and Beasom 1979). Negative effects on production may also occur, as some predator species may be attracted to feeders or food plots (Cooper and Ginnett 2000).

3. Serious negative effects associated with feeding have been documented, including mycotoxin contamination of stored and scattered grain (Quist et al. 2000), loss of wildness due to increased human contact, and increased chances of disease transmission due to artificial concentration (B. Arawakan, NWTF, personal communication). Most reports of aggressive wild turkeys can be traced to birds that have become habituated to humans by feeding (B. Arawakan, NWTF, personal communication). Additionally, feeders may be inefficient at delivering food to target species, with unknown effects on non-target species (Guthery et al. 2004).

4. As compared to direct supplemental feeding, demonstrated benefits to upland gamebirds due to elevated levels of nutrition are derived much more naturally from habitat enhancement, including food plot plantings, without many of the negative effects associated with direct feeding (Robel 1969, Porter et al. 1980, Bogenschutz et al. 1995). As a management consideration, negative effects of cultivation on invertebrate populations should be weighed against positive effects of planted crops (O'Leske et al.1997).

5. For upland gamebirds in general, there are few human health and safety concerns. However, although transmission of disease from gamebirds to humans has never been documented, recently elevated concerns about avian influenza, its rate of spread, and its transmission to humans (Centers for Disease Control and Prevention), may dictate increased care in limiting unnecessary human/gamebird contact — both for the safety of humans and for the gamebird population.

Migratory Game Birds

Behavioral Impacts

Geese provide the best example of challenges that result from feeding migratory birds. When feeding and baiting occurs, wild geese often reduce and concentrate movements, resulting in habitat degradation.

The Acton Maine Town Council (ARTICLE 88: WATERFOWL Sec. 4-77) found it necessary to ban feeding or baiting of wildfowl because "the large number of fowl attracted by feeding and baiting in and around Acton increases the presence of harmful bacteria, which present a threat to public health and well being. Fecal matter from waterfowl contributes to the phosphate loading of water bodies thereby resulting in lessened water quality. Large numbers of waterfowl feeding, trampling, and defecating cause damage to terrain and constitute a nuisance and health hazard to citizens. The purpose of this article is to control the feeding and baiting of migratory and non-migratory waterfowl in order to protect the public health and property and the water quality of lakes, ponds, rivers and streams in Acton by reducing the amount of fecal matter from these fowl deposited in the water and on the adjacent shoreline and waterfront property caused in part by the feeding and baiting of these fowl by the public." Where non-migratory Canada geese are established, the problem is even worse, and such geese are often the subject of expensive depredation management schemes.

Snow geese (*Anser caerulescens*) have shown dramatic habitat use, dispersal, and migratory responses to changes in food availability along the Gulf Coast and southern parts of their winter and migratory range. Snow goose populations multiplied several times in the last three decades. Milakovic and Jefferies (2003) documented modification of sub-arctic tundra plant communities caused by snow goose herbivory and associated reduction of arthropod biomass that severely depleted foraging resources available to nesting shorebirds. Numerous other authors report similar findings (Chang et al. 2001), with significant impacts on arctic ecosystems, providing motivation to reduce continental snow goose numbers.

The Arctic Goose Habitat Working Group, noting human land use is a principal factor contributing to population increases, recommended a "no holds barred" effort to forestall catastrophic damage to arctic ecosystems. The Group's "Priority Recommendations" emphasized increased hunting pressure and included relaxing baiting restrictions in the harvest of snow geese. Increased harvests have potential to reduce population growth rates and eventually population size. Menu et al. (2002) reported snow goose population growth rates were closely tied to harvest rates. The difficulties of managing continental snow goose populations suggest that baiting will be and should be implemented to enhance harvesting rates.

Geese are well known for adapting both migratory and local movements to availability of food; this behavioral adaptation contributed to geese abandoning traditional migration patterns along the Atlantic coast from 1940-1980. This change was facilitated by conversion of truck farming areas to corn, wheat, and soybeans, favored by geese. As geese adapted to these farming practices, hunters and wildlife agencies began planting the same grains as supplemental feed to lure birds into management areas where they might be available to hunters. Hestbeck (1994) and Trost et al. (1986) detailed these historical changes in Atlantic Coast goose populations.

Trampling of vegetation and accumulations of droppings that over-fertilize aquatic habitats have been cited as examples of negative effects of supplemental feeding of Canada geese (http://www.dec.state.ny.us/website/reg8/wild/feedWFowl.html).

Physiological Impacts

The relationship of diet to body condition, reproduction, and migration is well documented in geese (McLandress and Raveling 1981and Bromley and Jarvis 1993). Energy and protein-rich foods are required at appropriate times at various phases of the life cycle of geese. Unfortunately, most hand-feeding of wild waterfowl by the public involves nutritionally depauperate items such as bread, popcorn, and cheese puffs, which birds eat in excess, and can cause starvation, although this is poorly documented. McLandress and Raveling (1981) reported the importance of hyperphagia prior to migratory movements and most supplemental feeding or even baiting of wild waterfowl involves corn, an energetically rich food that generally allows animals to add mass.

Reproductive success is nearly always enhanced by good body condition, hence supplemental feeding can contribute to reproductive success (McLandress and Raveling 1981and Bromley and Jarvis 1993) In Maryland, supplemental feeding of mallards released by the Department of Natural Resources appeared to increase their survival to 7 weeks post-release (Smith 1999). Supplemental feeding could modify the timing of migration and cause birds to move at inappropriate times or conditions. Supplemental feeding and enhanced survival of trumpeter swans (*Cygnus buccinators)* is believed to be a principal reason for their recovery (Baskin 1993).

Diseases and Parasites Associated with Baiting and Feeding

The family Anatidae is widely impacted by Duck virus enteritis (DVE), avian cholera, avian botulism, and necrotic enteritis (Friend et al. 2001). Continental populations of Northern pintail (*Anas acuta*) are regulated by disease, and pintails often comprise the majority of victims to botulism and cholera each year (Friend et al. 2001). Supplemental feeding and baiting has the potential to concentrate waterfowl in a small locality and bring species together that normally would not feed and spend time in close proximity. Such conditions are ideal for development and transmission of a variety of pathogens. In Virginia, domestic Muscovy and Pekin ducks were released on a residential lake and increased in numbers. Wild mallards (*Anas platyrhynchos*) and Canada geese arrived from nearby lakes, attracted to the available food. Subsequently hundreds of ducks and geese were residing year-round on the lake, contracted DVE, and died (Bowman 1989).

Duck viral enteritis was first confirmed in the United States in 1967. Only 10 months later, DVE caused an epizootic in migratory waterfowl (Converse and Kidd 2001). There were 120 DVE epizootics in 21 states through 1995, although the largest number of epizootics was among captive flocks. The largest number of mortalities was migratory birds, mainly ducks. Transmission between wild resident, wild migratory, and domestic waterfowl seems well established (Brand and Docherty 1988).

Aflatoxin has been reported in doves provided supplemental feed. Experimentally fed white-winged doves were unable to distinguish between aflatoxin-infected and aflatoxin-free grain (Henke and Fedynich 2001). Windingstad et al. (1989) reported aflatoxin from moldy peanuts was implicated in extensive losses of sandhill cranes in Texas and New Mexico. In addition, Robinson et al. (1982) reported snow geese and mallards dying from aflatoxicosis traced to waste peanuts, a major portion of the diet of wintering waterfowl in north-central Texas. Wintering waterfowl concentrated by limited habitat, supplemental feeding, or agricultural practices may be vulnerable to disease outbreaks. However, the situation becomes especially problematic when the food itself becomes toxic.

The South Carolina Waterfowl Association (SCWA) (http://www.scwa.org/main_mallards.html) supports restoration of waterfowl populations via release and supplemental feeding of captive, reared wild strain mallards. The SCWA (and companion North Carolina Waterfowl Association) is a membership organization that coordinates release projects on private lands. Diseases and parasites are likely shared among wild and released birds where supplemental feeding as used by SCWA and NCWA occurs. Additional scientific study is needed to determine the impact on wild birds.

Genetics

Philopatry in migratory birds could result in inbreeding in small populations (Robertson and Cooke 1999). McCorquodale and Knapton (2003) reported no evidence of genetic swamping among the large numbers of wintering black ducks (*Anas rubripes*) and mallards that were fed in Cape Breton Island Parks for more than 30 years. Although numbers of ducks varied over the years, changes were always synchronous, hence unrelated to feeding.

Hybridization is a recognized problem among ducks of the genus *Anas*, especially mallard, black, and mottled ducks (*Anas fulvigula maculosa*). Hybridization may threaten Florida's mottled duck where feeding of released mallards occurs, but more data are needed to confirm this problem (Gray 1994). Regular hybridization is observed among snow and Ross's geese (*Anser rossii*) (Trauger et al.1971), but rarely between snow and Canada geese (Prevett and MacInnes 1973). No data were found to suggest these events were related to baiting or supplemental feeding activities.

Effects on Wildlife Management

Supplemental feeding of migratory game birds has been used to aid recovery of threatened species (Yellowstone Coalition Web site). Trumpeter Swans were close to extinction in the early 20th century, and the establishment of Red Rock Lakes Wildlife Refuge in the 1930s and a winter-time supplemental feeding program enabled the number of trumpeters that winter in Greater Yellowstone to increase from 60 in 1931 to more than 2,000 in the early 1990s. The largest increase was in swans that spend the summer in Canada and winter in Greater Yellowstone. In 1990, for example, 800 swans filled about 5 acres of ponds at Red Rock Lakes, where they were fed grain. Managers decided to end supplemental feeding at Red Rocks in 1992 to encourage birds to disperse themselves among wetland areas throughout the inter-mountain West (Baskin 1993, Trumpeter Swan Society, /www.trumpeterswansociety.org/washington/hunting.htm). While artificial feeding and sanctuaries saved the population from extinction, they discouraged southward migration which is essential to long-term recovery.

Archibald (1978) also reported the use of supplemental winter feeding to bolster shrinking populations of five critically endangered crane species. Four Asian species have benefited and were perhaps saved from extinction by supplemental feeding programs. Further, Archibald and Mirande (1985) suggest the whooping crane (*Grus americana*) of North America might benefit from supplemental feeding on wintering grounds in coastal Texas if populations increase, because winter habitat is increasingly limited by development.

Ecological Integrity/Stewardship

Habitat impacts from burgeoning snow goose populations were described previously, but Sherfy and Kirkpatrick (2003) found strong evidence of the direct impacts of snow goose herbivory on resource availability for other birds. Invertebrate taxon richness and diversity and abundance of Chironomidae, Coleoptera, and total invertebrates were higher in goose-excluded sites than in adjacent impacted areas. These effects were most pronounced during January, February, and early April and suggest management actions to reduce local goose populations or deter feeding in impoundments may be warranted (Sherfy and Kirkpatrick 2003).

Seasonally flooded wetland impoundments planted to corn or other row crops are often used in managed wetlands on public and private lands, to provide food and resting sanctuary for waterfowl. Crops planted on such lands are incompletely harvested, so a "rental" percentage for migratory birds remains. On some of these landscapes, such impoundments also serve to attract waterfowl (or other species) for hunting.

Human Health and Safety Concerns

Land use changes, including fragmentation and urbanization, increase opportunities for contact between humans and wild birds and the potential for zoonoses (Friend et al. 2001). Waterfowl use of suburban and urban waterways is often initially seen as desirable because people enjoy close interaction with wildlife. However, conditions that bring wild birds or their excreta into close contact with humans create potential for disease transmission. Feeding and/or handling wild birds hold potential for transmission either among birds, or as zoonoses.

Kullas at al. (2002) isolated bacteria from urban Canada goose feces that were positive for human virulence factors, and suggested such data would prove useful in focusing attention on the risks that increasing populations of urban Canada geese pose to public health. Avian influenza (AI) is a disease of viral etiology that ranges from a mild or even asymptomatic infection to an acute, fatal disease of chickens, turkeys, guinea fowls, and other avian species, especially migratory waterfowl (Webster et al. 1992). Released, fed mallards establish conditions where infected wild birds, attracted to supplemental feeding, may interact in dense flocks and provide ideal conditions for disease transmission. As wild migratory birds make large scale geographic movements, spread is inevitable. If birds are fed and harvested, some human contact is assured. In recent years, AI has a potential zoonoses, as at least one strain has been contracted by humans (Beard 2005). Beard (2005) also reported "The AI viruses are Type A influenza viruses, and the possibility exists that they could be involved in the development, through genetic re-assortment, of new mammalian strains."

An influenza virus isolated from harbor seals that died of pneumonia had antigens of an influenza virus isolated from turkeys a decade earlier (Callan et al. 1995). The infection and deaths of six of 18 humans infected with an H5 avian influenza virus in Hong Kong in 1997 resulted in reconsideration of the portentous role avian species may have on the epidemiology of human influenza. There was no evidence to indicate that humans coming in contact with large quantities of the H5N2 virus during depopulation efforts in the human pandemic avian influenza outbreak of 1983 in Pennsylvania became infected with the virus. Schafer et al. (1993) concluded that "conserved counterparts of the human Asian pandemic strain of 1957 continue to circulate in the avian reservoir and are coming into closer proximity to susceptible human populations," suggesting a concern is warranted regarding human health.

Widjaja et al. (2004), considered wild aquatic birds a primary reservoir of influenza A viruses, so it seems the rapid evolution of viral strains present a continuing challenge to human and wildlife veterinary pathologists and wildlife managers (see also Webster et al. (1992) and Callan (1996). Callan (1996) concluded that influenza is an enzootic viral respiratory disease affecting avian and mammalian species and that interspecies transmission plays an important role in the ecology and evolution of influenza A viruses. H2N2 influenza A viruses caused the Asian pandemic of 1957 and then disappeared from the human population 10 years later.

Friend et al. (2001) concluded that anthropogenic influences on global ecosystems will challenge our understanding of and abilities to manage diseases that will impact wildlife and human health. Outbreaks of H5N1 in wild migratory ducks and geese were widely reported by the media in August 2005 in Russia and China.

Large birds always present a potential hazard to aircraft and have been implicated in tragic accidents. The Civil Aviation Authority (2002) reported bird strike data from around the globe indicating most strikes occur at less than 154 meters when aircraft speeds exceed 149 km/hr. Most strikes occurred during approach or take off. Similar results were presented by the American Federal Aviation Authority (1997) and Dolbeer et al. (1998). Apparently, birds can evade oncoming aircraft at slower speeds. Airports frequently conduct harassment activities to reduce the attractiveness of habitats in the vicinity of runways for wildlife. Geese especially are attracted to mowed grassy areas surrounding runways. Wildlife plantings used to attract wildlife should never be used near airports, although plantings and/or supplemental feeding might be used to draw birds away from airports under certain conditions. No references suggesting the latter were found.

Motor vehicles are seldom involved with waterfowl, except in urban areas. Resident Canada geese rather than migratory geese are usually involved (Afton and Paulus 1992). Flightless goslings following adults across roadways are particularly vulnerable to mortality, although adults may also be killed and motorists avoiding collisions may be injured.

Exotic mute swans and native Canada geese can be aggressive when protecting nests and may injure children or adults by direct attacks with flailing wings. Numerous brochures and signage in public areas warn visitors of such behavior, but documentation in the literature could not be found. Conover and Kania (1994) reported threat behavior by mute swans but no actual attacks.

Economic Issues

Revenues from hunting waterfowl and other migratory birds represent significant input to regional and local economies. In 1996, The General Accounting Office (GAO) reported that national migratory bird hunting regulations collectively have an economic impact in excess of $400 million in direct expenditures. Mississippi (Grado et al. 2001) reported waterfowl hunting generated $27 million during the 1998-99 season and considered this estimate conservative because it did not include private land or blind leasing fees. These results suggest that the GAO estimates are conservative.

Summary

1. Continental populations of snow geese are exploding and increased pressure on habitats in arctic breeding grounds is severely damaging arctic ecosystems. Baiting is highly recommended as a tool to attract geese to hunters (Milakovic and Jefferies 2003, Chang et al. 2001, Menu et al. 2002, Hestbeck 1994, and Trost et al. 1986).

2. Feeding geese reduces movements, concentrates activity, and causes vegetation and terrain damage; feces accumulation constitutes a nuisance and health hazard to citizens and birds, and aquatic habitats are over-fertilized. (Kullas at al. 2002).

3. Supplemental feeding and baiting creates conditions ideal for development and transmission of pathogens. When released birds are fed with migratory wild birds, exchange of dangerous pathogens is likely. Duck viral enteritis and other pathogens may control continental populations of some species, and avian influenza is a particularly dangerous virus with pandemic capability in humans (Friend et al. 2001, Bowman 1989, Converse and Kidd 2001, Webster et al. 1992).

4. Body condition in migratory birds is correlated with migration and breeding success and supplemental feeding or baiting can be an important management tool. (McLandress and Raveling 1981, Bromley and Jarvis 1993,

Baskin 1993, Archibald 1978, Archibald and Mirande 1985).

5. Geese are a hazard to aircraft and supplemental feeding can be used to draw birds away from airports to minimize hazard. (American Federal Aviation Authority 1997, Dolbeer et al. 1998).

Black Bears

Of the three species of bear that reside in North America, grizzly/brown (*Ursus arctos*), black (*Ursus americanus*), and polar (*Ursus maritimus*), neither grizzly/brown or polar bears are lawfully or intentionally baited or fed for the explicit purposes of harvest or bear-watching, with rare exceptions. A recent exception occurred when the Alaska Department of Fish and Game (2005) began issuing special permits to resident hunters in a specific Management Unit to allow the use of bait for the purpose of harvesting brown bears to augment the established wolf (*Canis lupus*) control program in an effort to reduce moose predation and allow the moose population to recover. Occurrences of baiting and feeding for hunting and viewing of grizzly/brown and polar bears are circumstantial, and therefore we focus on the impacts of baiting and supplemental feeding of black bear in this report.

Baiting and supplemental feeding of black bears is a complex and controversial issue evident by the numerous challenges, ballot initiatives, and referendums in recent years in numerous states and provinces to ban its use, most recently in Alaska and Maine. Some states have banned bear baiting, (i.e., Colorado, Oregon, and Washington), while others have defeated political initiatives. The types of baiting (legal and illegal) and supplemental feeding for black bears ranges from the use of large (up to 907 kgs.) waste candy blocks, pallets of waste bubble gum, waste donuts, sweet rolls and bakery products, and other sugar-based baits for the purpose of "sugar-hooking" bears, to cereal grains such as corn, fish, or meat baits in varying stages of decay. The use of prepared pellet (bear) feed is used in feeders within parts of the Pacific Northwest to reduce significant bear damage to timber resources.

Some regulatory and management agencies feel that adequate black bear harvest cannot be attained by sportsmen without the use of baiting or supplemental feeding, while others have actually seen an increase in hunter participation, and experienced increased harvest of bears during regulated seasons despite the prohibition of baiting and supplemental feeding. There are varying restrictions on baiting and the types and amounts of bait or feed that can be used in different jurisdictions across North America, as determined by state or provincial agencies or as mandated via legislative decree.

Behavioral Impacts

Pelton (1982) reported that black bears are normally solitary animals except for female groups, (adult females and cubs) breeding pairs in season, and congregations at feeding sites. Black bear home range size and shape is primarily determined by the capability of an area to provide the animal's annual needs (Hamilton 1978, Garshelis and Pelton 1980). Home ranges are also somewhat dependent on factors such as age, sex, season, and population density. For example, some black bears have been known to move over 160 km to take advantage of isolated pockets of available food (Rogers 1977). Home ranges differ significantly by state and region, although the home range size of adult males is consistently 3 to 8 times larger than that of adult females (Pelton 1982). Concentrations of mast (hard and soft) or supplemental food sources directly or indirectly provided by people (Rogers 1977) provide the stimulus for extensive movements and temporary range expansion, suggesting that home ranges and movements of black bears can be significantly impacted by the availability of preferred foods — especially during periods of mast failure, drought, or other factors which cause natural food shortages. Dobey et al. (2005) also found that bear use of corn from deer feeders was the most probable reason for smaller home ranges, greater body masses, and increased reproductive output on the Florida study area as compared to a nearby study area in Georgia where baiting and supplemental feeding was prohibited.

Numerous studies have documented that bears provided with a high-energy diet, whether through baiting or supplemental feeding, through foraging at garbage dumps or where other year-round food sources are available, can substantially increase cub productivity and survival, e.g. Rogers (1976), Partridge et al. (2001), and Herrero (1983).

Ziegltrum (2004) concluded that a supplemental bear feeding program in western Washington efficiently reduced conifer damage and was a viable, non-lethal method. Another study by Feresterer (et al. 2001) of black bear movements in an area of extensive supplemental feeding indicated that bears did not significantly alter their home range size as a result of seasonal feeders being present. However, there were indications that individual bears significantly altered their travel and movement patterns to use feeding stations, which attracted and concentrated bears at specific locations.

Other authors found that intensive or high levels of baiting and supplemental feeding of black bears can cause serious behavior modifications that influence home range size and movement. Home ranges of bears addicted to waste candy block baits were significantly smaller than those not habituated to such bait (T.Langer, North Carolina State University, personal communication). Beckman and Berger (2003) studied urban versus wildland black bears and reported that feeding wildlife caused urban bears to experience: (1) a 70-90 percent reduction in home range size; (2) an average 30 percent increase in body mass; (3) greater than 3X increases in densities; (4) a depopulation from wildland areas; (5) heavily skewed sex ratios toward males in urban areas; and (6) changes in female reproductive success. This study suggested that shifts in behavior are caused by direct disruption from human activities, but also to anthropogenic sources of food. Although they conclude that jurisdictions should pass legislation prohibiting the feeding of bears or other wildlife, some conclusions (i.e., depopulation) have been questioned by other bear biologists.

Black bears typically make their way to denning sites each winter and hibernate for a few weeks to 7 months, during which gravid females give birth to cubs. Telemetry data on black bear obtained from a study in the Pacific Northwest (Fersterer et al. 2001) indicated bear movements were less extensive when feeders were used during the season when most timber damage generally occurred, and that bears significantly altered travel patterns to use feeding stations. In parts of the southeastern United States where feral hog populations are common in black bear range there is some interspecies competition, however, in most cases, bear population density is low enough that bait or supplemental feeding does not increase this marginal interspecies competition. Where black bear and grizzly/brown bear ranges overlap there is likely serious competition for some seasonal food. However, it is not known how much, if any, of this is due to baiting or supplemental feeding. Depending on the bait or feed used, there is very likely some interspecies competition for available food, but aside from feral hogs, a variety of birds, and other mammals taking some of the bait or feed, it does not appear to cause any significant interspecies competition.

There are occasional reports of black bear mortality attributed to cannibalism or infanticide (LeCount

1982, Schwartz and Franzmann 1991) by males toward younger bears, as well as antagonistic behavior toward conspecifics as well as humans. Where an abundance of food is located in a general area, bears tend to congregate and reduce their "personal space" requirements. They also form social hierarchies, and females with cubs tend to segregate themselves, apparently to avoid bears that may kill or endanger their cubs. However, Nolte et al. (2000) reported that in an area of high density feeders, there was no indication of intraspecific competition by black bears observed, either between sexes or by different age classes. They concluded bears were not competing with each other for food.

Numerous non-target species sometimes use bait and supplemental feed intentionally placed for specific target species. For example, Guthrey et al. (2004) noted that non-target species made up 98 percent of feeder visits. However, there is very little information in the scientific literature that quantifies the biological or ecological impacts of baiting and supplemental feeding on these non-target species. Conner et al. (2004) pointed out that the use of supplemental feeding for northern bobwhite quail in south Georgia reduced the size of home ranges for some small mammals and increased populations in areas of supplemental feeding. Their data suggested that spatially subsidizing quail through supplemental feeding can result in increased localized densities of small mammals. Although a study by Godbois et al. (2004) found little evidence that bobcat home-range sizes were affected by the availability of supplemental food for quail, they did observe a spatial response to the food for bobcats and other quail predators. Non-target species of wildlife are attracted, both visually and via olfactory senses, to specific kinds of bait and supplemental food placed for bear, and home ranges of some species are likely affected during the period that bait or food is available.

Dobey et al. (2005) noted that people feeding deer with corn have significantly altered home ranges and feeding behavior of black bear in the Osceola National Forest. T. Langer (personal communication 2004) reported that waste candy baits containing Theobromine and used for bear baiting to be toxic and possibly fatal to non-target species, including canids, wild fowl, poultry, domestic animals, hares (Lepus spp.), and rabbits (Sylvilagus spp.). Gray et al. (2004) reported that most respondents to their survey of bear hunters (77 percent of 133) identified 14 other animals that consumed food from bear baiting sites, including (by order of percent use) raccoon; squirrel (Sciurus spp.); raven (Corvus corax); whitetail deer; red fox, gray fox (Urocyon cineroargenteus); turkey; bobcat; coyote; opossum; crow (Corvus brachyrhyncos); mice (Peromyscus spp.); striped skunk (Mephitis mephitis); eastern chipmunk (Tamias striatus); and various songbirds. Raccoons frequented feeding sites most often and 90 percent of sites were used by them. With the recurring raccoon rabies epizootic in the eastern United States, this presents a potentially significant source of disease transfer.

Black bears are somewhat plastic in daily movements, except during breeding season or when food is made available at certain times of the day near or in areas of human activity. Bridges et al. (2004) noted that black bears were generally diurnal in summer and nocturnal in autumn, with a vespertine activity peak in both seasons. Baiting and feeding may cause individuals to become distinctly diurnal (on roadsides) or nocturnal (in campgrounds) as reported by Pelton (1982). Bears are notorious for taking advantage of careless human storage of food, bait, or garbage. Human-bear conflicts are best resolved by insisting that unnatural food sources created by humans are not made available to black bears (Pelton 1982). There are thousands of documented cases of black bear interactions with people (e.g. national parks campsites, hikers, people feeding bears, or the baiting of bears for wildlife-watching); most interactions are usually associated with purposefully or inadvertently feeding bears (Conover 2002).

Gray et al. (2004: page 194) reported that "feeding bears may increase their chance of becoming food-conditioned and habituated to people. Human scent undoubtedly remains at feeding sites after restocking by humans, and bears likely associate humans with the food they find at baiting sites."

"Habituated and food-conditioned black bears rarely revert to wild behavior: once persistent nuisance behavior is learned, animals usually have to be relocated long distances to remote areas or destroyed" (Poulin et al. 2003: page 21).

Because wildness and behavior of black bears can be influenced significantly by baiting and supplemental feeding, some jurisdictions have taken measures to address its negative impacts. In North Carolina, a resolution was passed (North Carolina General Statute 113-292.1 (b)(2)) to interpret more strictly the state's bear-baiting statute. This law prohibits "the taking of bears with the use or aid of any salt, salt lick, grain, fruit, honey, sugar-based material, animal parts or products, or other bait." Additional information provided by Cobb (2004a) indicates that around bait sites where candy blocks weighing up to 907 kg had been used, bears with both health and behavioral problems were commonly observed. Some bears observed around these sites displayed no fear of humans and were in such poor physical condition that they ignored the presence of people. The emergency resolution was determined to be necessary because of the negative impacts on bear health, their habituation to the bait sites, abnormal behavior, and the influence of excessive harvest near bait sites.

Physiological Impacts

Providing a high energy diet through year-round supplemental feeding may enhance milk production in female bears and improve cub survival. Rogers (1976) found black bears feeding on a protein-rich food source had significant weight gains and increased fecundity, particularly when high-quality bait or feed was accessible throughout the year prior to denning. Partridge, et al. (2001) summarized that supplemental feeding of black bears briefly in the spring appeared to be a worthwhile management option to reduce tree damage and does not appear to influence physiological condition. Herrero (1983) suggested in Jasper National Park, Canada, bear reproduction may have been positively influenced by feeding at dumps, and Rogers (1976) found that bears that fed at dumps in Michigan had far better reproductive success than bears that ate only natural food.

Dobey et al. (2005) found the mean annual home-range size for female Florida black bears with access to corn deer feeders was almost half that for females in the Okefenokee National Wildlife Refuge, less than 81 km from the Florida study site. Corn from these deer feeders used extensively by bears was the most probable reason for smaller home-range sizes, greater body masses, and increased reproductive output of bears on the Osceola study area. Dobey et al. (2005) also noted that corn feeders for deer provided bears with a consistent and abundant food supply comprising 37 percent of their annual diet. They summarized that the buffer corn provided was the likely reason for higher and more stable reproductive output among females in the Osceola study area, and higher average weights of bears prior to den entry. Other researchers have also found strong relationships between food availability and cub production (Rogers 1976, Elowe and Dodge 1989, McDonald and Fuller 2001) while others have demonstrated similar physical or demographic effects of supplemental feeding on bears (Landers et al. 1979, Partridge et al. 2001).

Conversely, Langer (2004) and Cobb (2004a) reported that bears at candy blocks had badly damaged teeth and appeared stressed, (i.e., moaning and unable to get to their feet when approached by observers). Robbins et al. (2004) suggested that baiting or supplemental feeding of bears may result in artificially high bear populations, or in higher skeletal-lean body mass size. Intuitively, such unhealthy conditions could have a negative effect on both bear reproduction and bear health in general.

Diseases and Parasites Associated with Baiting and Feeding

Supplemental provision of food/bait to wildlife has been implicated as a causative factor that increases the occurrence of infectious and non-infectious disease. There are a number of neoplastic, rickettsial, viral, and traumatic diseases reported for black bears, as well as numerous internal parasites, yet none appear to contribute significantly to the natural regulation of bear populations (Davidson and Nettles 1997). There was no literature that documented transmission of infectious diseases linked to baiting or use of supplemental feeding sites, although increased densities of bears around bait sites is a cause for concern. There may also be a potential of rabies transmission from the high incidence of raccoon use of bear baits. The high incidence of non-target species frequenting bear baiting sites suggests that diseases could be transmitted among these species at bait or feeding sites. While bovine tuberculosis and chronic wasting diseases have not been shown to impact black bears, the general principle of enhanced transmission of infectious disease, disruption of traditional movement patterns, and alteration of community structure might relate to bears in the long-term, adversely affecting the health of bear and human populations (Fischer 2003).

Black bear are rarely mentioned as major hosts or causative species for the spread of zoonoses such as rabies or trichinosis; however, there is concern as noted by Fischer (2003). The literature does report 25 genera and 37 species of endoparasites, and 8 genera and 12 species of ectoparasites for black bears (Pelton 1982). No evidence was found to link disease or parasite transmission to bait or supplemental feeding sites. Further research may provide additional insight, particularly given the diversity of non-target wildlife species frequenting bear bait sites that are also host to parasites known to be transmissible to bears.

Genetics

There was no information located that linked baiting or supplemental feeding with concern about genetic diversity/variation or hybridization and genetic introgressions. In areas with remnant black bear populations and some threatened subspecies, there may be strong concern that recovery may be partially limited by a lack of genetic diversity.
Where certain black bear population densities are reduced to remnant populations, threatened subspecies such as Louisiana black bear *(Ursus americanus leuteolus*) are subject to inbreeding concerns. Since baiting for other wildlife species is legal in Louisiana, there are occasions where this subspecies of bear is affected by baiting activities. A case in point is a Louisiana black bear that became habituated to bait and had to be removed from the marginal population and institutionalized in the Jackson, Mississippi Zoological Park (Rummel 2003).

Another factor that may be difficult to quantify is the number of bears harvested illegally with the use of bait intended for other species. Recent wildlife cases from both Florida and Louisiana report people harvesting bears while hunting over deer bait or supplemental food. Both Florida and Louisiana currently allow baiting for white-tailed deer, which often attracts bears. With both the Louisiana and Florida black bear (*Ursus americanus floridanus*) subspecies population being threatened and of heightened interest, this mortality is of great concern. In these situations where bait was a contributing factor to illegal harvests of a protected species, the impact on non-target species is significant (Florida Fish and Wildlife Conservation Commission 2004). Nowhere else have bear populations become more fragmented than in the Southeastern United States (Pelton and van Manen 1997). Only 5-10 percent of former bear range in the Southeast is currently occupied, making these animals especially vulnerable to genetic inbreeding, habitat loss, and over-harvest, (Dobey et al. 2005). This is of great concern among biologists and managers in the Southeast with remnant populations of Louisiana black bear and Florida black bear.

Effects on Wildlife Management

Black bear harvests throughout North America are affected significantly by the use of bait and supplemental feeding. Paquet (1991) reported the number of black bear killed by hunters over bait at Riding Mountain National Park, Manitoba is high, and based on low reproductive potential of black bears, this mortality from hunting is likely to be unsustainable. After a prohibition of hunting black bears in Colorado in 1993, annual harvest rate changed only marginally, the hunter success decreased, but the hunter participation increased (Beck 1997). Since 1993, annual harvest has averaged 563 bears compared to an average of 551 annually from 1985 to 1992 (Colorado Division of Wildlife 2001a) when baiting was allowed. Following a prohibition of hunting black bear over bait or with dogs in Oregon in 1995, hunter success decreased from 8 percent before prohibition to 4 percent after prohibition, whereas the number of hunters per year increased 71 percent over the same period (Gore 2003). In Arkansas, the long-term management goal for black bear is a 10 percent harvest of the population. Prior to 2001, harvest was incidental and insufficient to achieve the 10 percent goal. However, as the bear population increased and expanded, incidental harvest was felt to be inadequate and human-bear conflicts increased. Baiting was implemented in 2001 as a short-term mitigation strategy to minimize human-bear conflicts and to help achieve 10 percent annual harvest (Eastridge 2003). The 2001 harvest increased to 372 bears, compared to the previous harvest record of 207 bears in 1996 when baiting was prohibited. In 2003, with baiting continuing to be legal, 309 bears were harvested; 203 were reported not to have been killed over bait and 106 which were reportedly killed using bait. The bait most commonly used for bears in Arkansas is corn.

There have been numerous surveys conducted in many states regarding hunters' perceptions of baiting as an acceptable hunting technique. These and other surveys have produced widely disparaging results, influenced significantly by where the survey was conducted. As an example, Cobb (personal communication 2004) indicated that bear harvest data for one county in North Carolina indicated that 26 bears (14 percent of those harvested in the entire county) were harvested in one 372 hectare area where there were several of the candy blocks. Some of these bait blocks weighed close to 907 kg's. and were placed prior to the North Carolina Wildlife Resources Commission's emergency resolution prohibiting the use of sugar-based baits. The use of bait clearly influenced this abnormal concentration of bears during the hunting season. A spokesman for the North Carolina Bear Hunters Association voiced strong opposition to the use of the candy blocks as bear bait due to concern for extraordinary bear densities as well as from an ethical standpoint (NC Wildlife Resources Commission News Release, October 7, 2003).

There is disagreement about the use of bear baiting among professional wildlife biologists. The Maine Chapter of The Wildlife Society's (TWS) position on the 2004 Bear Referendum was opposition to a proposed ban on baiting. Other Position statements by TWS Chapters, (e.g., Virginia, Mississippi) oppose baiting except when used by wildlife biologists to achieve specific management purposes.

The issue of artificial versus supplemental feed in relation to black bears is summarized by Pelton (1982). He noted that ultimately the most effective management should be aimed at the human side of the problem — making unnatural food sources unattainable to the black bear. As noted by Nolte et al. (2002), even in the presence of high densities of bear feeders loaded with high quality food pellets, bears sometimes avoided the feeders and concentrated for short periods on natural foods when they were available in abundance. However, feeding stations attracted and concentrated bears at high densities in specific locations, with up to 18 different bears frequenting one feeder.

Wherever black bears exist, they have a strong tendency to adapt to the presence of people if allowed to do so. The most effective deterrent to human-bear conflict is avoiding the temptation of making unnatural food sources available to bears. Bears habituated to feeding sites become dependent on the availability of abundant food sources and those coming in contact with people are likely to ignore their presence unless threatened in some way. There are numerous records of people feeding bears and having resultant bear threats or aggressiveness that causes negative human-bear interactions, (Weaver 1999). "A fed bear is a dead bear" as quoted by Williamson (2000) from a New Hampshire Fish and Game Advisory, because so many fed bears become nuisance bears and their habituation to either bait or supplemental feed result in human-bear interaction problems. Gray et al. (2004) suggests that feeding bears may increase their chances of becoming food conditioned and habituated to people. Bears may make other associations with odors in supplemental food, such as domestic animal carcasses, which may cause bears to begin preying on livestock (Huber and Reynolds 2001).

Ecological Integrity/Stewardship

When bait or supplemental food is available (ad libitum), or when natural foods are plentiful, bears generally reduce their home range size, overlap home ranges in the area where bait or feed is provided, and concentrate at higher than normal densities. Dobey et al. (2005) noted that people providing corn to deer have significantly altered the home range and feeding behavior of bears in the Osceola National Forest study area and caused an obvious shift in habitat use by bears. In this study area, even though pine plantations in the seven different habitat types available to the bears ranked low in preferred use, they altered their feeding behavior and habitat use by eating corn placed in deer feeders located in the pine plantations, accounting for as much as 37 percent of their annual diet.

The baiting and supplemental feeding intensity and the amounts of baits, whether bears are the targeted species for the food or not, influences home ranges and significantly impacts habitat management. Habitat of black bears in different regions of North America is threatened by habitat loss due to changing land use, development, human population expansion, and demands for goods and services. Populations vary from low densities in several of the southeastern states to somewhat stable populations for sustainable harvests in other areas, to increasing densities in parts of the Northeast and Pacific Northwest. Because of their high adaptability, black bear populations can often be sustained in the presence of humans if they are not over-harvested. However, maintaining populations in relatively inaccessible terrain, thick under-story vegetation, and abundant sources of natural foods in the form of hard and soft mast are critical to their future sustainability (Pelton 1982). Clearly, baiting and supplemental feeding in states and territories where it is legal to place limited amounts of bait or feed as prescribed by regulation can have positive impacts on bear reproduction and annual harvest objectives, if this is determined to be appropriate by State or Territorial Agency professionals. There are distinct regional differences in habitat quality, bear population levels, and hunter densities that must be considered in defining appropriate regulations to achieve harvest and population objectives.

Prior to the ban on use of waste candy blocks for bear baiting in North Carolina, significant habitat destruction and alteration was occurring in the immediate area of bait sites (Cobb 2004a). Other than this example, information in the literature about the impact on wildlife habitat from the baiting or supplemental feeding of bears is sparse, although it is likely that long-term baiting or feeding sites would have similar detrimental habitat effects for bears as they do for other wildlife species using such sites.

While food plots planted for other wildlife species might also be seasonally used by black bears, no information could be found documenting food plots planted specifically for use by bears. Based on habitat requirements, planting food plots primarily for use by black bears is not advisable.

Black bear movements can be seasonally influenced by the availability of agricultural resources such as corn, apple, or fruit orchards and bee hives, especially in years of poor mast production. Vaughan and Scanlon (1989) reported that although bear damage averaged only $5,470/year in Virginia, Florida, the leading honey producing state in the nation (Sanford 1982), reported damages in the range of $100,000 annually. Baiting and feeding black bears would have the most significant effects on agriculture where such food or bait is placed in, or adjacent to, agricultural areas. Agricultural crops would also receive higher bear use following a drought or other weather factor when natural foods are extremely scarce.

Rarely is timber stand improvement (TSI) a major factor in terms of influencing bear behavior related to baiting or supplemental feeding, except where it is practiced via the increasing use of herbicides. This practice effectively eliminates many hard and soft mast-producing woody plants within the timber stand, (see Dobey et al. 2005), thus removing mast production potential. In any area where significant timber stand conversion is taking place, or where mixed pine/hardwood stands are being converted to even-aged stands of conifers, there is a loss of hard and soft mast natural foods that black bears need for year-around availability. In areas where bears cause extensive damage to timber stands, the use of seasonal supplemental feeding via "bear pellets" provided in feeders does appear to significantly reduce damage from bears stripping bark for food (Nolte et al. 2002).

Human Health and Safety Concerns

High bear densities existing close to airports could become a concern, especially if bear movement is impacted by the use of bait or supplemental feeding adjacent to airports. However, there is no evidence in the literature of any reported airport safety problems. Black bears are infrequently involved with motor vehicle accidents, which are often associated with increased bear movement patterns when mast failures occur and when food is provided near high density traffic corridors or in high density populations because young males are forced out of home ranges into new territories. It is likely that when bears are baited or supplemental food is made available near a highway or where major highway traffic intersects good bear habitat, there is greater potential for bear/motor vehicle collisions. Conversely, if bear-vehicle problems become too severe, providing a lure crop or food source distant from heavy traffic corridors could reduce such collisions.

Conover (2002) noted that about 30 people are attacked annually in North America by black bears. In 1998, black bears in Yosemite National Park broke into 1,103 vehicles, causing over $600,000 in damages (Conover 2002). Direct feeding by humans and the smell or visible presence of food in these vehicles exacerbated this problem. Tate and Pelton (1980) recorded 624 aggressive acts from black bears toward humans in the Smoky Mountains National Park. However, only 37 of these (5.9 percent) resulted in contact. No reference to the provision of supplemental feeding of bears in the park was recorded, but habituation of bears to people providing food is usually a major cause. The Manitoba Nuisance Bear Committee (Poulin et al. 2003) concluded that habituated and food-conditioned black bears rarely revert to wild behavior. Once persistent nuisance behavior is learned, animals usually have to be relocated long distances to remote areas or destroyed.

Economic Issues

In 2001 the number of licensed bear hunters was 360,000 (U.S. Department of Interior 2001). If the average bear hunter, as reported, expended $322, the total expenditure for bear hunting in the United States was $11.6 million dollars. According to Etter et al. (2003), during the 1998 bear season in Michigan, 7,196 hunters spent an average of $474 per individual for an estimated $3.4 million in total expenditures. Lamport (1996) reported that in 1993, approximately $13 million ($CAN) was spent in Ontario for supplies and services associated with spring and fall black bear hunting season, much of which is done over bait.

Black bears are currently distributed throughout North America in 40 states, northern Mexico, and all provinces and territories of Canada, except Prince Edward Island (Gore 2003). As of 2003, 28 states within the United States allowed regulated harvest of black bears, and 11 allowed baiting. Although no estimate of the economic value of baiting and supplemental feeding of black bears could be located, it is obvious that with 11 states allowing the use of bait, and only 12 states prohibiting the feeding of bears and other wildlife, a significant amount of money is spent on bait and feed, and as well on various feeding devices and implements. Winterstein (1992) reported that in 1991, hunters in Michigan used over 13 million bushels of bait for deer, with a net value in excess of $50 million. Lamport (1996) estimated an expenditure of $13 million ($CAN) in 1993 in Ontario for supplies and services for black bear hunting, of which the majority was for bait. Gray et al. (2004) reported that 113 bear hunters in Virginia between 1 July 1998 and 30 June 1999 spent $18,378 on supplemental food for bear feed. One-hundred-twenty-eight respondents to the survey provided 2,942,394 kilograms of food to bears during that same period. Wilkins (1999) calculated via a poll of major feed mills in Texas during 1999 that Texas hunters and managers purchased over 300 million pounds of “deer corn” annually, and one of the state’s largest feed mills reported 56 million pounds of “deer corn” sold in one year. Obviously another major economic expenditure is on feeders for distributing bait or feed and travel costs associated with “tailgate distribution” of feed and bait. Across North America, no estimates of total expenditures on the baiting and artificial/supplemental feeding of wildlife could be located in the literature; however, it is likely to amount to several billion dollars annually.

Gore (2003) provides relatively thorough coverage of the substantial complexities and differences of opinion on this topic. The contrast in opinion ranged from a *Wall Street Journal* article by Sterba (2004), with a statement by the Governor of Maine and the Maine Department of Inland Fisheries and Wildlife estimating that a ban on bear baiting would cost the state $62.4 million in annual income and 700 jobs, to several state agencies reportedly experiencing a significant increase in bear hunting licenses sold following bans on bear baiting, with resultant increases in revenues for the respective state fish and wildlife agency.

Property damage to individual landowners caused by black bears is expensive and a source of great frustration. Total damage by black bears to field row crops, bee hives/yards, fruit crops, livestock, and timber, if available for North America, would probably be staggering. However, as an average across the continent, bear damage would be significantly less than for numerous other wildlife species commonly associated with property damage. Unfortunately, once bears become habituated to artificial food sources and as human expansion further encroaches on black bear habitat, these types of interactions will become more common.

Damage by black bears can be reduced by creating mechanical barriers (e.g. electric fences), capturing and relocating problem bears, or in some areas, using seasonal supplemental feeding to reduce timber stripping, as described by Nolte et al. (2002). The only other effective means of control are lethal techniques. In some areas of North America, bears that become habituated and food-conditioned often do not revert to wild behavior and require lethal action to reduce property damage or threats to human health and safety. However, in other areas of North America, particularly specific northern states and provinces, bears that become conditioned to bait or feed for short periods of time while outfitters bait the bears apparently do revert to wild behavior after bait and feed is removed. Vaughan and Scanlon (1989) reported that although bear-related damage may often have an insignificant economic impact on the local community, individual property or livestock owners may suffer catastrophic loss in either an agricultural or outdoor recreational setting. The cost in both time and real dollars involved in trapping and moving nuisance bears to a remote location often far exceeds the cost of the damage. However, landowner tolerance may have been stretched to the point that damage can no longer be tolerated.

State by State Situation Regarding Bear Baiting and Feeding

A recent review by Puckett (2004) noted that Arkansas, Louisiana, New Jersey, New York, Pennsylvania, South Carolina, Virginia, and West Virginia all prohibited supplemental or intentional feeding of black bears, while Alaska, Colorado, Florida, and Montana prohibited feeding bears and some other species. However, several states that prohibit feeding allow the use of bait for black bear (e.g. Alaska and Arkansas). Often the justification for differences is based on achieving a specific harvest goal, or the economic impact that a prohibition on baiting would potentially create. Warbeck (2004), in a December 2004 survey of Canadian jurisdictions, reported that Alberta, Manitoba, Saskatchewan, New Brunswick, Nova Scotia, Quebec, Newfoundland, and Ontario currently allow baiting for bear, while British Columbia, the Northwest Territories, and the Yukon Territory prohibits baiting of black bear. Those who advocate the prohibition of baiting do so primarily to ensure sustainable populations, for human safety reasons, and because of the potential impact of baiting on non-target wildlife species, whereas those who advocate baiting suggest that it is justified for achieving sustainable harvest levels and to sustain the economic stability of the guiding and outfitting industry, which it purports would be severely impacted if baiting were eliminated.

In recent years, state legislators in Alabama, Mississippi, Georgia and several other states have proposed legislation that would make it legal to bait game wildlife species for the purposes of hunting over such bait and have attempted to pass this legislation even though previous surveys indicated that the majority of their hunters oppose such practices. These political efforts, if successful, would essentially remove the authority for wildlife management from their respective fish and wildlife agencies and wildlife professionals, and place it in the hands of elected politicians. This pressure in the Southeast is being stimulated not by concern for the sustainability of wildlife resources, but primarily because of potential economic revenues it generates or is perceived to generate. Such decisions need to be made understanding that impacts of baiting and feeding at unregulated levels can ultimately lead to privatization of wildlife resources. Respective state and provincial wildlife resource agencies must retain the authority to employ baiting and supplemental feeding as essential tools for the management of black bear populations, not because of perceived economic benefits to states, provinces, individuals, or corporations. Political solutions to this issue usually limit state wildlife and fisheries agencies' capabilities to appropriately manage the wildlife resources in their state, province, or territory. Other states and provinces, where baiting and feeding have been determined to be necessary to achieve population goals and hunter success, have hopefully been successful in basing such decisions on reliable scientific information rather than through the political process.

Summary

1. Black bear movement, behavior, and habituation to humans is affected by the use of baiting and supplemental feeding throughout North America (Hamilton 1978, Garshelis and Pelton 1980, Pelton 1982, Gray 2004).

2. Baiting and supplemental feeding can positively impact fecundity of black bears, reduce home range size, create high concentrations of bears around baiting sites, and increase the potential for nuisance bear problems (Beckman and Berger 2003, Dobey et al. 2005, Rogers 1977, Pelton 1982).

3. Numerous non-target species (both mammals and birds) are attracted to baiting and feeding sites and many species' behavior and movements are impacted by these activities, including black bear (Dobey et al. 2005, Guthrey et al. 2004, Gray et al. 2004, Langer 2004).

4. Black bear harvests can be severely impacted by baiting and supplemental feeding beyond the population's capability to be sustained, if not regulated (Paquett 1991, Dobey et al. 2005, Cobb 2004b).

5. Emergency resolutions by state wildlife agencies have been necessary to curb significantly increased bear harvest in relatively small areas associated with baiting and supplemental feeding with large waste candy blocks (Cobb 2004a, Langer 2004).

6. Numerous states and territories found increased hunter numbers following prohibition of bear baiting. Although bear harvests may decrease initially, in some states it actually increased over time, or changed only marginally (Gore 2003, Beck 1997, Colorado Division of Wildlife 2001).

7. Although there is evidence that supplemental feeding of black bears in some regions may contribute to reduced damage to timber, there is little evidence of cost-effectiveness, and it clearly increases bear concentrations around bait with the potential for disease spread (Nolte et al. 2002, Fischer 2003, Ziegltrum 2004).

SOCIAL, POLITICAL AND LEGAL ISSUES

Ownership of Wildlife Resources

The roots of wildlife law extend to the earliest known social institutions in *Homo sapiens* — when human tribes regulated access to wildlife resources (Yandle 1997). Early humans fed themselves by hunting, fishing, and trapping wild animals. When individuals banded into tribes, hunting efficiency increased. Large tribes could effectively defend a resource-rich hunting area and prevent other tribes from similar access to the resources contained therein. The tribes that controlled sole access to the best sources of food, water, and shelter were, from an evolutionary perspective, of greater fitness than those lacking access. Those tribes with the highest cooperation, enforced through rules and leadership, flourished.

Eventually agriculture replaced hunting/gathering and the labors of a few members of the tribe were sufficient to feed other members. This division of labor allowed specialization of those not producing food to focus on other aspects of civilization (Diamond 1977). Civilized societies were thus founded on a system of cooperative management of wildlife resources, owned by the community at-large and governed by rules established by its members. The Theory of the Commons was created (Yandle 1997).

As societies evolved, rules that increasingly limited access to resources paralleled increasing power of individual leaders. The system where wildlife was controlled as private property grew from feudalism. Immigrants to North America rejected the construct of wildlife as private property and, in so doing, returned wildlife to its earlier status as common property (Bean and Rowland 1997). This concept of ownership continues today in the United States.

Public Trust Doctrine

The public trust doctrine establishes the state as trustee over natural resources "too important to be owned" and therefore critical to modern society and future generations. The public trust doctrine has been applied in Canada and the United States to common public resources, specifically those resources not easily bounded or divided and those whose use by one person could potentially affect another person's ability to use (McCay 1996). The definition of public trust resources is evolving in North America, but generally includes large bodies of water, rivers, fisheries, wildlife, air, and genetic material (McCay 1996). Biodiversity may some day be a basis for public trust protection (Johnson & Galloway 1996). Wildlife in the United States was established as a beneficiary of public trust doctrine protection in several Supreme Court decisions during the 1800s (Bean and Rowland 1997).

Conceptually, baiting and feeding of wildlife may be regulated by governmental controls extended under the basis of public trust protection. State and federal agencies are thus empowered to limit or ban baiting and feeding if the practice transfers private property rights onto wildlife or if the practice jeopardizes public access to wildlife. Agencies are similarly empowered to limit or ban baiting and feeding if the practice jeopardizes health or well-being of wildlife.

Fair chase is one of the collective titles given to the various underpinnings of ethical hunting behavior — sportsmanship is the other. Fair chase, as defined by the Boone and Crockett Club, is the ethical, sportsmanlike, and lawful pursuit and taking of any free-ranging wild, native North American big game animal in a manner that does not give the hunter an improper advantage over such animals (http://www.boone-crockett.org/huntingEthics/ethics_fairchase.asp). The roots of fair chase evolved from public trust doctrine. Fair chase is an ethical decree, which serves as the embodiment of the difference in human attitudes towards domestic animals and wild game. Killing domestic animals is not defined as hunting because the precepts of fair chase — advantage to the game and uncertainty of kill — are absent. Those same precepts link fair chase to the public trust doctrine. Through fair chase, game is awarded enough advantage so as to make privatization impossible. By disallowing private ownership, fair chase buttresses public trust protection. No human can possess as private property living game animals to which have been provided fair chase protection.

When taken in the context of public trust protection, the ethical dilemma over baiting wildlife for hunting purposes becomes clear. If the use of bait awards unfair advantage to the hunter, then it narrows the distinction between game animal and domestic animal, and thus jeopardizes public trust protection. Using bait in a way that guarantees a kill, thereby awarding all advantage to the hunter, violates both the fair chase and public trust doctrines. Conversely, the use of bait in situations that do not give unfair advantage to the hunter falls comfortably within the definition of fair chase and, by extension, public trust protection.

Supplemental feeding may also be viewed in the context of public trust protection. The ease with which some game animals adapt to regular supplemental feeding affords the easy perception that wild game can be domesticated. For example, a 1984 survey of Colorado residents documented that most (72 percent) approved of big game feeding programs with only 8 percent concerned that winter feeding would cause the animals to become tame and dependent on humans for their existence (Anonymous 1984).

Supplemental feeding programs may blur the distinction of wild versus domestic and free-ranging versus private. Citizens who recreationally feed wildlife frequently assume that feeding conveys ownership rights to the animals they feed (Williamson, 2000). This shift to private ownership made possible by supplemental feeding violates the public trust doctrine of public ownership of wildlife resources.

Can Supplemental Feeding Mitigate Habitat Degradation?

The future of wildlife in North America depends on wild places that support diverse, healthy, sustainable populations of wildlife compatible with human interests and desires. Continued loss or degradation of wild habitats will eventually threaten the ability of the continent to support wildlife. To the dismay of wildlife professionals, the public frequently promotes supplemental feeding as a suitable replacement for wild habitats. The best of intentions camouflages the worst of outcomes and a public that associates feeding with stewardship is unprepared to understand and act on the real and substantive threats to wildlife viability. Residential development of elk winter range cannot be justified because elk can be fed at feed grounds. Oil and gas development on western big game ranges cannot be mitigated by supplemental feeding. Clear-cutting of northern deer winter yards cannot be deemed acceptable even if deer are provided a source of supplemental feed. The perception that feeding mitigates habitat loss is one of the most insidious consequences of policies that encourage or allow supplemental feeding.

Supplemental Feeding as a Population Management Tool

When, then, can the wildlife management profession endorse supplemental feeding and baiting? In general, examples of professional endorsement of feeding and baiting include situations where there was a comprehensive analysis of costs and benefits and some assurance of autonomy from interference in conducting feeding programs designed for a specific objective. In such situations, wildlife managers can manipulate food sources to influence the presence, size, distribution, and health of wildlife populations.

Wildlife managers frequently feed to divert animals from agricultural or forestry crops. For example, elk at the National Elk Refuge in Jackson Hole, Wyoming are fed to keep them from destroying ranchers' winter hay (Boyce 1989). Waterfowl are frequently lured away from farmer's fields with supplemental feed. Black bears in the Pacific Northwest are lured away from forestry plantations with supplemental feed.

Biologists assist recovery efforts for threatened and endangered species by providing supplemental feed. Biologists in the Northeast, for example, have placed road-killed deer carcasses on ice-covered ponds to increase bald eagle winter survival (McCollough et al. 1994). Diets of California condors have been supplemented with cow carcasses (Wilbur et al. 1974).

Supplemental feeding also can be used to deliver vaccines, other disease-fighting drugs and immuno-contraceptives (Davis 1996). Supplemental feeding can be used to attract wildlife to improve wildlife viewing opportunities.

Baiting, on the other hand, may facilitate the attainment of desired harvest management objectives. In certain regions of the country, density and structure of vegetation lowers white-tailed deer harvest rates and baiting is relied upon to increase hunter effectiveness. Baiting can increase the ability of black bear hunters to selectively harvest males and protect females and/or cubs. Baiting affords one method of harvesting reclusive predators.

Status of State and Provincial Supplemental Feeding Laws

As of June 2005, nine states do not allow the feeding of cervids, six states have certain restrictions, and two states are discussing a ban on feeding (http://www.cwd-info.org/index.php/fuseaction/policy.regulations).

Status of State, Federal, and Provincial Baiting Laws

As of June 2005, 25 states do not allow the baiting of cervids, five states have certain restrictions on baiting (CT, MI, NE, SC), and one state is discussing a ban on baiting. Two Canadian provinces (Alberta and Manitoba) have banned baiting (http://www.cwd-info.org/index.php/fuseaction/policy.regulations). The Migratory Bird Treaty Act gives the Secretary of Interior the authority to determine the "extent and means by which migratory birds are taken" (MBTA Section 3.) The Secretary has used this authority to ban the use of bait in taking migratory birds.

Baiting and Ballot Initiatives

Ballot initiatives allow a special interest group to draft a policy idea, collect petition signatures and, if of sufficient quantity, place the draft policy idea onto a general election ballot. If approved by voters, the policy idea is then transformed into law outside of the usual legislative process. Natural resource questions are increasingly being submitted to the public via the initiative process (Williamson 1998). The question of whether bait should be a legal method of take for black bear has been the topic of six ballot initiatives since 1994. Voters in Maryland, Washington, and Oregon have approved a ban on bear baiting, while voters in Idaho, Michigan, and Maine have rejected attempts to ban bear baiting.

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