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Dynamics and social issues of overpopulated deer ranges in the United States: a long term assessment

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Overabundant deer (*Odocoileus* spp.) populations can be detrimental to forests, agriculture, transportation, and human safety, and can alter abundance of flora and fauna causing shifts in ecosystem dynamics and sustainability. Deer populations were classified as irruptive, chronic, or troubled in 1947 and 1986 to document changes over 4 decades. We again conducted a survey of deer biologists in 2013 throughout the U.S. to determine how deer population status has changed since 1986. All states surveyed in 1947 and 1986 were included in the survey, and we also included other states to obtain information on status of their deer herds. We contacted the primary deer biologist in each state and asked a series of questions about status of deer. In 1947, biologists in 30 states reported that they had irruptive, chronic, or troubled deer ranges. In 1986 only Colorado, Massachusetts, New York, Oklahoma, and Texas reported overpopulated deer ranges. In contrast, in 2013, 18 of 47 states surveyed reported issues with overpopulated deer herds in urban areas. In many states the deer population is at or below biological carrying capacity (K) but exceeds social carrying capacity. Many current issues with white-tailed deer are related to an increasingly urban human population that is less tolerant of deer, and not necessarily with increases in deer populations. Mule deer populations have declined from drought, but humans have also encroached upon winter ranges, thereby causing a deterioration of their habitat.

Key words: mule deer, *Odocoileus* spp., overabundance, status, United States, white-tailed deer, urbanization

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Deer (*Odocoileus* spp.) have always been an important aspect of wildlife management due to their popularity by the public for recreation, meat, and aesthetics. When populations exceed carrying capacity (K), however, they can become problematic and result in conflicts with human safety and well being, damage to property, agriculture, and forests, and can alter flora and fauna so that ecosystem dynamics are changed (Rooney 2001, Cote et al. 2004, Allombert et al. 2005). In the U.S. deer overabundance will be a major ecological challenge in the 21st century (Warren 1997). Deer will continue to create biological and ecological challenges, but more importantly they are likely to exceed social K (i.e., deer population density that best satisfies human expectations [Ellingwood and Spignesi 1985]; also referred to as optimum K; McCullough 1992) as human attitudes towards deer change (Warren 1997). Indeed, in a recent issue of *Time*, the cover story was about deer and other abundant species in the U.S. (Von Drehle et al. 2013; Figure 1). The authors presented material that is supported by the scientific literature but in a manner suitable to public understanding. The article exemplified what Leopold et al. (1947) first described and what Warren (1997) meant when citing overpopulation as a social issue that will be a challenge to resolve. Von Drehle et al. (2013) made a good case to the public for managed hunting to avoid problems of overabundance.

Figure 1.—Cover of Time magazine (2013) exemplifying issues of overabundant wildlife and the role management and hunting play in solving the problem.

Leopold et al. (1947) conducted the first survey of overpopulated deer ranges in the U.S. and the survey was repeated in 1986 (Krausman et al. 1992). Overpopulated ranges were classified as "irruptive" (i.e., exceeded biological K and the habitat was damaged), "chronic" (i.e., problem area of long standing usually in the post-irruptive stage), or "troubled" areas (i.e., when deer have recently exceeded K but to a lesser degree than when irruptive; Leopold et al. 1947). Since 1992 there have been two proceedings (McAninch 1995, McShea et al. 1997) and a special issue on deer overabundance in the *Wildlife Society Bulletin* (Warren 1997). All of these references and others (Porter and Underwood 1999, Krausman et al. 2011, Polfus and Krausman 2012) have been instrumental in documenting problems with the successful management of deer and advancing deer management in the U.S., especially in urban areas. In this study reference to "urban areas" includes 3 human-dominated landscapes: (1) Urban or areas with a human density of >386 people/km^2 (U.S. Census Bureau 2002); (2) Suburban or the patchwork of residential, commercial, municipal, and industrial land uses and related transportation and utility corridors often adjacent to urban centers (Knuth et al. 2001); and (3) Exurban areas with approximately 6–25 homes/km^2 that includes urban fringe development on the edge of cities and rural residential developments that have natural amenities (Hansen et al. 2005).

In a literature review, Polfus and Krausman (2012) reported that of 80 studies directly related to effects of human development on ungulates in the Rocky Mountain West, only 25 specifically examined residential development and its influence on focal species. Very few studies linked responses to population-level consequences or tested the cumulative impact that multiple developments and types had on ungulate behavior. Most research has been short term and of small scale.

The studies of Leopold et al. (1947) and Krausman et al. (1992) were, in part, designed to be helpful in wildlife classes, and to emphasize problems associated with abundant deer populations. Thus, our objective was to determine how status of deer populations in the U.S. has changed in the past 27 years, the reasons why, the social implications of, and management efforts used to minimize overabundance.

Materials and Methods

We obtained our data from phone interviews with deer biologists (i.e., deer program biologists, big game program managers, survey specialists) from state wildlife agencies using open-ended questions (Dillman 2007:4-42). We contacted each biologist and sent him or her copies of the previous papers by Leopold et al. (1947) and Krausman et al. (1992), a copy of the questionnaire (see results), and arranged times to discuss the survey. Interviews were conducted from August 2013 to January 2014 and took 20–40 minutes each. If we were not able to make phone contact with biologists, we left messages asking each to return the completed questionnaire.

Results

We attempted to contact deer biologists in all states except Hawaii. We received responses from biologists in 48 of 49 states (99% response rate; West Virginia did not respond). Biologists in all states did not respond to all questions on the survey because the

question was not applicable to their jurisdiction; thus, some percentages presented are based on <48 responses. Number of responses is provided when <48.

In 1947, 99 deer ranges were classified as irruptive, chronic, or trouble areas (deer on Nantucket Island, Massachusetts were "exterminated"; Leopold et al. 1947), but in 1986 only Mount Desert Island, Maine was still similar to the 1947 survey (i.e., high densities; Krausman et al. 1992). Eight areas in six states in 1986 had populations above K or above long-term goals for that state (Appendix I; Krausman et al. 1992). Records were not kept by most states on the specific overabundant ranges described by Leopold et al. (1947), so we summarized data on a state-wide basis (Appendix I). Results of the responses follow the nine open-ended questions from the survey (in italics).

1.—What is the recent statewide status of your deer populations (mule deer [Odocoileus hemionus], white-tailed deer [O. virginianus], or Columbian black-tailed deer [O. h. ssp.] compared to that reported by Krausman et al. (1992)? Deer populations across the U.S. have been dynamic since 1986 (Appendix I). Four state biologists reported that status (i.e., population level relative to management goals) of white-tailed deer populations have not changed and two biologists from those states reported the same for mule deer. Twelve state biologists reported stable white-tailed deer populations and three reported stable mule deer populations. Twenty-two states reported an increase in white-tailed deer but no increases in mule deer populations. Most increases (86%) of white-tailed deer occurred in the midwestern and eastern U. S. (Appendix I). Urbanization, habitat improvement, reduced antlerless hunts, limited access for hunting, low hunter effort, and mild winters were the most cited reasons for increases in white-tailed deer populations (Appendix I).

Biologists in Texas and Idaho reported white-tailed deer encroaching into mule deer habitat and increasing at the expense of mule deer (Appendix I). Mule deer declined in 10 states and white-tailed deer declined in nine states. Numerous reasons were provided for declining deer populations; they declined more from drought, an increase in carnivores, and habitat deterioration than from other factors. White-tailed deer declined due to limited antlerless harvests and carnivores more than from other factors (Appendix I).

Biologists in Alaska were not included in the first two surveys, but we did include them in the 2013 survey. Populations of Sitka black-tailed deer (*O. h. sitkensis*) were regulated by severe winters and they do not have overabundant herds. Most of the concerns of deer biologists in Alaska are with low deer numbers due to reduced habitat quality from logging, or increased predation.

2.—Where in your state do you have irruptive areas, trouble areas, or chronic areas (if any)? Twenty-four states with >80 problem deer herds were surveyed by Krausman et al. (1992) that had been identified by Leopold et al. (1947) with irruptive, chronic, or troubled areas. Although Idaho, Pennsylvania, South Dakota, and Wyoming were included in the 1992 survey, their responses were not clear enough to be included in this paper. Only six states reported continued problem areas in 2013. In Colorado, deer in Dinosaur National Monument continued to be at densities less than the long-term objective, but in Rocky Mountain National Park, deer were at Colorado's long-term population objective. The other two areas in Colorado (Kanna Creek and Gunnison Basin) maintained populations lower than the long term average.

Biologists in Illinois reported that deer in the Rockford population were still at K, but they reported additional trouble areas in Fulton and Skyler counties. Biologists in Maine continued to report trouble areas on islands, and in Texas biologists reported continued

populations above K in the Edwards Plateau. Vermont is experiencing trouble areas in the southeast and southwest, and all farmland in Wisconsin were classified as a trouble area. In addition to the states addressed by Krausman et al. (1992), biologists from 9 more states reported chronic or trouble areas (Table 1). Biologists in 18 states reported that most of their problems with deer were in urban areas, primarily with white-tailed deer, but mule deer were problematic in Montana and Nebraska in some urban areas.

Table 1.—Irruptive (I),Chronic (C), or trouble (T) areas caused by deer in states (in bold) not addressed by Leopold et al. (1947) or Krausman et al (1992) and states with continued problems.

State	Problem areas
Connecticut	Islands and peninsular areas especially Chimon Island, and Sheffield Island, (C), and Fairfield County (T).
Delaware	WM Zone 1A, Zones 7, 11, 12, 14, and coastal communities(T)
Indiana	Switzerland, NW, and east of Lake Michigan (T).
Kansas	Shawnee Mission Park (I); Kirwin, Quivira, Marcias des Cygnes National Wildlife Refuge, Cedar Bluff, Kaw, Norton, Kanapolis, Webster reservoirs; Grord Osage wildlife area (C)
Kentucky	Mammoth Cave National Park, Fort Knox (T); 17 counties >management goals
Maine	Islands, and southwest (T)
Maryland	Statewide (C)
Minnesota	North-central and northeast (C)
Pennsylvania	Northwest (C)
Texas	Edwards Plateau (C)
Virginia	Northern mountains (C); northern Virginia, including metropolitan Washington, D.C. (T)
Wyoming	Black Hills (I)

3.—One conclusion from Krausman et al. (1992) was that the terminology of irruptive, trouble, and chronic were not satisfying terms to biologists. Can you recommend better terms to characterize deer overabundance? The term "irruption" was "unsatisfactory as applied to deer" (Leopold et al. 1947:163), and biologists in 1992 did not like the terms, irruptive, chronic, or trouble in relation to overpopulation. Biologists in 38 of 47 states (81%), however, did not suggest alternative terms. Biologists in nine states (19%) made suggestions for more meaningful terms. Biologists in Colorado and Maine suggested terms should be tied to the management objectives of the state (e.g., for Maine terms would be tied to forest health, deer health, or social tolerance). Biologists in Louisiana preferred using high, medium, or low as measures of abundance, whereas biologists in Arkansas and Tennessee preferred increasing, decreasing, or stable as descriptors. Biologists in Nebraska, North Carolina, Washington, and Wyoming suggested terms should be tied to biological and social K.

4.—What has been your most successful management option for decreasing overabundant deer populations? Rank the top 3 among increased antlerless harvest, public bow hunting, public gun hunting, increased use of crossbows, special or controlled hunts (i.e., any hunt with additional restrictions to state regulation or traditional deer-hunting season, and taking place in a localized area), lethal targeted removal such as sharpshooting or trap-and-euthanize programs (i.e., culling deer in a localized area using bait, spotlights at night, suppressed firearms, and operated by a contracted agent or by government or law enforcement staff), habitat alteration, agricultural depredation permits aside from traditional deer-hunting season or bag limits, non-lethal methods (trap-and-transfer or contraceptive programs), predator introduction or recolonization, and other. Most biologists (96%) listed increased antlerless harvests as the most successful to decrease abundant deer herds. Most tools used by biologists to decrease populations involved some form of harvest (Table 2).

Table 2.—Successful management options (top 3[a]) used to decrease deer populations in 37 states of the United States.

Response	%
1. Antlerless harvest	96
Weather	4
2. Special or controlled hunts	27
Public gun hunting	20
Public bow hunting	18
Agriculture depredation hunts	16
Habitat alteration	7
Lethal removal	4
Other: land acquisition	2
Water distribution	2
Unlimited permits	2
3. Special or controlled hunts	36
Agricultural depredation hunts	15
Lethal removal	13
Public bow hunting	10
Public gun hunting	8
Antlerless hunts	3
Carnivore introduction	3
Other: public participation	
In deer management	3
Vehicle collisions	3
Education	3

[a] 47, 45, and 39 biologists in states responded with choices in the first, second, and third categories, respectively.

5.—Please rank the top 3 reasons for deer population overabundance: hunting weapon discharge restrictions (gun or bow, including discharge setbacks from roads and dwellings), private land access restrictions, low hunter effort (for any deer), low hunter effort (for antlerless harvest specifically), increased supplemental food resources (including landscaped or garden variety plants, baiting or feeding programs, or access to concentrated food plots), reduced predator populations, optimal natural habitat, low weather related mortality, regulatory or statutory restrictions to using alternative deer management approaches, and others. Private land access restrictions and hunting weapon discharge restrictions were the top reasons for deer increases; there were, however, numerous reasons noted for deer overabundance (Table 3).

Table 3.—Top 3[a] reasons for deer overabundance in the United States since 1986.

Ranking	Reason	%
1	Private land access restrictions	41
	Hunting weapon discharge restrictions	20
	Low hunter effort for does	7
	Low hunter effort for any deer	4
	Optimal natural habitat	4
	Increased supplemental food	2
	Reduced carnivore populations	2
	Regulatory or statutory restrictions	2
2	Private land access restrictions	32
	Low hunter effort for any deer	25
	Hunting weapon discharge restrictions	11
	Increased supplemental food	14
	Regulatory or statutory restrictions	7
	Low weather related mortality	5
	Low hunter effort	2
	Reduced carnivore populations	2
	Optimal natural habitat	2
	Other: hunting for trophies	2
	Historic management	2
3	Hunting weapon discharge restrictions	32
	Optimum natural habitat	21
	Low hunter effort for any deer	13
	Low hunter effort for antlerless deer	13
	Reduced carnivore populations	11
	Increased supplemental food	8
	Private land access restrictions	3
	Regulatory or statutory restrictions	3
	Social issues	3
	Less interest in game meat	3

[a] Biologists from 46, 44, and 38 states responded to rankings 1, 2, and 3, respectively.

6.—Have you identified a threshold or range (either through deer density estimates or a target number of human-wildlife incidents/unit area) for social carrying capacity when managing deer toward a population objective or goal? Response = yes or no. If yes, please list and describe by category (e.g., human health, human safety, and property damage incidents, or any other type of identified threshold). Most biologists (34 of 48; 71%) responded that they have not established a threshold; the remainder had. Many of the thresholds were based on social K and landowner attitudes (e.g., Maryland, Massachusetts, North Dakota, Ohio, Pennsylvania, Vermont). In Delaware, Mississippi, and Washington, tolerance was based on agricultural and property damage, whereas in Maine, Rhode Island, and Wisconsin social K towards deer was based on human health and public safety. Utah also used social K with range trend data, and Illinois incorporated deer vehicle collisions into their 10-year deer plans. Human tolerance of deer is a dominating factor in contemporary deer management.

7.—What do you measure to determine an "overabundant" deer population? Choose all that apply: derived population density estimates or trend counts from harvest data, minimum count data (or other non-harvest survey, including aerial survey), native habitat condition, vital rates within a deer population, negative human-wildlife conflicts (deer vehicle collisions, Lyme's disease reports, agricultural depredation), observations by deer hunters during hunting season, observation rates by non-deer hunters during other hunting seasons (e.g., moose or bear), and other. Biologists from 47 states (98%) responded to this question. Most biologists measured overabundance from derived population measures from harvest data (74%), followed by the number of negative human-wildlife conflicts (65%), native habitat condition (43%), vital rates (41%), observations by deer hunters during the hunting season (33%), minimum count data (26%), observations by non-deer hunters (7%), forestry models (4%), and fawn: doe ratios (2%).

8.—Has deer overabundance measurably reduced native biodiversity in any of these ranges? If yes, briefly describe and include any pertinent publications. Most biologists (33 of 48; 69%) reported that they did not monitor biodiversity related to deer abundance. Fifteen (31%), however, did so at varying spatial scales (Delaware, Illinois, Indiana, Maine, Maryland, Minnesota, Mississippi, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and Wisconsin). Of the fifteen, 66% reported monitoring efforts were fine scale studies of vegetative communities or forest regeneration, and resulted in technical reports or qualitative summaries only. Massachusetts, New Jersey, Pennsylvania, Virginia, and Wisconsin provided 6 specific peer-reviewed manuscripts that were published as a result of these efforts (Tilghman 1989, DeCalesta 1994, Healy 1997, McShea and Rappole 2000, Rooney and Waller 2003, Eschtruth and Battles 2009). Pennsylvania was the only state that incorporated annual measures of forest health at a deer management unit scale, although New York and Virginia reported plans to incorporate similar measures in the future.

9.—Have resources for management and research of deer been reduced and diverted to other wildlife species programs since 1986? If yes, briefly describe which species have been allocated funding. Most states (32 of 46; 70%) have not had funds for deer research reallocated to other species or projects. Fourteen states (30%), however, diverted funds to other species of big game, other game, non-game, feral hogs, carnivores, upland game birds, and wildlife research (Table 4).

Table 4.—States that have reallocated resources from deer to other activities in the United States between 1986 and 2013.

State	Resources reallocated from deer to:
Arkansas	Feral hogs and public relations
California	Other big game
Idaho	Carnivores
Indiana	Purchasing land
Maine	Other game
Massachusetts	Non-game
Minnesota	Non-game and fisheries
Mississippi	Non-game
Missouri	Rare and endangered species
Montana	Wildlife research
Nevada	Carnivores and law enforcement
New York	Non-game
Oklahoma	Upland game birds
Tennessee	Feral hogs, elk, and chronic wasting disease

Discussion

When the special issue on deer overabundance was published (Warren 1997), the editor distinguished between urbanization and urbanism. While urbanization is the increase in human populations and structures,"…Urbanism is a way of looking at life. It is an outlook. It is a much broader concept than urbanization… [T]he single, biggest obstacle, to good deer management that urbanization brings is urbanism. Urbanism results from the plastic environment—and the profound ignorance of the natural world by the people living in it. Today's urbanites differ from their city-dwelling predecessors in this regard. Three or 4 generations from a rural life seems to end all direct functional ties to—and spiritual bonding with—the Natural World… Most importantly, now we have a public that seems to be developing a very unnatural relationship with nature" (Marchinton 1997:21-22). The importance and impact of this "detachment from natural things" was discussed by Louv (2008), citing profound impacts on child development. Indeed, expansion of the human population and associated expansions in urbanism will challenge wildlife management with unprecedented impacts on natural systems (Liu et al. 2003, Von Drehle et al. 2013). The social significance of wildlife management was identified by Leopold (1933) when he wrote that human "progress" in the U.S. has skyrocketed over the past 20 centuries. However, that "progress" has not been accompanied with "…the capacity to live in high density without befouling and denuding his environment, nor a conviction that such capacity, rather than such density, is the true test of whether he is civilized. The practice of game management may be one of the means of developing a culture which will meet this test (Leopold 1933:423)".

That is a test we appear to be failing. Even understanding how urbanization is influencing deer is in its infancy, despite historic (Leopold et al. 1947) and current warnings (Von Drehle 2013). In a review of impacts of residential development on ungulates in the

Rocky Mountain West, only 20 studies reported on the actual influence of development on mule deer and white-tailed deer (Polfus and Krausman 2012). However, urbanization and human population growth were clearly important reasons for explaining trends in deer populations throughout the U.S. in 2013 (Appendix I, Table 3).

Due to increased urbanization in the midwestern and eastern U.S., it is not surprising that white-tailed deer have increased in these areas as evidenced by recent investigations (Hygnstrom et al. 2011, Polfus and Krausman 2012). Deer biologists claimed that the main reasons for white-tailed deer abundance was from restrictions on access to land resulting in low hunter effort, and restrictions on weapons discharge (Table 3). Thus, managers are limited in what they can do to manage deer in urban areas. It is a lot easier for deer to habituate to human activity when they are not hunted or harassed (Thompson and Henderson 1998). White-tailed deer commonly habituate to humans in urban settings (Swihart et al. 1995, Kilpatrick and Spohr 2000), where they have high survival rates due to decreased movements, decreased mortality from hunting, limited predation, and increased forage from ornamental plants, shrubs, fertilized lawns, and supplemental feeding areas (Swihart et al. 1995, Etter et al. 2002, Grund et al. 2002, Porter et al. 2004).

Mule deer have also become habituated to urban areas as reported herein by biologists in Texas and Wyoming. Habituation of mule deer was also reported by Kloppers et al. (2005). Biologists in mule deer range more commonly reported decreases in mule deer and overall, biologists did not report increased mule deer populations. The decreases were related to weather and drought and a reduction of habitat. In their review of deer and residential developments, Polfus and Krausman (2012) reported that much of the habitat that was lost to mule deer was the result of land development on winter ranges.

The issue of effects of urbanization again arose when we asked biologists about irruptive, chronic, and trouble areas in their states. Irruptive areas have decreased since the earlier surveys (Leopold et al. 1947, Krausman et al. 1992). Biologists did, however, report chronic or trouble areas in 12 states not included in earlier surveys (Table 1), most of which were white-tailed deer; chronic and troubled areas arose from urbanization in the eastern U.S.. Mule deer in the Black Hills in Wyoming have been described as irruptive since the 1947 study (Leopold et al. 1947). As urbanization increases in the West, it is likely that mule deer will increasingly create similar overpopulation issues in urban areas.

The terms related to overabundance were generally considered passe, likely because management has been able to maintain populations that can be controlled and there are very few irruptive areas. Biologists did prefer that terms related to overabundance be changed to reflect the management objectives of the state. At, above, or below management objectives is straightforward, easily understood by the public, and management objectives typically consider social K; thus, the terminology is changing with the issues deer present to managers. If terms are tied to management objectives, managers may be able to avoid the problems of doing too little too late, as described by Leopold et al. (1947) and may be able to avoid the nebulous concept of carrying capacity.

We were not surprised that hunting was the primary tool to control deer abundance. Harvest has been recognized as important by biologists for decades and is a central theme of the North American Model of Wildlife Conservation (Organ et al. 2012), which emphasizes the role of hunting in conservation and management. Recent articles in major news outlets (e.g., *Time* [Von Drehle et al. 2013] , *The Economist* [Anonymous 2013], and *The New Yorker* [Rosen 2014]) related the positive aspects of hunting to the public and indicate how

important hunting is to wildlife management and successful co-existence between humans and wildlife.

Biologists in most states did not have specific thresholds to determine when deer were too abundant, and those that did generally relied on social K related to human health and safety, and the level of negative human-wildlife interactions. These negative interactions must be addressed because they can undermine public support for management agencies and conservation initiatives (Kretser et al. 2009), in addition to the problems they create. Overall, biologists used a variety of biological measures (74%) to assess when a population was too high, but negative human-wildlife interactions (65%) were also a widely used metric.

Biologists in 32% of the states indicated that abundant deer populations measurably reduced biodiversity. The remainder did not have measures in place to measure biodiversity. Overabundant deer in deciduous or mixed forest communities reduced regeneration of native tree species, altered vegetative community composition, reduced migratory songbird abundance, reduced abundance of endangered plant species, and reduced forest nesting songbird diversity (Tilghman 1989, DeCalesta 1994, Jones et al. 1997, Healy 1997, McShea and Rappole 2000, Rooney and Waller 2003, Eschtruth and Battles 2009). In states that reported reduced biodiversity but had less rigorous measurements or lacked well-documented findings, biologists reported a general reduction in native vegetation and reduced regeneration of some native trees. Minnesota indicated active communication with forestry professionals for additional measures of forest health on public lands in relation to deer herbivory. It was clear that most states do not systematically collect information on impacts of deer populations on native species diversity, but most biologists commented on anecdotal signs of intensive deer herbivory in areas of deer overabundance.

Finally, our survey suggested that funds for continued deer research and management were shifting in nearly a third of the states to other species and issues (Table 4). Many of these states are in the midwestern and eastern U.S., where there are serious issues related to white-tailed deer and more funds, not less, are needed. For example, biologists in Mississippi reported that their white-tailed deer population has "exploded" in the past 27 years and more management and research are needed to address issues related to this increase.

This survey has revealed that deer management in the U.S. continues to be an important aspect of wildlife management, and that managers still struggle with populations that are too low or too high. However, there has been a shift in how society thinks about overabundant deer populations. We have moved from a biological concern for overabundant populations, when exceeding biological K was the norm, to considering deer populations overabundant when they exceed social K. This illustrates the importance of human dimensions in wildlife management and ensuring that the public is involved in deer management issues and initiatives from the beginning.

The survey also pointed to areas of research and management that need more attention. There is room for more information about deer populations and their management on islands with dense human habitation, and with restrictions on land access and weapons discharge. Understanding how deer alter biodiversity is also an important concept to explore through long-term monitoring of plant composition and change. That 32% of the states did measure, and reported, changes in biodiversity suggests that if the other 68% of states did the same, we would learn more about alterations to habitat caused by deer, learn more about community ecology, and be able to better manage deer populations and their habitats. It

is important to note, however, that habitat management is often the responsibility of land management agencies and not wildlife agencies, which we surveyed.

Research is also needed to determine acceptable methods to remove deer from urban areas while educating residents to accept and allow efficient and safe harvest methods to be used to reduce herd size. This will coincidentally require an outreach program that educates urbanites of the issues pertaining to overabundant deer and the need to reduce their populations to ensure human safety, minimize property damage, and maintain the ecological integrity of adjoining ecosystems. Lastly, our survey demonstrates clearly that deer population issues, particularly regarding white-tailed deer, are national in scope and quite consistent in management goals and harvest methodologies. With this in mind, there must be a multi-state effort to monitor deer populations (such as the National Feral Swine Mapping System coordinated by the Southeastern Cooperative Wildlife Disease Study). Disease issues are becoming critically important and a national database on deer herd distribution and herd dynamics could be useful for assessing disease spread and impacts, and other applications to ensure sound and sustainable deer management programs throughout the United States.

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APPENDIX I: STATUS (SOCIAL K [SK], IRRUPTIVE [I], LONG TERM AVERAGE [LTA], DECREASING [D], STABLE [S]) OF MULE DEER (MD) AND WHITE-TAILED DEER (WT) IN RELATION TO CARRYING CAPACITY (K) IN THE UNITED STATES FROM 1986 TO 2013.

State	Overall change	Stable to stable to increased (SI)	Increased, >social K (>SK), >long term average (>LTA)	Decreased, <K, <LTA, decreased to stable (DS)	Reason for change[a]
Alabama		WT			1, 2, 13
Arizona				MD, WT	1, 4, 8, 12, 19
Arkansas		WT			1, 3, 18
California	WT/MD[b]				9, 21
Colorado		WT (SI)		MD	5, 10, 20
Connecticut			WT (at K)		30
Delaware			WT (increased 3X)		3, 9, 29
Florida		WT (SI)			2
Georgia			WT (>SK)		2, 6
Idaho		WT[c]		MD	4, 5, 10, 14
Illinois	WT				1, 29
Indiana			WT (<K)		2
Iowa				WT	1
Kansas			WT		3
Kentucky			WT		2, 3, 7
Louisiana				WT (DS)	1, 22, 23
Maine			WT		2, 4, 11,29
Maryland			WT (>SK)		2, 6, 7, 11
Massachusetts		WT			6, 7
Michigan			WT (lower pennisula)	WT (upper pennisula)	1, 8
Minnesota			WT		1, 11
Mississippi			WT[d]		6, 7, 25
Missouri				WT (<K)	1, 6
Montana			WT(>LTA)	MD (<LTA)	1
Nebraska				WT, MD	5,8,11,16, 25
Nevada				MD (DS)	4, 5, 24
New Hampshire			WT		4, 25
New Jersey				WT	3, 6, 11
New Mexico				WT, MD	4, 8, 15, 29
New York			WT		2, 6, 25
North Carolina		WT			1, 9
North Dakota	WT,MD				4, 17, 28
Ohio			WT		1, 7
Oklahoma		WT			1
Oregon		WT		MD (<K)	4, 5, 8, 15
Pennsylvania		WT (W and SE)		WT (central)	1
Rhode Island			WT		2
South Carolina	WT				8, 14, 18
South Dakota		WT,MD			6, 7
Tennessee			WT (>SK)		3, 26
Texas			WT[c]	MD	2, 4, 5
Utah		MD			2, 3, 5, 8, 14
Vermont			WT (<K)		1, 2, 6
Virginia			WT (>K)		2, 4
Washington		WT, MD (SI)			4, 8, 9, 16
Wisconsin			WT		11, 25
Wyoming			WT (Irruptive)	MD (<LTA)	2, 5, 17

[a] 1 = antlerless harvest, 2 = urbanization, 3 = habitat improvement, 4 = habitat deterioration, 5 = drought, 6 = limited access for hunting, 7 = low hunter effort, 8 = predators, 9 = increased human population, 10 = severe winters, 11 = mild winters, 12 = special hunts, 13 = more accessible land for hunting, 14 = increased highway traffic, 15 = livestock over-browsing, 16 = disease, 17 = energy production, 18 = forestry practices, 19 = water distribution, 20 = competition with elk and cheat grass, 21 = anti-hunting groups, 22 =longer hunting seasons, 23 = liberal weapon use, 24 = fire, 25 = reduced doe harvest, 26 = greater law enforcement, 27 = lack of predators, 28 = vehicle collisions, 29 = liberal hunting, 30 = unknown.

[b] Generally the same but appears to be a slow overall decline.

[c] WT are moving into MD habitat.

[d] Population exploded in the past 20 years.