



## Impacts of wildlife baiting and supplemental feeding on infectious disease transmission risk: A synthesis of knowledge

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### ABSTRACT

Baiting and supplemental feeding of wildlife are widespread, yet highly controversial management practices, with important implications for ecosystems, livestock production, and potentially human health. An often underappreciated threat of such feeding practices is the potential to facilitate intra- and inter-specific disease transmission. We provide a comprehensive review of the scientific evidence of baiting and supplemental feeding on disease transmission risk in wildlife, with an emphasis on large herbivores in North America. While the objectives of supplemental feeding and baiting typically differ, the effects on disease transmission of these practices are largely the same. Both feeding and baiting provide wildlife with natural or non-natural food at specific locations in the environment, which can result in large congregations of individuals and species in a small area and increased local densities. Feeding can lead to increased potential for disease transmission either directly (via direct animal contact) or indirectly (via feed functioning as a fomite, spreading disease into the adjacent environment and to other animals). We identified numerous diseases that currently pose a significant concern to the health of individuals and species of large wild mammals across North America, the spread of which are either clearly facilitated or most likely facilitated by the application of supplemental feeding or baiting. Wildlife diseases also have important threats to human and livestock health. Although the risk of intra- and inter-species disease transmission likely increases when animals concentrate at feeding stations, only in a few cases was disease prevalence and transmission measured and compared between populations. Mostly these were experimental situations under controlled conditions, limiting direct scientific evidence that feeding practices exacerbates disease occurrence, exposure, transmission, and spread in the environment. Vaccination programs utilizing baits have received variable levels of success. Although important gaps in the scientific literature exist, current information is sufficient to conclude that providing food to wildlife through supplemental feeding or baiting has great potential to negatively impact species health and represents a non-natural arena for disease transmission and preservation. Ultimately, this undermines the initial purpose of feeding practices and represents a serious risk to the maintenance of biodiversity, ecosystem functioning, human health, and livestock production. Managers should consider disease transmission as a real and serious

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concern in their decision to implement or eliminate feeding programs. Disease surveillance should be a crucial element within the long-term monitoring of any feeding program in combination with other available preventive measures to limit disease transmission and spread.

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## 1. Introduction

Many wildlife populations aggregate in small spatial areas in response to human modifications of the environment. A good example of such a modification is the placement of supplemental feed, either via bait, or natural or artificial forage within the native habitat of species. Supplemental feed is provided to wildlife across numerous parts of the world to address various ecological and socio-economic purposes such as alleviating winter mortality (Weidman and Litvaitis, 2011), increasing reproductive success (Robb et al., 2008b), controlling wildlife damage to crops and the environment (van Beest et al., 2010), reducing wildlife–vehicle collisions (Andreassen et al., 2005), controlling animal migration routes (Sahlsten et al., 2010), and optimizing hunting and tourism opportunities (Corcoran et al., 2013; Geisser and Reyer, 2004).

The effectiveness of wildlife feeding to fulfill the above mentioned factors is ambiguous and reviewed in more detail elsewhere (Putman and Staines, 2004; Robb et al., 2008a). Less well-known, and an under-appreciated biological problem, is the potential role of feeding and baiting on inter- and intra-species disease transmission risk. This is surprising as the risk of disease transmission and outbreak in native species has been recognized as one of the major threats to biodiversity around the globe (Daszak et al., 2000). In North America specifically, concerns have been raised regarding the ecological and economic impacts of such feeding practices following the emergence of chronic wasting disease (CWD) in free-ranging and domestic elk (*Cervus canadensis*), mule deer (*Odocoileus hemionus hemionus*), black-tailed deer (*Odocoileus hemionus columbianus*), white-tailed deer (*Odocoileus virginianus*), and moose (*Alces alces*), and outbreaks of bovine tuberculosis and brucellosis in elk and white-tailed deer (Brown and Cooper, 2006; Cross et al., 2010; O'Brien et al., 2011; Peterson et al., 2006; Brook et al., 2013).

The purpose of this paper is to provide a comprehensive review of existing literature on the effects of baiting and feeding wildlife on species health; particularly in relation to disease transmission in large herbivores in Northern America. Our objectives were to: (1) define and characterize the aims of baiting and feeding of wildlife, (2) examine the mechanisms that facilitate disease transmission in relation to feeding and baiting, (3) present a set of case studies that have investigated the role of feeding and baiting on transmission of infectious diseases, (4) evaluate the implications of baiting and feeding wildlife for human and livestock health, and (5) assess the potential and efficacy of current management approaches available to reduce disease transmission risks associated with baiting and supplementary feeding of wildlife.

## 2. Baiting and feeding wildlife: definitions and objectives

Baiting of wildlife involves the purposeful placement of natural or artificial food resources in the environment to manipulate the behavior of wild species so as to attract and/or retain them in an area. Regulations regarding baiting wildlife vary significantly between regions and countries, ranging from being fully accepted to complete bans on their use. Additional attractants such as scent lures, calling devices, or decoys may be utilized for baiting purposes (Lothrop et al., 2012). Baiting is typically used for the purposes of (i) attracting wildlife to a specific location to enhance hunter harvest, trapping, or viewing opportunities (Litvaitis and Kane, 1994; Obbard et al., 2008); (ii) capturing wildlife for research purposes including animal relocation or population augmentation and restoration (Barrett et al., 2008); (iii) capture, vaccination, and/or treatment of animals for control of infectious diseases and vectors (Cross et al., 2007a,b; Fletcher et al., 1990).

Supplemental feeding can be broadly defined as the placement of natural or non-natural food into the environment with the goal of augmenting the regular natural food source of a given wild species. Feeding is conducted across a wide range of spatial scales including citizens occasionally distributing feed on their property (Robb et al., 2008a), as well as large scale provincial or state-funded programs. For example, several thousand elk are artificially fed each winter in the National Elk Refuge, Wyoming, USA (Smith, 2001). Supplemental feeding can also be unintentional, as wild species target garbage dumps (Lunn, 1986), livestock feeding troughs (Atwood et al., 2009), compost heaps (Gabrey et al., 1994), and standing or baled agricultural crops (Brook, 2010; Brook et al., 2013).

Supplemental feeding is the provision of food by humans with the intention to enhance some specific physical characteristics of individuals or to benefit population dynamics, e.g. increased antler growth, fecundity, and survival (Hansen, 1987; Ozoga and Verme, 1982). Winter feeding is a specific type of supplemental feeding to compensate for lower natural food availability for wildlife and higher energetic demands during winter conditions, primarily to prevent starvation mortalities and maintain body condition (Baker and Hobbs, 1985; Doenier et al., 1997). Intercept or diversionary feeding is the provision by humans of food at strategic places to modify animal distribution and movements so as to reduce environmental damage (Geisser and Reyer, 2004; van Beest et al., 2010; Ziegler, 2004), to divert wildlife away from major vehicle traffic corridors to reduce animal–vehicle collisions (Andreassen et al., 2005; Wood and Wolfe, 1988), or prevent disease transmission among wildlife and livestock (Brook, 2008).

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