Impacts of Predators on Northern Bobwhites in the Southeast

John P. Carroll
University of Georgia, Warnell School of Forestry and Natural Resources
Athens, Georgia

Susan N. Ellis-Felege
University of Georgia, Warnell School of Forestry and Natural Resources
Athens, Georgia

William E. Palmer
Tall Timbers Research Station and Land Conservancy
Tallahassee, Florida

Introduction

The northern bobwhite quail (*Colinus virginianus*) is an important game bird that is intensively managed for hunting recreation in the southeastern United States. Despite interest regionwide, populations have been declining for much of the last 40 years (Brennan 1999). Population declines in the Southeast have occurred as a result of widespread habitat loss associated with land-use changes (Brennan 1999). These land-use changes include both conversion from agricultural to forest landscapes and changes in forest management practices, which result in dense forest canopies that shade required ground vegetation (Brennan 1999, Rollins and Carroll 2001). In addition, low-quality habitats may predispose bobwhites to high rates of predation, resulting in accelerated rates of population decline (Rollins 1999, Rollins and Carroll 2001, Cook 2004).

Although both avian and mammalian predator populations have increased across the bobwhite's southern territory at the same time that bobwhite populations have declined, focus on mammalian predators appears to be greatest. This group of species, often called mesomammalian predators (medium-size carnivores) are known to be major predators of bobwhites and of their nests (Stoddard 1931, Rollins and Carroll 2001). In general, these predators include coyotes (*Canis latrans*), bobcats (*Felis rufus*), raccoons (*Procyon lotor*), opossums (*Didelphis marsupialis*), nine-banded armadillos (*Dasypus*

novemcinctus), striped skunks (*Mephitis mephitis*), red foxes (*Vulpes vulpes*) and gray foxes (*Urocyon cinereoargenteus*). Decreases in hunting and trapping, due to declining fur markets, and beneficial land-use changes have resulted in increased predator abundance, with some species reaching historically high densities across the Southeast (Peoples et al. 1995).

Long-standing paradigms in quail management suggest that predation was rarely a concern and that predators could be controlled indirectly through habitat manipulation (Errington 1934). The response of predators to habitat manipulation is unknown, but bobwhite populations and predator communities may both benefit from intense habitat manipulation (Taylor and Burger 1997).

The use of predator removal as a tool in bobwhite management has become increasingly important. For example, since 2001, Georgia has issued permits to private landowners for nuisance-wildlife damage control. These permits allow trapping and removal of furbearers outside of traditional trapping seasons. Many plantations have been issued such permits to control mammalian predators during the bobwhite nesting season. This practice is controversial, and some professional biologists would suggest that it is contrary to modern wildlife management principles.

Although there is a long history of predator removal to increase populations of bobwhites and other game birds, empirical evidence of its efficacy is limited. In addition, predator-removal studies have produced contradictory results on the benefits for target species. In particular, it is not clear if predator removal can increase avian breeding populations (Cote and Sutherland 1997). Although there are studies on several species of game birds in North America and Europe, there is little quantitative data on bobwhite responses to predator removal (Rollins and Carroll 2001).

In this paper, we review some of the basic, biological issues relative to predator removal within game bird management, and we outline some paradigm shifts that might allow management to be undertaken within a modern social context.

Bobwhites and Predators

Bobwhites, like many other ground-nesting bird species, experience high annual mortality rates (Rollins and Carroll 2001, Yarrow and Yarrow 2005). Approximately 80 percent of annual mortality is observed in bobwhites from

natural predation, hunting, disease, exposure and other factors (Yarrow and Yarrow 2005). Predation is the primary source of mortality for bobwhites at all life stages (Rollins and Carroll 2001). Bobwhites are vulnerable to predation since they spend most of their time on the ground, including when nesting. Game bird populations can be limited by predators, but the effects of predation on the population depend on the extent to which predation is counteracted by compensatory reductions or by increased reproduction (Newton 1998). Nest predation has been considered the primary cause for bobwhite nest failure (Staller et al. 2005), and the most common bobwhite nest predators are reported to be mammals (DeVos and Mueller 1993, Taylor and Burger 1997, Staller et al. 2005). Nest predation studies have reported that between 52 and 60 percent of bobwhite nest losses are due to mesomammals (DeVos and Mueller 1993, Staller et al. 2005). The most commonly reported mammalian nest predators of bobwhites are skunks, raccoons, armadillos, opossums, bobcats, foxes and coyotes (Hernandez et al. 1997, Fies and Puckett 2000, Staller et al. 2005). Other known nest predators include snakes (*Elaphe* spp.), several avian species and fire ants (*Solenopsis invicta*) (Fies and Puckett 2000, Staller et al. 2005). Recent studies in the Southeast have only just begun to tease out the role of nonmammalian predators on bobwhite nests. For example, the use of cameras at nests of a number of different bird species suggests that snakes may be one of the most important avian nest predators (Weatherhead and Bloun-Demers 2004). A camera study of bobwhite nest predators in northern Florida and southern Georgia showed 29 percent of nest depredations from 1999 to 2001 were caused by snakes (Staller et al. 2005).

Game Birds and Predator Removal

A wide range of outcomes have been reported for avian population responses to predator removal (Cote and Sutherland 1997, Newton 1998, Rollins and Carroll 2001). The effects of predator control upon game species can vary, depending on the kind and intensity of predation, on the degree of predator control, and on the prey species (Chesness et al. 1968). Most studies examined nest success or some other index of productivity, such as ratios of young to adults in the fall. Some studies observed fall abundance, and a few studied subsequent breeding populations to assess the effects of predator removal on a target bird species. Nesting success or hatching success is the most commonly reported

response variable to predator control. It is most often defined as at least one egg in the clutch hatching, and many studies have observed higher hatching success for ground-nesting birds when predator control was conducted. For example, increased nest success was observed when predators were controlled for ring-necked pheasants (*Phasianus colchicus*) (Chesness et al. 1968, Trautman et al. 1974), ruffed grouse (*Bonasa umbellus*) (Edminster 1939), and ducks (*Anas* spp.) (Schranck 1972, Duebbert and Lokemoen 1980, Sargeant et al. 1995). An increase in wild turkey (*Meleagris gallopavo*) production was also observed when mammalian predator removal was conducted (Beasom 1974). It is important to note that there has been very little standardization of definitions of predator removal in research or management. The impact of predator removal on predator populations is often unmeasured, which lends uncertainty to inferences of the relationships among predator and prey populations. Further, important issues of cost effectiveness, scale and movement of predators back to study areas are more difficult to understand when predator populations are ignored in predator removal studies.

Limited empirical evidence of the impact of predator management on quail breeding success exists in the literature, and no study in the Southeast has ever examined mesomammal predator removal on bobwhites in high-quality habitat. No treatment effect was observed for bobwhite or scaled quail when a mammalian-predator removal study was conducted on only 6 square miles (15 km^2) in southern Texas (Guthery and Beasom 1977). On 12 farms in North Carolina, predator removals had no effect on bobwhite populations unless habitat improvements were incorporated. While predator removals increased the response of bobwhite populations to habitat improvements, habitat was the most limiting factor on the modern farmed landscape (Palmer et al. 2005).

Relatively few avian studies examined fall abundance in response to predation management. Again, variable results have been reported for postbreeding population responses to predator control. Increased postbreeding numbers were observed in studies of pheasants (Trautman et al. 1974), gray partridge (*Perdix perdix*) (Tapper et al. 1991), black grouse (*Tetrao tetris*) (Marcstrom et al. 1988), and turkey and bobwhite (Beasom 1974). Whereas in other studies, no increase in postbreeding abundance was observed in ruffed grouse (Bump et al. 1947), pheasant (Chesness et al. 1968) or black grouse (Parker 1984).

From a population ecology standpoint, recruitment into a population is based, in part, on the number of individuals available for breeding in the spring. Thus, breeding population size is an important component in maintaining or increasing population size. After predator removal, increased breeding numbers were observed for various ducks (Duebbert and Lokemoen 1980), black grouse (Marcstrom et al. 1988) and gray partridge (Tapper et al. 1991). However, other studies did not find increased breeding numbers after predators were removed for ruffed grouse (Bump et al. 1947), pheasant (Chesness et al. 1968) or black grouse (Parker 1984). These studies reported varied responses to predator control, even within the same species. This variation may be due to different intensities of predator removal, or it may be due to differences in geographic areas where factors other than predation may be limiting the population. No studies reported bobwhite breeding population responses to predator removal.

Factors That Influence Avian Responses to Predator Removal

Cote and Sutherland (1997) conducted a meta-analysis to examine responses to predator removal in hatching success, in postbreeding populations and in subsequent breeding populations across a wide range of avian species. This study generally showed increased hatching success and increased postbreeding populations, but no overall increase in subsequent breeding populations occurred when predators were removed (Cote and Sutherland 1997). Since this study looked at both migratory and nonmigratory game birds, some of these results are probably an artifact of the different life histories. Migratory birds, such as waterfowl, may respond differently to localized predator removals than nonmigratory gamebirds since they are subjected to predation pressure across a much a larger area than nonmigratory species are, and they likely have different population limitations throughout the year. The environment (weather), resources (water, food, nest sites, breeding grounds), inter- and intraspecific competition, parasites, disease, and predation are all possible limitations upon avian populations (Newton 1998).

Europe has a long history of predator removals as a means of game management that can be traced back to the early 19th century when predators were removed on large, privately owned sporting estates (Reynolds and Tapper 1996). Several studies of the gray partridge reported increased production as a result of predator removals (Potts 1986, Tapper et al. 1996). In particular, Tapper

et al. (1996) found that predators play a key role in limiting both production and breeding density of partridges; they observed increases in nesting success, average brood sizes and subsequent breeding densities in areas that received predator control. In Great Britain, red grouse (*Lagopus lagopus*) shooting estates have observed sharp declines in their populations when no predator management was conducted, but estates with active predator control have not seen these same declines (Reynolds and Tapper 1996, Redpath and Thirgood 1999). In fact, estates with predator removal have maintained populations with consistently high grouse densities (Reynolds and Tapper 1996). Thus, European studies suggest predator removal is an effective management tool to increase a fall population and even to increase the subsequent breeding population.

Regional differences in bobwhite response to predator control may exist. Early studies of bobwhite populations in Georgia, Florida and other southeastern states suggest that predators may limit populations size, especially during the summer months (Stoddard 1931). However, predation on bobwhites during winter in Wisconsin and Iowa seems to demonstrate a density-dependent relationship where severe weather and food limitations might act in conjunction with predation to limit abundance (Errington and Stoddard 1938, Newton 1998).

Small-scale Bobwhite Demographic Shifts

Few studies have examined mechanisms for possible increases in avian production as a result of predator control. Among studies of the impacts of predator control on gamebirds, few have investigated finer demographic parameters. For example, grey partridge studies (Tapper et al. 1996) reported changes in parameters, such as average brood size, as a result of predator reduction. Demographic parameters, such as brood size and clutch size, can reflect changes in per capita productivity that may otherwise be overlooked when only examining components of reproductive effort, such as nest success. None of the studies on bobwhites report small-scale demographic shifts that may occur across the breeding season as a result of predator control.

Predation Risk

Most predator studies on bird populations do not examine the predators themselves or the factors that account for how they affect nesting birds

(Weatherhead and Bloun-Demers 2004). Changes in the predator community from predator control over the course of the breeding season could alter risk factors associated with nest survival. There are a large number of complex relationships that exist among predator communities. Removal of one species of predator could result in increased populations of other smaller predators; the cascade effect could contribute higher levels of mortality on the target species than these larger predators. Predation that occurs among predator guilds is important in the shaping of predator communities (Reynolds and Tapper 1996). For bobwhite populations, the role of other predators that also serve as prey for larger predators, such as snakes, could increase as a result of decreased predator pressure from mesomammals, such as bobcats (Sovada et al. 1995).

In addition, it is important to consider alternative prey sources. Population cycling of rodents could provide some reprieve for bobwhites, allowing them an opportunity for population gains. Recent studies demonstrate dramatic shifts in annual survival of bobwhites (Palmer and Wellendorf 2007), which are negatively related to alternative prey abundance. These studies suggest that regional and temporal shifts in the avian predator community may help explain dynamics of bobwhite populations but also indicate the complexity of predator-prey relationships in the southeastern United States.

Southeastern U.S. Ecosystems and Predator Management

When assessing the potential impacts of predator control on game bird abundance, there is an obvious bias in where and in what types of ecosystems most studies have been undertaken. For example, the studies by Marcstrom et al. (1988), Sovada et al. (1995), Tapper et al. (1996), and Redpath and Thirgood (1999), which represent some of the best research on game bird-predator interactions relative to predator control, were all conducted in northern, temperate ecosystems. All of these systems can be characterized as having relatively simple predator and prey communities. In addition, habitat wasn't very complex and, in most cases, was dominated by agriculture. Translations of these results to more complex ecosystems found in warmer climates might be limited. It should be noted that these ecosystems are far less complex than those in the southeastern United States. Only a few key predators are critical to understanding population behaviors in those areas and, thus, are capable of being controlled with minimal potential interaction with nontarget species. In contrast,

the southeastern ecosystems have a large number of mammalian, avian, ant and snake species that are all known bobwhite predators (more than 20 species).

Predator Control versus Predation Management

Lethal means of predator reduction has led to much controversy about the objectives and process of predation management. There is a clear distinction between predator control and predator management. Control is simply reducing predator numbers while management is just that—management of the system to minimize the effects of predators on a prey species. It may involve lethal or nonlethal removal methods. Predator management, as it is now defined, may include removal, but it may also include other management options, such as improving habitat for predator avoidance or supplementally feeding bobwhites. Even removal of predators might be defined quite differently; control implies that the purpose is to eliminate or significantly reduce abundance of predators. Whereas, management suggests removal only to the extent that the target species is released during some crucial period.

Conclusion

Predator management as a tool to enhance wildlife populations and hunting opportunities for game birds has a long and controversial history. This management paradigm appears to have shifted from the early 20th century's when predators were viewed as competitors with humans for a shared resource and their impact was additive. During much of the latter 20th century, the contrasting view that predators were not important in driving game bird populations, that is, that predation was compensatory, was predominant. We believe, like much dogma in wildlife management, that both views were based on little science and mainly on anecdote. Scientific investigation has been key to understanding the impact of predation and predator management on game birds, and we see a trend in places with rather simple predator and prey communities. How this translates to more complex systems remains to be seen.

Recent authors have suggested that predator-prey relations are important and complex (Closs et al. 1999, Stouffer et al. 2005, Rockwood 2006). As a result, we see a shift in this paradigm to encompass predation management rather than predator control. Like all management systems, we should not think

about predator removal and how it might impact prey and predator species. Instead, we should focus on the predation process. What managers of bobwhites and those interested in ecosystem integrity should desire is management of predation, not necessarily reduction of predators. This movement of interest and research toward understanding processes and how to manage those processes is important to allow us to manage our ecosystems in a way that provides opportunities for reasonably intense management of popular game species within the context of societal goals of maintaining biodiversity.

Reference List

Beasom, S. L. 1974. Intensive short-term predator removal as a game management tool. *Transactions of the North American Wildlife Conference*. 39:669–82.

Brennan, L. A. 1999. Northern bobwhite *Colinus virginianus*. In *The birds of North America, no. 397*, ed. A. Poole, and F. Gill. Philadelphia, Pennsylvania: The Birds of North America, Inc.

Bump, G., R. W. Darrow, F. C. Edminster, and W. F. Crissey. 1947. *The ruffed grouse*, New York, NY: Authority of New York State Legislature.

Chesness, R. A., M. M. Nelson, and W. H. Longley. 1968. Effect of predator removal on pheasant reproductive success. *Journal of Wildlife Management*. 32:683–97.

Closs, G. P., S. R. Balcombe, and M. J. Shirley. 1999. Generalist predators, interaction strength and food-web stability. *Advances in Ecological Research*. 28:93–126.

Cook, P. 2004. Effects of field margin management on bobwhite quail demographics. M.S. Thesis, Warnell School of Forestry and Natural Resources, University of Georgia.

Cote, I. M., and W. J. Sutherland. 1997. The effectiveness of removing predators to protect bird populations. *Conservation Biology*. 11:395–405.

DeVos, T. D., and B. S. Mueller. 1993. Reproductive ecology of northern bobwhite in north Florida. *Proceedings of The Third National Quail Symposium*. 3:83–90.

Duebbert, H. F., and J. T. Lokemoen. 1980. High duck nesting success in a predator-reduced environment. *Journal of Wildlife Management*. 44:428–37.

Edminster, F. C. 1939. The effect of predator control on ruffed grouse populations in New York. *Journal of Wildlife Management*. 3:345–52.

Errington, P. L. 1934. Vulnerability of bob-white populations to predation. *Ecology*. 15:110–27.

Errington, P. L., and H. L. Stoddard. 1938. Modifications in predation theory suggested by ecological studies of the bobwhite quail. *Transactions of the North American Wildlife Conference*. 3:736–40.

Fies, M. L., and K. M. Puckett. 2000. Depredation patterns of northern bobwhite nest predators in Virginia. *Proceedings of Fourth National Quail Symposium*. 4:96–102.

Guthery, F. S., and S. L. Beasom. 1977. Responses of game and nongame wildlife to predator control in south Texas. *Journal of Range Management*. 30:404–9.

Hernandez, F., D. Rollins, and R. Cantu. 1997. Evaluating evidence to identify ground-nest predators in west Texas. *Wildlife Society Bulletin*. 25:826–31.

Marcstrom, V., R. E. Kenward, and E. Engren. 1988. The impact of predation on boreal tetraonids during vole cycles: An experimental study. *The Journal of Animal Ecology*. 57:859–72.

Newton, I. 1998. *Population limitation in birds*. San Diego, CA: Academic Press.

Palmer, W. E., and S. D. Wellendorf. 2007. *Effects of radiotransmitters on northern bobwhite survival rates*. U.S. Geological Survey. http://www.npwrc.usgs.gov/resource/wildlife/telemtry/harvest.htm.

Palmer, W. E., S. D. Wellendorf, J. R. Gillis, and P. T. Bromley. 2005. Effects of field borders and mesomammal reduction on bobwhite abundance on North Carolina farms. *Wildlife Society Bulletin*. 33(4):1,398–405.

Parker, H. 1984. Effect of corvid removal on reproduction of willow ptarmigan and black grouse. *Journal of Wildlife Management*. 48:1,197–205.

Peoples, J. C., D. C. Sisson, and D. W. Speake. 1995. Mortality of wild turkey poults in coastal plain pine forests. *Proceeding of the Annual Conference of Southeastern Associations of Fish and Wildlife Agencies*. 49:448–53.

Potts, G. R. 1986. *The partridge: Pesticides, predation and conservation*. London, United Kingdom: Collins Professional & Technical.

Redpath, S. M., and S. J. Thirgood. 1999. Numerical and functional responses to generalist predators: Hen harriers and peregrines on Scottish grouse moors. *Journal of Animal Ecology*. 68:879–92.

Reynolds, J. C., and S. C. Tapper. 1996. Control of mammalian predators in game management and conservation. *Mammal Review*. 26:127–55.

Rockwood, L. 2006. *Introduction to population ecology*. Oxford, United Kingdom: Blackwell Publishing.

Rollins, D. 1999. Is there a place for predator control in quail management? In *Preserving Texas' quail heritage into the 21st century*, ed. K. A. Cearley, 45–8 . San Angelo, TX: Texas Agricultural Extension Service.

Rollins, D., and J. P. Carroll. 2001. Impacts of predation on northern bobwhite and scaled quail. *Wildlife Society Bulletin*. 29:39–51.

Sargeant, A. B., M. A. Sovada, and T. L. Shaffer. 1995. Seasonal predator removal relative to hatch rate of duck nests in waterfowl populations areas. *Wildlife Society Bulletin*. 23:507–13.

Schranck, B. W. 1972. Waterfowl nest cover and some predation relationships. *Journal of Wildlife Management*. 36:182–6.

Sovada, M. A., A. B. Sargeant, and J. W. Grier. 1995. Differential effects of coyotes and red foxes on duck nest success. *Journal of Wildlife Management*. 59:1–9.

Staller, E. L., W. E. Palmer, J. P. Carroll, R. P. Thornton, and D. C. Sisson. 2005. Identifying predators at northern bobwhite nests. *Journal of Wildlife Management*. 69:124–32.

Stoddard, H. L. 1931. *The bobwhite quail: Its habits, preservation and increase*. New York, NY: C. Scribner's Sons.

Stouffer, D. B., J. Camacho, R. Guimera, C. A. Ng, and L. A. N. Amaral. 2005. Quantitative patterns in the structure of model and empirical food webs. *Ecology*. 86:1,301–11.

Tapper, S. C., M. H. Brockless, and G. R. Potts. 1991. The Salisbury Plain experiment: The conclusion. *Game Conservation Annual Review*. 1990:87–91.

Tapper, S. C., G. R. Potts, and M. H. Brockless. 1996. The effect of an experimental reduction in predation pressure on the breeding success and population density of grey partridges (*perdix perdix*). *The Journal of Applied Ecology*. 33:965–78.

Taylor, J. D., and L. W. Burger. 1997. Reproductive effort and success of northern bobwhite in Mississippi. *Proceedings of Annual Conference Southeastern Association of Fish and Wildlife Agencies*. 51:329–41.

Trautman, C. G., L. F. Fredrickson, and A. V. Carter. 1974. Relationship of red foxes and other predators to populations of ring-necked pheasants and other prey, South Dakota. *Transactions of the North American Wildlife Conference*. 39:241–55.

Weatherhead, P. J., and G. Bloun-Demers. 2004. Understanding avian nest predation: Why ornithologists should study snakes. *Journal of Avian Biology*. 35:185–90.

Yarrow, G. K., and D. T. Yarrow. 2005. *Managing wildlife: On private lands in Alabama and the Southeast*. Montgomery, AL: Alabama Wildlife Federation.