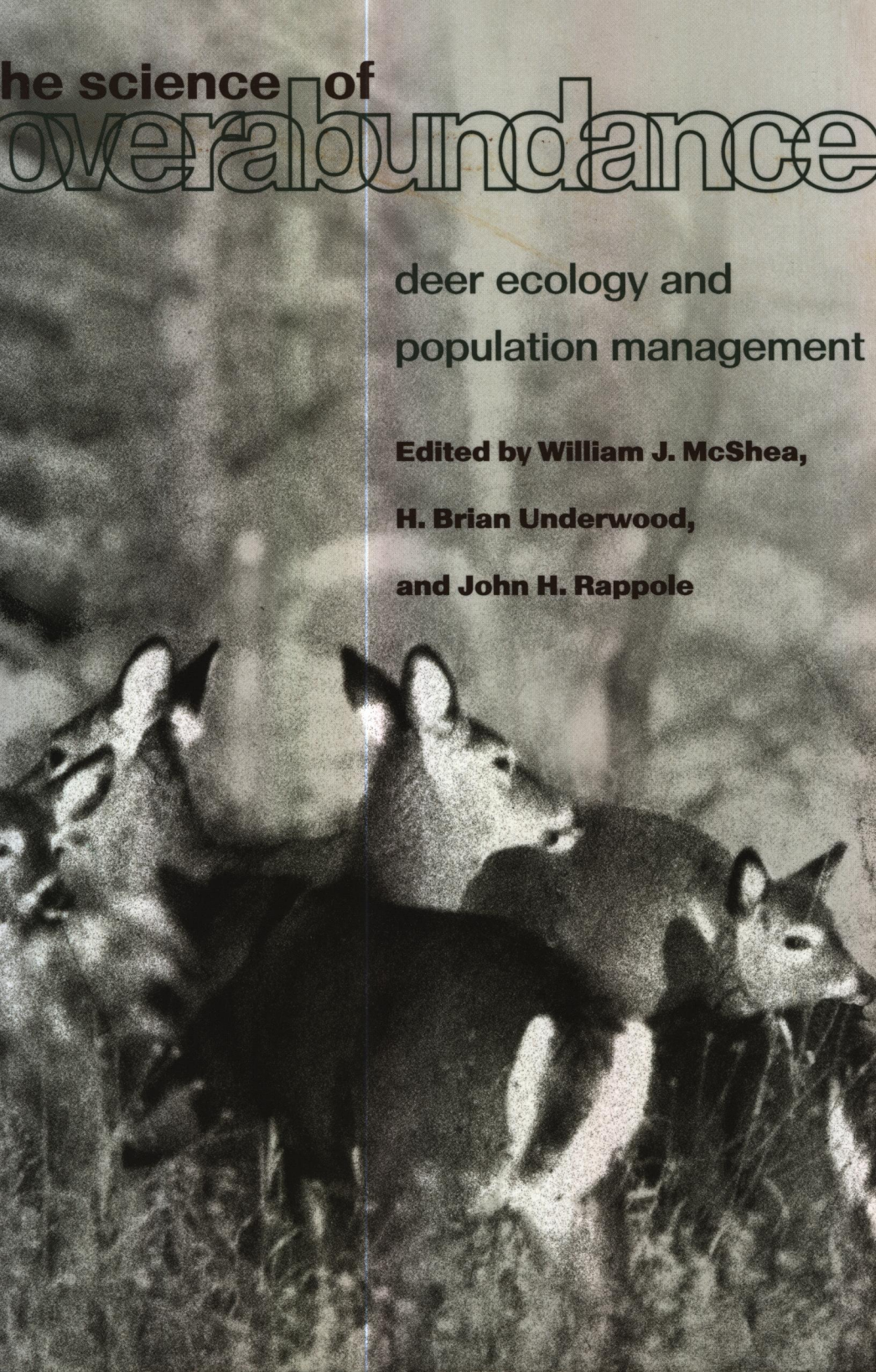
The Science of Overabundance

deer ecology and population management

Edited by William J. McShea,
H. Brian Underwood,
and John H. Rappole



THE SCIENCE OF OVERABUNDANCE

DEER ECOLOGY AND POPULATION MANAGEMENT

EDITED BY WILLIAM J. McSHEA,
H. BRIAN UNDERWOOD, AND JOHN H. RAPPOLE

SMITHSONIAN BOOKS
Washington and London

4 The Science of Deer Management

An Animal Welfare Perspective

ALLEN T. RUTBERG

The success of the white-tailed deer in colonizing and multiplying in the late-twentieth-century landscape of croplands, woodlots, parks, and suburbs has brought the issue of deer "overpopulation" before the public in many different contexts. In suburbs, high deer densities raise concerns about traffic safety, damage to ornamental plantings, alteration of so-called natural areas, and other issues. In agricultural communities, deer depredation of crops and orchards is the fundamental issue. In state and national forests and parks high deer densities may raise concerns about the achievement of management objectives, whether they be oriented towards timber production, recreation, historical interpretation, or the preservation of biodiversity and natural ecosystem dynamics.

As other chapters in this volume instruct us, deer population and community ecology are complex and highly interesting. Unfortunately, this picture of deer ecology does not resemble the "science" applied to deer management in the field, especially in the context of suburban deer conflicts. The scientific arguments in favor of deer management are commonly founded more on dogma than on data and more on intuition than on logic. Slide shows substitute for studies. The weakness of these arguments is not lost on large segments of the public and does much to fuel controversy and suspicion.

In this chapter, I argue that the scientific justification for using specific management actions to reduce deer populations, especially public hunts, commonly is weak, especially in suburban and park settings. I further

argue that those deficiencies remain in large measure because it is in the interest of the public hunting advocates, who dominate wildlife management agencies, not to correct them. Pure sport hunting is far less acceptable to the public than is management or subsistence hunting, and by discouraging rigorous scientific inquiry into the management effectiveness and biological impacts of hunting, the agencies blur the line between sport and management hunting and shield the public from awareness of the impacts of hunting. I also discuss how these scientific weaknesses become amplified and distorted in public discussion and outline the course by which I believe deer overpopulation controversies must be resolved.

First, I describe the ethical perspective from which I write.

AN ANIMAL PROTECTION PERSPECTIVE

Like all large social movements, the animal protection movement incorporates a broad range of views on hunting and wildlife management. One view, which for simplicity I will label the "animal rights" view, is truly antimanagement. In this view, animals have a right to exist without human interference of any kind. Killing, injuring, or otherwise meddling in the lives of wild animals is morally wrong, and killing wildlife for sport is especially obnoxious because of the human presumptuousness it implies.

In a second simplified view, which I will label the "animal welfare" view, human interference in the lives of animals is acceptable, but suffering must be minimized; deliberate cruelty is immoral. "Suffering" is defined broadly to include psychological as well as physical pain, such as may be caused by close confinement, neglect, lack of appropriate stimulation, or other failures to provide for normal behavioral responses. In the animal welfare perspective, wildlife management may be accepted to prevent or end suffering of the animals themselves; to reduce risks to public health or safety; to prevent harm to other wildlife, especially endangered wildlife, to habitat, or to rare or otherwise desirable wild plants; and—sometimes—to prevent wildlife from interfering excessively with the ability of people to support themselves economically. Lethal management is acceptable only as a last resort, and higher standards of justification are required if lethal management is being considered. Human recreation is no justification for killing; consequently, sport hunting is considered to be morally wrong.

Among practitioners, of course, animal rights and animal welfare perspectives often blend. For example, animal rights supporters will fre-

quently endorse euthanasia to end animal suffering and may tolerate benign, nonlethal wildlife management; animal welfare supporters frequently endorse "let nature take its course" policies even though animal suffering may result. In this chapter, I write as a behavioral ecologist who has an animal welfare perspective.

HUNTING: MANAGEMENT, SUSTENANCE, AND SPORT

Most species currently hunted in the United States do not require management and provide only minimal sustenance. Ducks and geese; pheasants, mourning doves, and other upland birds; squirrels, rabbits, raccoons, and other small- to medium-sized mammals may be consumed, but very few American hunters effectively feed their families with such small game. As a rule, these species are not associated with ecological or social problems that would justify population management, and where they might be (i.e., where medium-sized mammals are disease vectors), hunting is usually not an appropriate management tool. Thus, hunting of most species in the United States is primarily, if not entirely, recreational.

Consequently, the hunting community has focused the hunting debate on large mammals such as deer, where plausible arguments for subsistence and management hunting may be presented to the public. A deer in the freezer makes a significant contribution to a family's annual protein budget, and charitable programs where hunters donate deer meat to needy families drive home that point. When an estimated one million deer are hit by cars in the United States each year (Conover et al. 1995), it is easy to justify sport hunting as a necessary management tool for controlling deer populations.

Although these arguments are plausible, they are not necessarily supported by data. There are certainly rural areas in the United States where deer hunting provides an important, even vital, contribution to the family food budget. But estimates of cost per pound of venison calculated from total expenditures on deer hunting, number of deer taken, and estimates of dressed weights show that hunting is not, for most Americans, a cost-effective way to secure meat. As early as 1975, Williamson and Doster (1981) estimated that deer hunters spent $1.1 billion on food, transportation, lodging, licenses, equipment, and supplies to harvest 44.3 million kg of venison. Even excluding the costs of processing and freezing, as well as the time costs of hunting, this comes out to $24.85/kg ($11.27/pound)—in 1975 dollars. More recently, the Mary-

land Department of Natural Resources (unpublished data) estimated that hunters spent $51 million to harvest 46,317 deer in 1990, or $1,101/deer. Assuming a dressed carcass weight of 40.9 kg and that meat makes up 48% of dressed weight (McCabe and McCabe 1984; Sauer 1984), the average Maryland hunter spends $56.20/kg ($25.49/pound) for venison, not including processing. Clearly, the nourishment provided by deer hunting can be provided much more cheaply from other sources, and deer hunting is motivated by something other than basic food needs.

In my view, managers currently rely on two fundamental dogmas to justify most deer management actions. The first fundamental dogma is that deer management is always necessary to prevent deer overpopulation. That dogma is implicit in the title of this volume and is routinely encountered in state game agency pronouncements about deer management in parks, refuges, and suburbs.

The second fundamental dogma is that hunting is essential for deer management. In wildlife management conferences, "hunting" is often used synonymously with "management," and "antimanagement" is used as a misleading codeword for "antihunting." This dogma lies at the heart of the problem; it is used to justify hunting that is primarily recreational, especially hunting with bows, muzzleloaders, and other exotic weaponry that is too ineffectual to provide time- and cost-effective population control.

Purely recreational hunting is not popular with the public. A nationwide poll of 1,612 adults published by the *Los Angeles Times*, 25 December 1993, found that 54% "generally oppose the hunting of animals for sport." A similar poll conducted for the Associated Press by ICR Survey Research Group (Media, Pennsylvania) found that 51% of Americans surveyed believed that "it's always wrong to hunt an animal for sport." Opposition to sport hunting may be even higher in suburban areas, where deer controversies are becoming common. In one Long Island, New York, community confronting a deer controversy, nearly 70% of residents "strongly disagreed" with recreational hunting of deer (Decker and Gavin 1987).

In a 1987 survey of California residents, however, 55.5% of respondents agreed that hunting was a useful tool for balancing wildlife populations with habitat (Schmidt 1989).

The differences in public perception of hunting as recreation versus management is explicitly recognized in the management community. In advising hunters how to debate antihunters, the official periodical of a western state natural resource agency (Gasson and Kruckenberg 1993) urges readers, "Don't defend hunting as sport. Remember that, despite what we

might think, most of the American public opposes 'sport' hunting. Instead emphasize the personal . . . [and] utilitarian values of hunting."

Thus, state game agencies, which continue to associate closely with the hunting community, have a strong interest in convincing the public that hunting is necessary for management. And, consequently, careful scientific scrutiny of the fundamental dogmas is not encouraged by the traditional wildlife community.

HOLES IN THE FUNDAMENTAL DOGMAS

In spite of repeated assertions of the fundamental dogmas and their corollary—sport hunting is necessary to prevent deer overpopulation—scientific tests are rare enough and counterexamples are common enough to raise doubts in the minds of both scientists and thoughtful laypersons. The exponential rise in white-tailed deer populations in the United States during the last two decades makes a strong case that sport hunting has not controlled deer populations.

Rigorous Testing Is Not Applied

Tests of deer population control efforts rarely include even the most basic elements of scientific methodology. Controls, or baseline data, against which to evaluate treatment effects are rarely presented. Without a baseline for comparison, there is no clear measure of success. One commonly cited study (Wolgast and Kuser 1993) purports to show that bow hunting stabilized a deer population in Princeton Township, New Jersey. The study presents data from Princeton that (1) deer mortality caused by vehicle collisions (used as an index of deer population) rose from 1972 to 1983 and then stabilized from 1983 to 1992 and (2) deer mortality due to archery hunting rose steadily from 1972 to 1986 and then stabilized from 1986 to 1992. The article further describes a progressive liberalization in archery regulations from 1972 to 1986. No data are presented from areas experiencing different management over that period, thus precluding comparison. The result is a loose time correlation between archery regulations, archery mortality, and vehicle mortality.

Without baselines for comparison, the hypothesis that hunting controls deer populations cannot be rejected. In my experience with wildlife managers, a hunt that is followed by a reduction in deer population size is considered effective; a hunt that is followed by a stabilization in deer

population size is considered effective; and a hunt that is followed by a rise in the deer population size is considered effective because, the rationalization continues, without the hunt the population would have grown even more. Under these rules, failure is impossible.

Replicate studies, with multiple treatment and control sites, are rare. In practice, success is often claimed when animals are removed from the population without criminal violations, damage to property, or injuries to hunters or bystanders. One paper, for example, concludes that "deer kills in urban and suburban areas during archery hunting seasons . . . have contributed significantly to controlling deer at levels tolerated by residents" (McAninch 1993). However, the paper presents only data on harvest numbers in different suburban areas, along with a description of hunt methodology. No direct data on deer populations or impacts are offered.

The science surrounding deer management may be weak in part because much of it escapes peer review. Most data relevant to day-to-day management are presented in agency reports, compilations of meeting proceedings, master's theses, and other unrefereed formats. Articles reproduced in *Transactions of the North American Wildlife and Natural Resources Conference* are routinely cited as if these were refereed, which they are not. Hadidian (1993) evaluated 61 reports of studies on white-tailed deer biology in the national parks; only 28% had undergone journal-quality peer review. A glimpse of this phenomenon may even be seen in the *Journal of Wildlife Management,* which itself subjects submissions to a rigorous peer review process. The 1995 volume, for example, includes one article on deer population dynamics (McNay and Voller 1995); approximately 40% of the references in this article are theses, unpublished reports, proceedings, symposium volumes, and state agency publications. By contrast, two articles on other aspects of deer biology (nutrition, Gray and Servello 1995; molecular biology, Travis and Keim 1995) each contain only one reference (of 19 and 39, respectively) to sources other than refereed journals and standard reference works. Thus, I believe, much of the deer management literature may lack strict scrutiny that would screen out flawed methodology and unwarranted conclusions.

Data on Unhunted Deer Populations Are Scarce

Several authors in this volume (McCullough, Chapter 6; Palmer et al., Chapter 10; Underwood and Porter, Chapter 12) review the handful of long-term studies on deer populations that were neither hunted nor sys-

tematically culled. They describe population dynamics that vary in different environments and at different times: irruption and crash cycles, stable high-density populations, stable low-density populations, populations whose dynamics change through time, and populations that show density dependence and populations that do not. Other volume authors (Bowers, Chapter 19; Schmitz and Sinclair, Chapter 13; Seagle and Liang, Chapter 21) note that the impacts of deer populations on plant communities and on the ability of vegetation to recover from heavy browse vary with history, latitude, plant type, and other variables. The unpredictability of deer population dynamics and community impacts, which is entirely typical of complex ecological systems, does not prevent most game managers and public advocates of hunting and culling from repeating the predictions of catastrophe should deer be left "unmanaged."

Hunting Often Fails to Control Deer Populations

The most visible weakness in the assertion that hunting is necessary to control deer populations is that it has largely failed to do so over the last two decades. In the absence of better measures, harvest trends are often used as a population index (Hayne 1984). An analysis of white-tailed deer harvest trends in states east of the Rockies (Table 4.1; Anonymous 1995) shows that harvests more than doubled in the 20 years between 1973 and 1993 in 26 of 29 states surveyed; harvests increased by a factor of five or more in 12 of those states. In the 10 years between 1983 and 1993, harvests more than doubled in 21 of 36 states. The only states among the 36 showing relatively stable harvests were Maine, New Hampshire, Vermont, and South Dakota. These trends are supported by population estimates for nine northeastern states (Storm and Palmer 1995). These data suggest that sport hunting, as it has been administered and practiced over the last two decades, controls white-tailed deer populations either not at all, only in isolated areas, or in habitats near the boundaries of the species' range.

Failures exist at the particular as well as the general level. Since 1974, managers of the Great Swamp National Wildlife Refuge, New Jersey, have been holding a "management hunt" to control the refuge's white-tailed deer population. Total harvests have risen erratically but consistently since 1974, and the 1995 harvest was almost exactly twice the 1974 harvest (U.S. Fish and Wildlife Service, unpublished data; Figure 4.1). Again, to a skeptical citizen, this does not look like effective population control.

If there are enough hunters in the woods, and they are shooting a high

TABLE 4.1
White-tailed deer harvest by state

State	1973	1983	1993
Alabama	121,953	192,231	350,500
Arkansas	33,794	60,248	110,401[a]
Connecticut	—	3,791	10,360
Delaware	—	2,231	7,465
Florida	57,122	77,146	104,178
Georgia	—	164,000	306,253[a]
Illinois	13,862	28,666	115,491
Indiana	8,244	25,232	101,214
Iowa	14,030	35,619	76,430
Kansas	4,112	17,558	30,900[a]
Kentucky	—	18,732	73,278
Louisiana	74,500	137,000	213,100
Maine	24,720	23,799	27,402
Maryland	—	18,420	51,234
Massachusetts	—	—	8,345
Michigan	70,990	158,410	330,980
Minnesota	69,035	138,390[b]	202,928
Mississippi	976	196,147	262,409
Missouri	34,723	64,427	172,120
Nebraska	7,955	18,761	26,683
New Hampshire	5,462	3,280	9,889
New Jersey	11,318	23,305	49,942
New York	75,193	167,106	220,288
North Carolina	47,469[c]	96,236	217,743[a]
North Dakota	27,780	35,709	62,252
Ohio	7,594	59,812	138,752
Oklahoma	7,567	21,920	57,831
Pennsylvania	126,891	136,293	408,557
Rhode Island	102	222	1,462
South Carolina	23,703	57,927	142,795
South Dakota	—	46,727[d]	48,394
Tennessee	11,411	48,875	138,542
Texas	—	318,344	452,509
Vermont	9,600	6,630	13,333
Virginia	60,789	85,739	201,122
West Virginia	25,863	89,840	169,014
Wisconsin	90,561	230,476	270,592

Source: Anonymous 1995. (Reprinted with permission from the *1996 Deer Hunters' Almanac*, © 1995, Krause Publications.)

[a] 1992 deer harvest; 1993 data not available.

[b] 1984 deer harvest; 1983 data not available.

[c] 1972 deer harvest; 1973 data not available.

[d] 1985 deer harvest; 1983 and 1984 data not available.

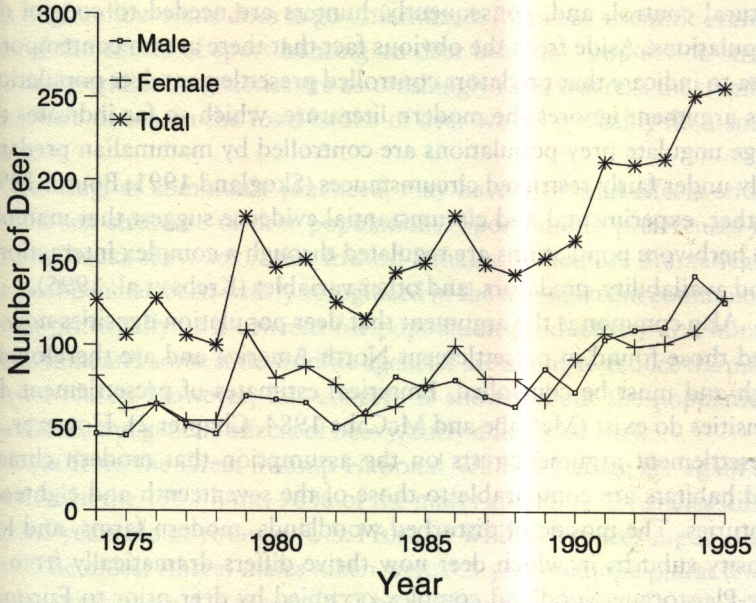


FIGURE 4.1. Deer harvests at the Great Swamp National Wildlife Refuge, New Jersey, 1974–1995 (U.S. Fish and Wildlife Service, unpublished data).

enough proportion of females, deer populations will be significantly reduced (e.g., Hesselton et al. 1965; McCullough 1984). However, there is often a large gap between what is possible and what is real, and an honest science of wildlife management must methodically examine which strategies lead to success and which strategies lead to failure. Just because deer are being killed doesn't mean that deer populations are being controlled.

OTHER SHORTCOMINGS OF THE SCIENCE OF DEER MANAGEMENT

The Complexities of Ecological Systems Are Not Recognized

Both data (discussed above) and models (Risenhoover et al., Chapter 22) of deer ecology demonstrate that the population dynamics and community effects of deer are difficult to predict, as is true of any complex ecological system. In practice, however, game managers rely on a few specious ecological arguments to justify hunts and other lethal reductions.

Probably the most widely used of these myths is that presettlement populations of deer were controlled by predators, removal of predators ended

natural control, and, consequently, hunters are needed to control deer populations. Aside from the obvious fact that there are no contemporary data to indicate that predators controlled presettlement deer populations, this argument ignores the modern literature, which so far indicates that large ungulate prey populations are controlled by mammalian predators only under fairly restricted circumstances (Skogland 1991; Boutin 1992). Rather, experimental and circumstantial evidence suggest that mammalian herbivore populations are regulated through a complex interaction of food availability, predators, and other variables (Krebs et al. 1995).

Also common is the argument that deer population densities now exceed those found in presettlement North America and are therefore too high and must be controlled. Empirical estimates of presettlement deer densities do exist (McCabe and McCabe 1984, Chapter 2). However, the presettlement argument rests on the assumption that modern climates and habitats are comparable to those of the seventeenth and eighteenth centuries. The mosaic of disturbed woodlands, modern farms, and low-density suburbs in which deer now thrive differs dramatically from the late-Pleistocene woodland complex occupied by deer prior to European settlement. Additionally, the period of European settlement of North America coincided with the Little Ice Age, which extended from 1350 to 1870. Continental and alpine glaciers expanded in the west and north and bitterly cold winters, cooler summers, and increased precipitation prevailed in other areas, including those occupied by white-tailed deer (Pielou 1991). Managing deer populations to presettlement levels has little biological justification.

The Biological Effects of Hunting Are Rarely Studied

In responding to recent research in wildlife contraception, the wildlife management community has, appropriately, asked a series of tough questions about the potential risks of these technologies to deer and deer populations. Managers have asked about effects of contraception on deer behavior and social organization, energetics, population health and genetics, and other issues.

Such advocacy of scientific rigor would be admirable were it not so hypocritical. Almost no one in the wildlife management community has asked these questions about sport hunting, even though the answers are likely to prove harsh. In his summary of white-tailed deer research needs, Halls (1984) does not mention any of the possibly harmful effects of hunting, except indirectly, when he examines whether a female-skewed sex

ratio might allow some does to go unfertilized. Rigorous scientific evaluations of the effects of sport hunting on deer behavior, population structure, and population genetics are astonishingly rare, whereas the number of master's theses on the food habits of deer would probably fill a small library.

Hunting, as commonly practiced, may have profound effects on the age and sex structure of deer populations. Sport hunter preferences for shooting bucks skew sex ratios toward females, sometimes dramatically. This problem has been widely recognized in the management community, though principally as a concern for population productivity and hunter satisfaction, and some state wildlife agencies are acting to reduce the more extreme biases. However, less concern is shown about the population, behavioral, and genetic effects of heavy, early adult mortality.

Data from the Great Swamp National Wildlife Refuge are again instructive. In the 1995 hunt, 98% of the males and 93% of females killed were 2.5 years old or younger (U.S. Fish and Wildlife Service, unpublished data). The oldest (three) males taken were 3.5 years old; the oldest (two) females taken were 4.5 years old. The implications for deer biology are potentially staggering. I mention two below.

First, hunting may select for early reproduction. In most large terrestrial mammals, including deer, mortality in natural populations tends to be concentrated very early and very late in the potential life span (Deevey 1947; Sinclair 1977; Clutton-Brock 1988). Females that survive to maturity commonly experience a number of years of low mortality before the onset of senescence (Hayne 1984; Clutton-Brock et al. 1988). Heavy hunting pressure changes that pattern of mortality, imposing heavy mortality on young adults that would normally show high survivorship and fecundity.

A well-established body of life history theory suggests that reproductive strategies are profoundly affected by the relative magnitude of juvenile and adult mortality (Stearns 1976; Horn and Rubenstein 1984). Under this theory, heavy adult mortality should select females for early reproduction and reduced body size, as energy for growth is diverted to reproduction. Application of this theory to deer suggests that heavy hunting pressure should select for more frequent reproduction by fawns, production of larger litters by yearlings and young adults, and reduced body size in females; these changes should be genetically based. I know of no data to support or refute this hypothesis.

Second, although mammalian social structure varies widely between and within species, matrilineal societies are extremely commonplace

(Greenwood 1980; Wrangham 1980; Clutton-Brock et al. 1982; Armitage 1986). In such societies, close spatial associations between mothers, daughters, and other matrilineal relatives are maintained into adulthood. Presumptively, knowledge about the location of food, water, cover, and potential dangers are actively or passively transmitted along generations of female relatives. At least some populations of white-tailed deer in which females are not hunted show this social structure (Nelson and Mech 1987; Porter et al. 1991). In heavily hunted populations, where adult does rarely live long enough to see their granddaughters' first winter, it is unlikely that such a social structure can be maintained. With the disintegration of such a structure may come a loss in knowledge of resources, especially resources used during special circumstances, such as severe snow cover or drought. I know of no comparative studies of social structure in hunted and unhunted populations or of the diversity of resource use in hunted and unhunted populations.

State Agencies Avoid Sponsoring Controversial Research

This critique of the science of deer management is not entirely novel. Wildlife scientists have already discussed many of the concerns raised and amplified here (Romesburg 1981; Wagner 1989). It is not uncommon for applied science to lag behind "pure science"; dogmas entrenched in professional thinking and popular culture persist for decades before the public becomes aware that these ideas have been seriously questioned or even discarded by scientists. I do not believe, however, that the gap between deer ecology and deer management can be completely explained by a simple "trickle-down" delay. Instead, I believe that the state wildlife agencies will not fund, and the cooperative research facilities will not sponsor, studies that may embarrass hunters or damage hunting interests.

CONCLUSIONS: THE PUBLIC VIEW OF DEER MANAGEMENT

Resolving deer overpopulation controversies is extraordinarily difficult. As discussed above, deer ecology is complex, and these complexities are routinely ignored by game managers who rely instead on fundamental dogmas and instinct. One problem is that the term "deer overpopulation" conceals an unrecognized mix of biology and values. In my own experience with deer conflicts, "deer overpopulation" encodes not a problem

but a solution, which is usually lethal population reduction. When pressed for a rationale for deer population reduction, advocates may mention a specific ecological or social problem (e.g., failure of oak regeneration, damage to ornamental plantings, or Lyme disease), but when alternative solutions to that specific problem are suggested, other problems are raised. Methodical identification of problems associated with high deer numbers is rare, and comprehensive, solution-oriented responses are even rarer. Commonly, "deer overpopulation" is nothing more than the intuitive, experience-based response of a game manager that "there are just too many deer," or, "the system is out of balance."

Inadequate science and confusion over the meaning of deer overpopulation is just the beginning of the problem, however. The print and broadcast media have not played a constructive role in resolving deer controversies. Newspaper, radio, and television reporters encourage polarization by structuring their stories around simple, clearly contrasting viewpoints. More often than not, "reporting" consists of predesigning a story and then identifying appropriate spokespersons who can fill in the quotes that the story assigns them. Someone in the hunting community will be found to call the local animal advocates "Bambi-lovers," and someone in the local animal advocate community will be found to call the hunters "murderers." The story is followed by published exchanges of angry letters between members of the identified factions, exchanges that sometimes degenerate into personal threats.

Science that is already weak and data that are usually inadequate are further simplified and distorted once they reach the public domain. Advocates on both sides grab hold of half-truths and shout them in each others' faces. I have heard population reduction advocates argue without evidence that a deer population is starving en masse yet is doubling every 2 years—an assertion that is biologically dubious. I have also heard population reduction advocates argue that a deer population of over a thousand individuals is both increasing and inbred, although inbreeding is more likely a problem for small and shrinking populations (Futuyma 1986). On the other hand, animal welfare advocates routinely argue that hunting increases deer populations, a misleading interpretation of the data.

It is the responsibility of wildlife managers to discourage the use of plausible myths and half-truths by both sides. Unfortunately, wildlife managers are not in a very good position to do this. To begin with, the inadequacy of the science that is often presented to the public by wildlife managers invites criticism from thoughtful laypersons and undermines the

managers' position as arbiters of good science. In my experience, public skepticism may become so severe that it is difficult for wildlife managers who are collecting good data to convince critics of the integrity of their efforts.

Public skepticism is also aggravated by the identification of state wildlife managers with hunting interests. Regardless of the integrity and intentions of any specific wildlife manager, the conflict of interest, or at least the appearance of a conflict of interest, is real and inescapable. As long as state wildlife commissions and departments are dominated by hunters and other consumptive users, and as long as wildlife departments are principally funded through the sale of hunting and fishing licenses and other income from consumptive uses (Hagood, in press), there will be significant public skepticism about the impartiality of state wildlife managers in resolving deer controversies. State representatives advocating public hunting to solve urban wildlife problems instantly raises suspicions.

The greatest difficulty in resolving deer overpopulation controversies is that they revolve not around questions of biology but questions of fundamental values (Decker et al. 1991; Underwood and Porter 1991). In virtually every deer controversy that I've encountered (probably close to 50), concerned citizens on all sides ask officials, "How many deer should there be?" Most officials answer the question with a number or range, for example, "5–15 per square kilometer of deer habitat." These numbers have emerged from a history of balancing agricultural and silvicultural interests against hunting interests, but in most present-day deer controversies these numbers are both irrelevant and indefensible. The best answer a deer manager can give to the question of "How many deer should there be?" is another question, "How many do you want?"

It is, of course, up to wildlife scientists and managers to provide to the public quantitative information on the relationship between deer density and deer impacts. As deer have become the source of important public policy questions, data have begun to accumulate on their impacts on forest regeneration, wildlife species diversity, vehicle accidents, economic losses, and other factors (Alverson et al. 1988; Tilghman 1989; DeCalesta 1994; Conover et al. 1995; McShea and Rappole, Chapter 18). These are enormously important studies and must be multiplied.

Ultimately, however, it is up to the public to decide what kind of deer impacts will be tolerated (see also Decker et al. 1991). It is up to the public to decide whether it is willing to accept 100 deer–vehicle collisions a year to be able to view deer regularly in an urban park or whether it is willing to reduce deer populations to promote oak regeneration, preserve

wild *Trillium,* or eliminate damage to hybrid azaleas. Wildlife managers trying to facilitate the resolution of deer controversies must resist the tendency to prescribe arbitrary densities to the public and should instead focus public attention on finding specific solutions to specific problems.

Unfortunately for the resolution of deer controversies, the public is not a single constituency. Although concern for public safety is relatively consistent, people vary widely in the value they place on oak seedlings, *Trillium,* azaleas, and the lives of deer. One constituency (e.g., The Nature Conservancy) may find itself opposed to policies put forth by another (e.g., The Fund for Animals), even if these groups are in substantial agreement on related issues, such as endangered species protection. Finding common ground between bow hunter associations and animal rights groups is even harder. In the end, a solution that satisfies 51% of the public, and doesn't offend most of the rest, may be the best that can be achieved. Finding that solution is the task of the deer manager and the land manager; it is up to the wildlife biologist to give the manager and the public the information needed to make that solution an effective one.

ACKNOWLEDGMENTS

The author thanks J. Grandy, J. Hadidian, S. Hagood, J. Kirkpatrick, and the Humane Society of the United States Mid-Atlantic Regional Office for their help with the manuscript. P. McElroy assisted in final manuscript preparation.

REFERENCES CITED

Alverson, W. S., D. M. Waller, and S. I. Solheim. 1988. Forests too deer: Edge effects in northern Wisconsin. Conservation Biology 2:348–358.

Anonymous. 1995. Deer Hunters' 1996 Almanac. Krause Publications, Iola, WI.

Armitage, K. B. 1986. Marmot polygyny revisited: Determinants of male and female reproductive strategies. Pages 303–311 *in* Ecological Aspects of Social Evolution. (D. I. Rubenstein and R. W. Wrangham, eds.) Princeton University Press, Princeton, NJ.

Boutin, S. 1992. Predation and moose population dynamics: A critique. Journal of Wildlife Management 56:116–127.

Clutton-Brock, T. H. 1988. Reproductive Success. University of Chicago Press, Chicago.

Clutton-Brock, T. H., S. D. Albon, and F. E. Guiness. 1988. Reproductive success in male and female red deer. Pages 325–343 *in* Reproductive Success. (T. H. Clutton-Brock, ed.) University of Chicago Press, Chicago.

Clutton-Brock, T. H., F. E. Guiness, and S. D. Albon. 1982. Red Deer, Behavior and Ecology of Two Sexes. University of Chicago Press, Chicago.

Conover, M. R., W. C. Pitt, K. K. Kessler, T. J. DuBow, and W. A. Sanborn. 1995. Review of human injuries, illnesses, and economic loses caused by wildlife in the United States. Wildlife Society Bulletin 23:407–414.

DeCalesta, D. S. 1994. Effect of white-tailed deer on songbirds within managed forests in Pennsylvania. Journal of Wildlife Management 58:711–718.

Decker, D. J., and T. A. Gavin. 1987. Public attitudes toward a suburban deer herd. Wildlife Society Bulletin 15:173–180.

Decker, D. J., R. E. Shanks, L. A. Nielsen, and G. R. Parsons. 1991. Ethical and scientific judgements in management: Beware of blurred distinctions. Wildlife Society Bulletin 19:523–527.

Deevey, E. S., Jr. 1947. Life tables for natural populations of animals. Quarterly Review of Biology 22:283–314.

Futuyma, D. J. 1986. Evolutionary Biology. 2nd edition. Sinauer Associates, Sunderland, MA.

Gasson, W., and L. L. Kruckenberg. 1993. Hunting, with or without a future? Wyoming Wildlife, September: 36–41.

Gray, P. G., and F. A. Servello. 1995. Energy relationships for white-tailed deer on winter browse diets. Journal of Wildlife Management 59:147–152.

Greenwood, P. J. 1980. Mating systems, philopatry and dispersal in birds and mammals. Animal Behaviour 28:1140–1162.

Hadidian, J. 1993. Science and the management of white-tailed deer in the U.S. national parks. Pages 77–85 *in* Proceedings of the Seventh Conference on Research and Resource Management in Parks and Public Lands, George Wright Society, Hancock, MI.

Hagood, S. In press. State Wildlife Management: The Pervasive Influence of Hunters, Hunting Culture, and Money. The Humane Society of the United States, Washington.

Halls, L. K. 1984. Research problems and needs. Pages 783–790 *in* White-Tailed Deer: Ecology and Management. (L. K. Halls, ed.) Stackpole Books, Harrisburg, PA.

Hayne, D. W. 1984. Population dynamics and analysis. Pages 203–210 *in* White-Tailed Deer: Ecology and Management. (L. K. Halls, ed.) Stackpole Books, Harrisburg, PA.

Hesselton, W. T., C. W. Severinghaus, and J. E. Tanck. 1965. Population dynamics of deer at the Seneca Army Depot. New York Fish and Game Journal 12:17–30.

Horn, H. S., and D. I. Rubenstein. 1984. Behavioural adaptations and life history. 2nd edition. Pages 279–298 *in* Behavioural Ecology. (J. R. Krebs and N. B. Davies, eds.) Sinauer Associates, Sunderland, MA.

Krebs, C. S., S. Boutin, R. Boonstra, A. R. E. Sinclair, J. N. M. Smith, M. R. T. Dale, K. Martin, and R. Turkington. 1995. Impact of food and predation on the snowshoe hare cycle. Science 269:1112–1115.

McAninch, J. B. 1993. Bowhunting as an urban deer population management tool. Pages 33–36 *in* Proceedings of the Western Bowhunting Conference, Bozeman, MT.

McCabe, R. E., and T. R. McCabe. 1984. Of slings and arrows: An historical retrospection. Pages 19–72 *in* White-Tailed Deer: Ecology and Management. (L. K. Halls, ed.) Stackpole Books, Harrisburg, PA.

McCullough, D. E. 1984. Lessons from the George Reserve, Michigan. Pages 211–242 *in* White-Tailed Deer: Ecology and Management. (L. K. Halls, ed.) Stackpole Books, Harrisburg, PA.

McNay, R. S., and J. M. Voller. 1995. Mortality census and survival estimates for adult female Columbian black-tailed deer. Journal of Wildlife Management 59:138–146.

Nelson, M. E., and L. D. Mech. 1987. Demes within a northeastern Minnesota deer population. Pages 27–40 *in* Mammalian Dispersal Patterns. (B. D. Chepko-Sade and Z. T. Halpin, eds.) University of Chicago Press, Chicago.

Pielou, E. C. 1991. After the Ice Age. University of Chicago Press, Chicago.

Porter, W. R., N. E. Matthews, H. B. Underwood, R. W. Sage, and D. F. Behrend. 1991. Social organization in deer: Implications for localized management. Environmental Management 15:809–814.

Romesburg, H. C. 1981. Wildlife science: Gaining reliable knowledge. Journal of Wildlife Management 45:293–313.

Sauer, P. R. 1984. Physical characteristics. Pages 73–90 *in* White-Tailed Deer: Ecology and Management. (L. K. Halls, ed.) Stackpole Books, Harrisburg, PA.

Schmidt, R. H. 1989. Animal welfare and wildlife management. Pages 468–475 *in* Transactions of the 54th North American Wildlife and Natural Resources Conference, Wildlife Management Institute, Washington.

Sinclair, A. R. E. 1977. The African Buffalo. University of Chicago Press, Chicago.

Skogland, T. 1991. What are the effects of predators on large ungulate populations? Oikos 61:401–411.

Stearns, S. C. 1976. Life history tactics: A review of the ideas. Quarterly Review of Biology 51:3–47.

Storm, G. L., and W. L. Palmer. 1995. White-tailed deer in the northeast. Pages 112–115 *in* Our Living Resources. (E. T. LaRoe, G. S. Farris, C. E. Puckett, P. D. Doran, and M. J. Mac, eds.) U.S. National Biological Service, Washington.

Tilghman, N. G. 1989. Impacts of white-tailed deer on forest regeneration in northwest Pennsylvania. Journal of Wildlife Management 53:524–532.

Travis, S. E., and P. Keim. 1995. Differentiating individuals and populations of mule deer using DNA. Journal of Wildlife Management 59:824–831.

Underwood, H. B., and W. F. Porter. 1991. Values and science: White-tailed deer management in eastern national parks. Pages 67–73 *in* Transactions of the 56th North American Wildlife and Natural Resources Conference, Wildlife Management Institute, Washington.

Wagner, F. H. 1989. American wildlife management at the crossroads. Wildlife Society Bulletin 16:354–360.

Wolgast, L. J., and J. E. Kuser. 1993. Bowhunting stabilizes a New Jersey white-tailed deer population. Bulletin of the New Jersey Academy of Sciences 38: 5–6.

Wrangham, R. W. 1980. An ecological model of female-bonded primate groups. Behaviour 75:262–300.

Williamson, L. L., and G. L. Doster. 1981. Socio-economic aspects of white-tailed deer disease. Pages 434–439 *in* Diseases and Parasites of White-Tailed Deer. (W. R. Davidson, ed.) Tall Timbers Research Station, Tallahassee, FL.