The Future of Managing Ungulate Species: White-tailed Deer as a Case Study

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Introduction

Ungulate populations provide benefits and accrue costs for people, economies, and the environment. In the USA, viewing of large mammals accounts for 50% of wildlife-watching trips away from home and is participated in by 11.8 million people, of which 75% are not hunters or anglers (USFWS and USCB 2018). Almost $76 billion was expended on all types of wildlife watching in 2016 in the USA, and the non-consumptive enjoyment of wildlife dwarfed the $14.8 billion spent related to the consumptive use of big game species (USFWS and USCB 2018). Consumptive use of big game species funds most wildlife conservation. Nearly 8 of 10 hunters hunt deer (Fuller 2016) and hunting license sales provide more than a third of wildlife agency funding (AFWA 2017).

In addition to economic benefits, recreational hunting serves as the primary method of regulating deer populations to achieve management goals. As a polygamous species, white-tailed deer (*Odocoileus virginianus*) populations can readily sustain harvests of males. As a result, most wildlife agencies allow each licensed hunter the opportunity to harvest at least one antlered deer. On the other hand, female survival is the driving factor influencing population growth rate (Gaillard et al. 1998) and hunting is generally regulated through some type of permitting system

to control the number of females harvested. By adjusting the number of females taken by hunters, deer populations can be increased, stabilized, or decreased to achieve management goals. Historically, hunters and administrators of wildlife agencies have embraced conservative harvest regulations to ensure sustained or increased deer populations (Nugent and Mawhinney 1987, Decker and Connolly 1989, Fuller and Gill 2001, Frye 2006).

In North America, wildlife is held in the public trust and hunting is regulated by government agencies rather than by landowners. This approach to wildlife management has been termed the North American Model for Wildlife Conservation (NAM), in which hunting and hunters are considered the foundation for wildlife conservation and provide the bulk of conservation funding (Heffelfinger et al. 2013). Elsewhere in the world there are different approaches to wildlife management where private landowners have greater control over the harvest of big game (Gill 1990). In some countries, landowners have historically had significant control over management decisions for ungulates under both public and private approaches because the right to shoot deer usually cannot be separated from land ownership.

Both the NAM and landowner models of ungulate management have shortcomings identified as resulting in increased human-wildlife conflicts (Milner et al. 2006, Lindqvist et al. 2014, Peterson and Nelson 2017). In the U.S. and Canada, it has been difficult for wildlife agencies to manage deer to balance competing objectives because hunters are the primary constituency for ungulate management in North America and fund most wildlife conservation (Leopold et al. 1947, Diefenbach and Palmer 1997). Similarly, in Europe hunting organizations are primarily responsible for setting wildlife population goals, which may conflict with other activities such as agriculture or forestry. Conflicts that arise with abundant ungulate populations include deer-vehicle collisions that cause human fatalities and injuries and economic losses

(Seiler 2004, Bissonette et al. 2008), agricultural damage (Bleier et al. 2012), and disease transmission (Martin et al. 2011). Abundant ungulates also have environmental effects that may conflict with human goals and objectives. Environmental effects of ungulate herbivory have been identified all over the world with many different ungulate species, including moose (*Alces alces*) in Scandinavia (Hornberg 2001), red deer (*Cervus elaphus*) in northern Europe (Lilleeng et al. 2016), sika deer (*Cervus nippon*) in Japan (Tamura and Nakajima 2017), white-tailed deer in North America (Tilghman 1989), roe deer (*Capreolus capreolus*) and fallow deer (*Dama dama*) in Europe (Apollonio et al. 2010), and multiple ungulate species introduced to New Zealand (Cruz et al. 2017).

Minimizing conflicts with humans may require population goals that are below ecological carrying capacity (Zoë et al. 2010). Similarly, ensuring a sustainable population requires keeping ungulate populations below ecological carrying capacity but large enough to ensure long-term viability of the population. Maximizing recreational opportunity, either for consumptive or non-consumptive purposes, can be in direct conflict with human-conflict and ecological objectives. In general, ungulate populations have increased worldwide as suggested by the number of species and locations throughout the world where ungulate herbivory is affecting ecosystem processes.

The future challenge to managing ungulate populations to meet objectives is likely to become more difficult as participation in recreational hunting declines and ungulate populations become more abundant. We use the white-tailed deer in North America as a case study to illustrate the management challenges facing decision makers. First, we show that declining participation combined with an older age structure will likely lead to dramatic declines in hunting participation in the coming decades. Second, we argue that traditional regulation changes

intended to increase hunter efficiency may be ineffective given demographic factors involved. Finally, we identify potential strategies that could be considered, which may help wildlife managers meet management objectives.

Population Demographics of Hunters

Compared to the general population, demographics and residency of big game hunters have changed little over the past 30 years. According to the National Hunting, Fishing, and Wildlife-Associated Recreation (NHFWAR) surveys of 1991 and 2016, big game hunters have remained ≥90% male and 97% white; whereas the U.S. population is 48% male and non-whites have increased from 15% to 22% of the population (USFWS and USCB 1993, 2018). Similarly, the percentage of big game hunters who live in urban areas has not changed (44% to 45%), but the percentage of the general population living in urban areas has increased from 73% to 82%. Fewer than a quarter of hunters lived in an area of >1 million people (21%–23%) between 1991 and 2016, yet in the general population the percentage living in large metropolitan areas has increased from 43% to 57%. Lack of change in characteristics of big game hunters, relative to the general population, indicates hunting does not seem to appeal to the portion of the U.S. population that is growing most rapidly.

Despite efforts to increase hunter numbers, age structure of big game hunters indicates the decline in numbers will continue in the future. Big game hunters are aging faster than the general population. In the general U.S. population there has been an increasingly older age structure (Figure 21.1). In 1991, 41% of the U.S. population was ≥45 years old, which had increased to 52% by 2016. However, hunters ≥45 years old increased from 28% to 60% during the same time period. In Pennsylvania, the average age of deer hunters increased from 40 years old in 1991 to 51 years old in 2016 (Pennsylvania Game Commission, unpublished data; Table

21.1). Moreover, it appears a significant proportion of hunters drop out of the sport after age 65 (Figure 21.1; bottom). Deer hunters are not being replaced as they age out of the hunting population. Also, regardless of age, hunter numbers have been declining for the past several decades. According to the 2016 NHFWAR the number of hunters decreased 16% from 2011 to 2016, which included a 20% decline in big game hunters. The 2016 level of hunting was at the lowest level in the past 25 years (USFWS and USCB 2018).

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To illustrate the potential decline in deer hunters that may occur in the USA, we used demographic data from hunters in Pennsylvania (2009–2017) and Virginia (2008–2018) to predict the number of hunters 10 and 20 years from now. We used age-structure data of general hunting license buyers in Pennsylvania (80% of license buyers hunted deer in 2018) and licensed deer hunters in Virginia (hunters who purchased a deer license) to predict population growth and age distribution of hunters. In Pennsylvania, the number of 12-year-olds purchasing hunting licenses declined approximately 408 licenses per year during 2009–2017. In Virginia during 2007–2018, 12-year-olds purchasing deer licenses declined 7%/year. In addition, we calculated the average proportional change in license buyers between age i to age $i + 1$ ($i = 12 – 89$). We used the number of 12-year-olds purchasing a hunting license (recruitment) and the proportional change in number of hunters by age to project the number of hunters through 2030 and 2040. We predicted the number of hunters, 12–90 years old, in Pennsylvania would decline by 17% by 2030 (compared to 2020; decline from 807,227 to 670,302 hunters) and by 37% by 2040 (to 512,263 hunters; Figure 21.2). In Virginia, we predicted the number of deer hunters would

decline by 32% by 2030 (compared to 2020; decline from 173,058 to 118,027 deer hunters) and by 57% by 2040 (to 75,178 deer hunters; Figure 21.2).

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Although much of the decline in hunters was driven by the decline in number of new hunters recruited each year, aging of older hunters out of the population was a significant factor (Figure 21.2). For example, Pennsylvania would have to recruit approximately 450 additional 12-year-olds every year for the next 20 years and retain hunters and increase reactivation of older hunters by 1%, to result in a no net loss of hunters by 2040. Similarly, Virginia would have to increase recruitment of 12-year-olds >6% each year compared to the previous year through 2040 and retain hunters and increase reactivation of older hunters by 2%, to result in no net loss of hunters. Aging and numerical decline of big game hunters will create real challenges for resource managers and recreational hunting as a management method in the near future.

General Framework for Managing Deer

Management of white-tailed deer in North America is a top-down process by which wildlife agencies develop a management plan with input from the public, agency staffs monitor the deer population, and then agency staffs make recommendations to decision makers regarding hunting regulations to meet established goals. There are four components to any management program. First, application of management actions and deer harvest and population monitoring generally occurs within defined management units. Management units can be based on political boundaries or possess ecological and social characteristics that are as homogeneous as possible within physical boundaries such as roads and rivers (Karns et al. 2016, Swihart et al. 2020). Effective management units should be sized to meet desired precision of a monitoring program given cost and logistical constraints. For management and monitoring purposes, smaller political

units are not necessarily more effective than larger ecological and social units (Rosenberry and Diefenbach 2019). Even so, many agencies use management units that are based on political boundaries rather than ecological-based units (Table 21.2).

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Second, management goals and objectives must be developed for each management unit that represent public values within the context of the wildlife agency's mission and legal authority. To identify the goals and objectives, public engagement often takes the form of citizen advisory committees, public meetings or open houses, and public surveys (e.g., Stout et al. 1996, Fleegle et al. 2011). Management objectives for each goal must be defined such that they can be quantitatively evaluated by a monitoring program (Artelle et al. 2018). The importance of scientifically rigorous monitoring programs has been highlighted in recent years with lawsuits and legislatively sponsored reviews and audits of agency deer management programs (Millspaugh et al. 2007, Wildlife Management Institute 2010, Office of Legislative Auditor 2016).

Third, within each management unit data are collected to monitor either deer abundance directly or indicators that can provide trends in deer population characteristics (Table 21.1). Most states monitor harvest statistics (e.g., buck kill per unit area; Table 21.1) and some use sex-age-kill models or accounting-type population models (Diefenbach and Shea 2011). Some states use annual surveys of direct abundance (Kaminski et al. 2019). In addition to deer abundance, other data may be collected to assess how well objectives are being achieved, such as stakeholder opinions (Curtis and Hauber 1997) and habitat conditions (Rosenberry et al. 2009).

Fourth, a strategy to attain population management goal needs to be identified. For white-tailed deer, changes in abundance are accomplished primarily through manipulation of the

harvest of female deer. Manipulation of the male population can effect changes in social behavior and sex-age structure of the population (e.g., Wallingford et al. 2017) but has little effect on population trends. Strategies to achieve management goals may be applied at the management unit scale (e.g., allocation of antlerless licenses) or at smaller scales to address local deer-human conflicts, such as excessive crop damage or deer-vehicle collisions.

These four components of a management program are repeating loop processes that occur at different time scales. On an annual basis, the result of harvest strategies with regard to management objectives are evaluated based on monitoring data (3 and 4 above). Then new recommendations for harvest strategies are developed for the next year. However, at longer time intervals agencies may revise management goals and objectives based on stakeholder input (2 above). Although deer management programs vary by agency, the challenge remains the same; achieving deer management goals in a manner that balances the values of stakeholders in a transparent manner that is defendable.

Traditional Harvest Management Strategies

White-tailed deer populations increased throughout the 20th century in North America, but with these increasing populations hunter participation also increased. Consequently, a successful strategy for managing deer populations was to regulate hunting season length (number of days of opportunity to harvest a deer) and the number of deer each hunter could harvest each year (bag limit). In most situations, longer seasons and a smaller bag limit could achieve the same level of harvest as a shorter season and larger bag limits.

In states like Pennsylvania which had >1 million deer hunters in the late 1980s, changes in season length or antlerless harvests were sufficient tools to maintain stable deer populations and provide sustained harvests (Diefenbach and Palmer 1997). In the early 1900s, deer hunting in

Pennsylvania consisted of antlered-only harvests with sporadic antlerless hunting seasons, and it was not until 1953 that antlerless seasons were held annually (Kosack 1995). Even with declining hunter numbers, in 2018 Pennsylvania had 660,000 deer hunters (15 hunters/mi^2; Table 21.1) and limited hunters to one antlered deer per year and two antlerless deer for most management units. Changes in season length and antlerless license allocations in the early 21st century allowed Pennsylvania to reduce the statewide deer population by 23% in three years (Wallingford et al. 2017). The population reduction was achieved by shifting from a 12-day antlered deer and 3-day antlerless deer seasons to a single 12-day concurrent antlered and antlerless deer season and increased allocation of antlerless licenses. Except in more urban areas surrounding large cities, hunting was sufficient to control deer populations in Pennsylvania (Table 21.2).

In states with fewer licensed deer hunters and large urban areas, such as Virginia (5 deer hunters/mi^2; Table 21.1), changes solely to season length and bag limits may be insufficient to control deer populations. Northern Virginia (Arlington, Fairfax, Loudoun, and Prince William counties; 1,301 mi^2) is highly urbanized (1,724 people/mi^2) and was experiencing increasing deer populations by the 1990s. To reduce the deer population the Virginia Department of Wildlife Resources implemented a series of regulatory changes over >20 years (Table 21.3). Changes to hunting regulations were intended to increase hunter access to public green space, motivate hunters to harvest antlerless deer, and provide more opportunities to harvest deer through longer seasons and larger bag limits.

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Perhaps the most effective tool to increase the antlerless harvest in northern Virginia was implementation in 2008 of an earn-a-buck regulation, in which a second antlered deer could not

be harvested until an antlerless deer was harvested (Table 21.3). Traditionally, earn-a-buck has been used to increase antlerless harvest by requiring hunters to harvest an antlerless deer before harvesting an antlered deer. Although an effective regulation to increase antlerless harvest, such implementation of the earn-a-buck regulation is disliked by hunters (Van Deelen et al. 2010). However, implementation of the earn-a-buck regulation only after the first antlered deer is harvested is more acceptable and has allowed Virginia to increase the percentage of antlerless deer in the harvest (Tables 21.1 and 21.3) and accomplish removal of 30 deer/mi^2 in 2018 on thirty square miles of public lands in Fairfax County.

A Strategy to Maintain Efficiency of Hunter Harvest

Simply extending season lengths and bag limits will fail to control deer seasons when there are too few hunters willing to harvest a sufficient number of antlerless deer. Also, the effectiveness of increasing seasons and bag limits is reduced when recreational hunting cannot occur either because restricted access to private land or safety issues require less effective sporting arms (e.g., bows or crossbows rather than firearms). The regulatory changes implemented in northern Virginia have been effective where hunting opportunity has been maximized (Table 21.3) such that they currently have the longest hunting season (8 months) and most liberal bag limits (unlimited for antlerless deer daily and season) in North America for white-tailed deer.

In coming decades, more wildlife agencies may reach the limits of recreational hunting to control deer populations because of the declining trend in hunter numbers (Figures 1 and 2, Winkler and Warnke 2013). Hunters generally are not motivated by ecological concerns or deer-human conflicts because other priorities inform their motivation for hunting (Diefenbach et al.

1997, Holsman 2000). Consequently, most hunters desire to harvest only 1–2 deer/year (Brown et al. 2000), and some are interested in primarily harvesting antlered deer (Bhandari et al. 2006).

Season lengths and bag limits are a top-down management technique that fits with the NAM, but regulations and policy can be changed to also support bottom-up approach to deer management. For example, providing private landowners and government land management agencies with methods to increase deer harvest can address localized problems. Many states have implemented Deer Management Assistance Programs that provide landowners with property-specific means to increase antlerless harvests (Table 21.2). Similar programs have been established to address crop damage or urban deer problems (Table 21.2). The success of bottom-up approaches to deer management depends on cooperation from private landowners, as well as agency resources to administer and promote such programs, but the motivations for landowners to allow hunting are complicated. Fee-based hunting may work in some situations (Guynn and Schmidt 1984) but landowner attitudes towards hunting and property rights may be impediments (Wright et al. 1988, Raedeke et al. 1996).

Incentivizing antlerless harvest beyond traditional reasons of recreation and sustenance may be necessary. The ideal method would encourage antlerless harvest within traditional hunting seasons and methods while minimizing agency costs and upholding the value of white-tailed deer as a native wildlife species. For example, Virginia has employed two strategies that have increased antlerless harvest via hunting. First, venison donation programs created by charitable non-profit organizations allow hunters to donate harvested deer, with the deer processing cost paid by the non-profit organization, to support community assistance programs. About 25% of successful Virginia deer hunters harvest ≥3 deer and venison donation programs distribute about 300,000 pounds of venison annually, which represents about 7,500 deer or 7% of the annual

antlerless harvest (Table 21.1). Second, Virginia has found that an effective way to encourage hunters to harvest more antlerless deer may be to implement an earn-a-buck regulation, such as implemented in Virginia, in which antlerless deer must be harvested before a second antlered deer may be harvested. Biologically, this type of regulation is compatible with white-tailed deer's polygamous breeding system. Socially, such a regulation may encourage hunters who primarily hunt for antlered deer to harvest antlerless deer (e.g., Stedman et al. 2008, Bhandari et al. 2006). Although applied in a limited area, this type of regulation in Virginia was successful in increasing the percentage of females in the harvest (Table 21.3).

The Future of Deer Management

In locations where deer populations do not exceed management objectives, hunting likely will remain the primary method of deer management because it is cost-effective. Hunting provides recreational opportunity for sportspersons and can regulate deer populations with limited or no cost to society. Even if hunter numbers decline, in northern deer populations hunting likely will continue to be effective in controlling deer numbers because antlerless harvest is prohibited or limited where winter mortality can limit deer population growth (e.g., DelGuidice et al. 2002), although climate change could influence population dynamics and distribution of deer (Dawe et al. 2014). However, in areas with limited mortality factors other than hunting, declining hunter participation and harvest will create significant challenges. Such challenges have existed in urban and suburban areas for decades where the effectiveness of hunting has been limited because of safety and access to land (e.g., Weckel et al. 2011, Williams et al. 2013).

We envision in the future that multiple methods will be required to control deer populations that likely will require an adaptive management approach (Nielsen et al. 1997).

Methods to control deer populations, other than hunting, will incur costs to landowners and government agencies and acceptable methods will depend on resident attitudes toward lethal and nonlethal control measures and costs (Kilpatrick et al. 2010). Culling deer either through sharpshooting or capture and euthanasia can be effective, and the results are comparable to hunting (Etter et al. 2000, DeNicola et al. 2008). Culling can target deer in locations where they are causing problems and the population reduction is immediate. However, culling is expensive (119–310 USD/deer; Etter et al. 2000).

Another alternative to hunting is fertility control where populations are regulated by reducing fecundity. In principle, use of immunocontraceptive vaccines can reduce deer populations (Rutberg and Naugle 2008), but for rapid population reduction some lethal control methods would be required because adult female white-tailed deer can reproduce for >10 years. Boulanger et al. (2012) applied sterilization of females and estimated that ≥80% of deer would need to be treated at a cost of approximately 1000 USD/surgery. Boulanger and Curtis (2016) evaluated the efficacy of a sterilization program and concluded that as a stand-alone method it was ineffective at reducing abundance in an open deer population.

Commercializing harvest of deer has been suggested as an approach to address deer population control, although it would have to be carefully integrated with the principles of the NAM (Vercauteren et al. 2007, Hygnstrom et al. 2014). Mawson et al. (2016) provided an example where commercial harvest accomplished population reduction goals for western grey kangaroos (*Macropus fuliginosus*) and was acceptable to the public at relatively low cost. Commercial harvest of deer has potential benefits but also potential conflicts under the NAM for wildlife management. Besides potentially reducing deer abundance, commercialization of deer could provide a natural source of protein and benefit the economy (Vercauteren et al. 2007).

However, implementation would require changes to laws and regulations and would create challenges for law enforcement and meat processors. Also, recreational harvest and commercial harvest would be competing for the same resource and may create conflicts. Regulation of commercial and recreational harvest of fisheries might provide insights into how to implement commercial harvest of deer (e.g., Sutinen and Johnston 2003).

Some combination of hunting, culling, fertility control, and commercialization of wildlife has the potential to address future challenges to deer management. However, disease issues could reduce the likelihood of successful application of these tools. For example, chronic wasting disease (CWD) is an example of what happens when hunting alone cannot achieve management objectives and is a problem that may result in further erosion of the effectiveness of hunting. In managing deer to address CWD, reducing deer abundance is often the primary objective. When hunting cannot reduce deer abundance, agencies have used sharpshooting (Manjerovic et al. 2014, Mysterud et al. 2019). Thus, management actions related to CWD provide a look to the future of how hunting may be supplemented with alternative methods to achieve management objectives.

The problem with diseases is that they can also reduce the effectiveness of some potential management actions. For example, the presence of CWD could reduce hunter participation and recruitment (Needham et al. 2007). In Wisconsin, hunters rejected agency goals to manage CWD for a number of reasons and harmed efforts to control the impact of the disease (Holsman et al. 2010). Wisconsin hunters rejected the deer density goal, did not support extended hunting opportunities that conflicted with hunting traditions and consumption norms (i.e., number of deer killed per hunter), and questioned severity of the effect of CWD on deer populations in part due to lack of agency credibility. Holsman et al. (2010) questioned whether recreational hunting

could achieve disease management objectives of the scale attempted in Wisconsin. Furthermore, disease could nullify the commercialization of wildlife if there is no economic value to be derived from deer carcasses (e.g., sale of meat for human consumption).

Recreational deer hunting will continue to have a role in deer management, but it may transition from the primary method to one of many alternatives. The magnitude of hunting's contribution to the wildlife manager's toolbox will likely be determined by future hunter participation, as well as hunter and general public acceptance of changes in regulations or management actions. We note that societal interest in how domestic animals are raised and processed has increased interest in wild game as a source of protein and this interest has, in part, increased hunting participation by non-traditional hunters, especially women (Pollan 2006). In addition, many state agencies are engaged in efforts to recruit and retain hunters (Price Tack et al. 2018). However, we identified declining trends in hunter numbers as an important factor that will determine the future and importance of deer hunting to achieve social, ecological, and disease-related management objectives.

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Table 21.1. White-tailed deer harvest statistics, hunter characteristics, and estimated deer population size by state and province in the USA and Canada, 2018 or 2019 hunting seasons.

	Harvest[a]				Hunters[b]					
	%									Pre-season
State or province	Antlered	Antlerless	Antlerless	Density	Number	Density	Trend	Age	Success	population
Alabama[c]	79,084	123,956	61	1.7	191,054	4.1	-2	50		1,250,000
Arkansas[c]	97,607	112,458	54	2.5	239,629	6.2	-15		60	1,000,000
Connecticut[c]	5,747	5,411	48	1.5	25,573	6.8	-17	50	25	110,000
Delaware[c]	4,861	12,108	71	3.1	15,638	9.8	4	52	51	46,000
Florida[c]	48,250	26,724	36	1.8	91,432	3.3	-17	52		
Georgia[c]	81,323	157,921	66	2.1	242,057	6.3	0	46	56	1,000,000
Illinois[c]	71,186	81,988	54	2.6	228,329	8.5	-17	43	44	
Indiana[c]	51,646	63,236	55	4.3	212,719	3.4	-11	41	36	
Iowa[c]	42,073	51,519	55	0.8	237,235	4.3	-30	41	28	450,000
Kansas	41,056	38,902	49	0.5	106,896	1.3	-1	43	53	690,000
Kentucky[c]	70,362	78,023	53	1.8	262,887	6.8	-2	50	37	908,291

Louisiana[c]	62,816	57,284	48	2.4	136,000	5.1	-20	47	46	500,000
Maine[c]	20,093	8,230	29	0.7	209,000	7.2	7	50	15	310,000
Maryland[c]	29,233	46,777	62	3.3	55,000	6.3	-5	44	56	240,000
Massachusetts[c]	7,764	6,156	44	2.1	50,000	10.7	0	51	20	100,000
Michigan[c]	211,754	148,912	41	6.0	554,331	15.8	-34	44	48	
Minnesota[c]	101,910	85,677	46	1.3	464,086	5.9	-5	42	36	NA
Mississippi[c]	90,697	106,200	54	2.1	137,983	3.2	-18		63	1,475,000
Missouri[c]	134,092	151,781	53	2.1	483,745	7.6	-5	40	43	1,400,000
Nebraska[c]	29,899	19,191	39	3.7	84,804	10.6	-3	41	47	300,000
New Hampshire[c]	7,870	4,436	36	1.0	55,853	7.0	-1	52	17	100,000
New Jersey[c]	19,240	26,412	58	3.7	88,025	16.7	-11	50	21	133,500
New York[c]	120,403	103,787	46	2.6	545,536	11.6	-5	49	30	1,200,000
North Carolina[c]	82,724	79,217	49	2.6	229,711	6.4	-4	53	47	1,000,000
North Dakota[c]	22,660	14,120	38	0.4	86,000	1.4				
Ohio[c]	77,027	107,441	58	5.2	287,875	19.3	-20	40	34	
Oklahoma[c]	69,927	39,333	36	1.9	184,032	4.9	4	48		750,000

Pennsylvania	163,240	226,191	58	3.6	660,000	14.8	-10	51	32	
Rhode Island[c]	1,072	1,213	53	1.2	4,834	5.4	-9	48	30	
South Carolina[c]	100,201	94,785	49	4.6	145,535	6.6	-1	45	67	730,000
South Dakota[c]	25,389	19,079	43	0.3	69,252	0.9	-15	42	43	350,000
Tennessee[c]	71,884	63,288	47	2.8	547,635	21.3				
Texas[c]	508,155	375,408	42	2.9	808,464		11	42	63	5,585,497
Vermont[c]	10,058	6,492	39	1.2	77,289	8.9	-25	46	20	140,000
Virginia[c]	99,994	106,985	52	2.6	185,000	4.9	-24	50	60	1,030,000
West Virginia[c]	56,189	43,248	43	2.4	183,000	8.0	-17	45	50	562,000
Wisconsin[c]	137,877	152,335	52	3.7	610,146	16.2	-5	43	34	1,780,000
New Brunswick[c]	6,025	1,278	17	0.2	42,483	1.7	-11	53	17	80,700
Nova Scotia[c]	7,797	2,458	24	0.5	46,990	2.2	9	62	21	44,743
Ontario[c]	34,898	25,014	42	0.2	187,954	0.9	2		31	
Quebec[c]	26,091	21,509	45	0.7	130,513	3.4	-16	50	34	

[a] Antlered = number of antlered deer harvested; Antlerless = number of antlerless deer harvested; % Antlerless = percent of harvested deer comprised of antlerless deer; Density = number of antlered deer killed per square mile of estimated deer habitat.

[b] Number = number of hunters; Density = number of hunters per square mile of estimated deer habitat; Trend = 10-year change in number of hunters; Age = mean age of hunters; Success = percent of hunters who harvested at least 1 deer.

[c] Hunter numbers are number of deer hunters, all other states are total number of hunters.

Table 21.2. Special seasons, bag limits, season length, and management characteristics by state and province in the USA and Canada, 2019.

State or province	Special seasons/ regulations[a]	Season bag limit		Firearms Season (days)	Plan[b]	Unit type[c]	% Management units relative to population goal			Method[d]
		Antlered	Antlerless				At	Below	Above	
Alabama	P,D	3	1/day	82	N	A				D
Arkansas	P,D,U	2	6	62	Y	E	70	25	5	D
Connecticut	D,U,EAB	7	6	36	Y	E	62	15	23	Q
Delaware	D	2	∞	44	Y	E	83	0	17	D
Florida	P,D	3–5[e]	≤2[e]	129	Y	E	58	42	0	D,Q
Georgia	P,D,U,EAB	2	10	85	Y	E	58	42	0	D,Q
Illinois	D,U	2	∞	10–17	N	A	75	5	20	Q
Indiana	D,U	1–2		16	Y	A				Q
Iowa	D,U	2	0–∞	42	Y	A	56	25	19	Q

Kansas	D,U	1	6	12	N	E	50	33	17	D
Kentucky	D	1	1–∞	16	N	A	39	18	43	Q
Louisiana	P,D	3	4	84–93	Y	E	40	20	40	D
Maine	D,U	1	0–∞	25	Y	E	21	59	21	Q
Maryland	D,U	2 or 3	3, 35, or ∞	18	Y	E,A	50	0	50	D
Massachusetts	D,U	2	1–∞	12	Y	E	73	0	27	Q
Michigan	P,D,U	2	≤10	16	Y	E,A	5	5	90	Q
Minnesota	D,U	1	0–∞	9–23	Y	E	36	18	46	Q
Mississippi	P,D	3	5	77	N	A				D
Missouri	P,D	2	3–∞	30	Y	A	88	11	1	D,Q
Nebraska	D,U,EAB	2	0–∞	9	N	A	80	15	5	Q
New Hampshire	P,D	3	2	26	Y	E	75	0	25	D
New Jersey	P,D,U,EAB	6	1–∞	19–65	N	A	17	17	65	Q
New York	P,D,U	2	0–∞	23–44	Y	E				Q
North Carolina	P,D,U	2	4–∞	18–80		E,A	77	13	10	D
North Dakota				16.5		38	75	25		

Ohio	D,U	1	5–6	9	Y	A				
Oklahoma	P,D,U	2	6	16	Y	E,A				D,Q
Pennsylvania	P,D	1	2–∞	13	Y	E,A	56	0	44	Q
Rhode Island	D	1–2	2–3 or ∞	17	N	E,A	50	0	50	Q
South Carolina	P,D,U	5+	3–∞	83–140	N		25	25	50	Q
South Dakota	D,U		-[f]	25	Y	A	34	64	2	Q
Tennessee	P,D,U,EAB	2	1–330	49–63	Y	A				Q
Texas	P,D	1–3	2–5	79–93	N	A				D
Vermont	D	1	≤4	16	Y	E	52	0	48	Q
Virginia	P,D,U,EAB	2–3	3–∞	14–49	Y	A	41	10	46	D
West Virginia	D,U,EAB	≤3	≤8	27	Y	A	63	37	0	D,Q
Wisconsin	P,D,U	2	0–∞	9	N	E,A				Q
New Brunswick	P,U	1 deer/year		28	Y	E,A	11	82	7	Q
Nova Scotia	P,U			39	N	E				Q
Ontario	D,U	1 deer/year		5–93	Y	E,A				Q
Quebec		2 deer/year		9–16	Y	E	16	42	42	Q

[a] Increase antlerless harvest to address: P = landowner concerns, D = deer damage, and U = urban deer problems. EAB = earn-a-buck regulation requiring harvest of an antlerless deer before an antlered (or second antlered) deer can be harvested.

[b] Does the agency have a deer management plan: Y = yes; N = no.

[c] Type of management units: A = administrative; E = ecological.

[d] Whether antlerless harvest is regulated through number of days of hunting (D) or quotas (Q).

[e] Total harvest cannot exceed 5 deer of which ≤2 are antlerless.

[f] Archery license allows either sex deer statewide; otherwise, licenses issued via hunter application and random drawing by management unit.

Table 21.3. Regulatory and policy actions in northern Virginia (Arlington, Fairfax, Loudoun, and Prince William counties) and resulting deer harvest during 1991–2019. Deer hunters are restricted to three antlered bucks per year during October-December archery, muzzleloader, and firearm deer seasons.

		Harvest		
Year	Action	Antlered	Antlerless	Antlerless: Antlered Ratio
1991	Bonus deer permits[a] created and limited to one per hunter per year	4,071[b]	3,417	
1995	Extended deer seasons on public lands in Fairfax County	3,553	4,952	1.4 : 1
1998	Fairfax County government implements deer management program on public lands; bonus deer permits are antlerless only and unlimited	3,439	4,159	1.2 : 1
2002	Urban archery season implemented in Fairfax County	4,310	5,340	1.2 : 1
2004	The number of antlerless-only tags on basic deer license is doubled from 2 to 4	4,216	5,358	1.3 : 1
2006	Establish a late 4-week antlerless-only firearm deer season (January)	3,859	5,808	1.5 : 1
2008	Late antlerless-only firearm season extended through March (3 months); require harvest of an	3,739	6,834	1.8 : 1

	antlerless deer before a second antlered deer can be harvested			
2009	Number of antlerless-only deer tags on bonus permits increased from 2 to 6	3,561	6,837	1.9 : 1
2011	Establish unlimited daily/season antlerless deer bag limit	3,600	7,079	2.0 : 1
2013	Establish September antlerless-only firearms deer season; require harvest of 2 antlerless deer before 2nd antlered deer allowed	3,543	8,477	2.4 : 1
2019	Same regulations 2014–2019	2,825	5,453	1.9 : 1

[a] 2 deer tags; one either-sex and one antlerless-only but antlerless-only since 1998.

[b] Includes male fawns

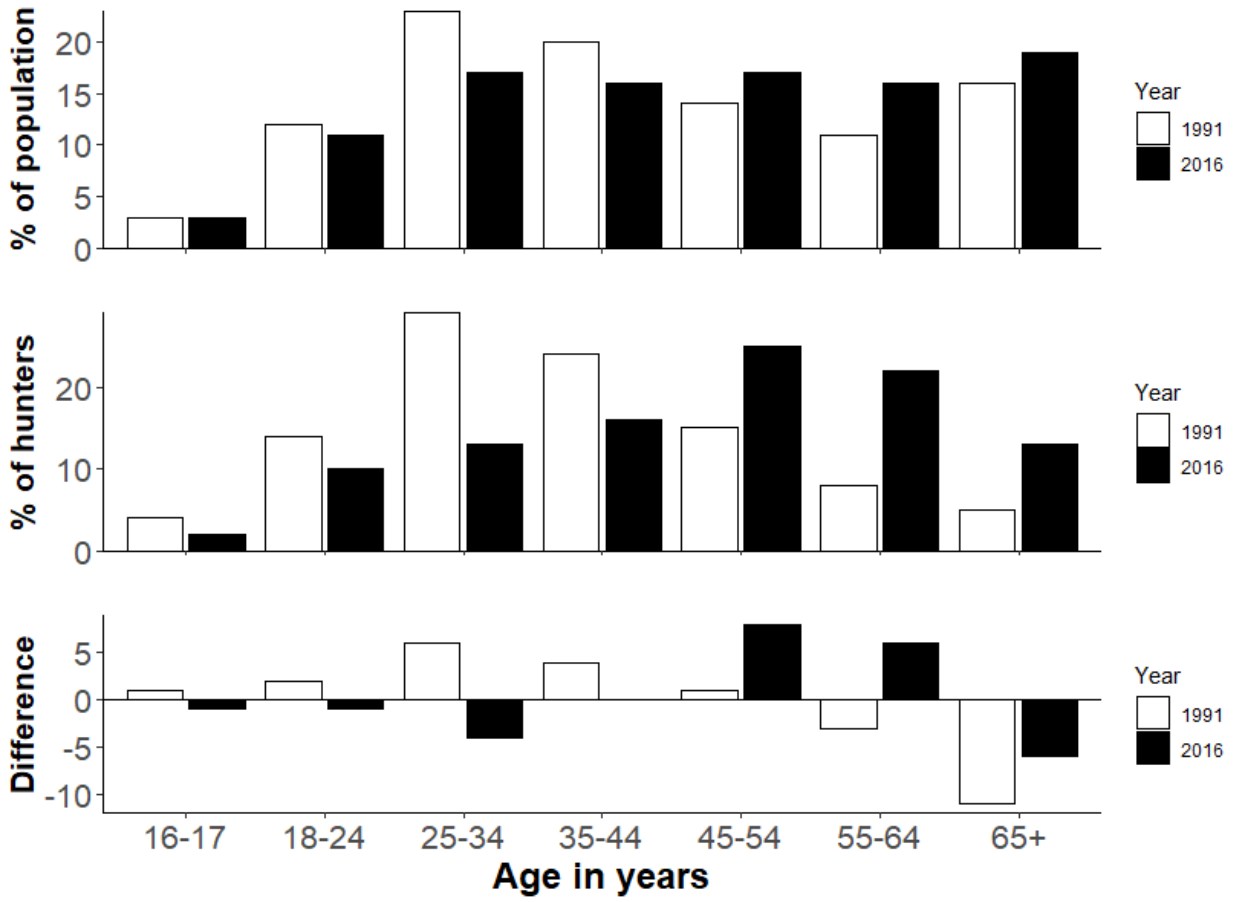

Figure 21.1. Age structure of hunters according to the National Survey of Hunting, Fishing, and Wildlife-Associated Recreation, 1991 and 2016 (USFWS and USCB 1993, 2018), (top) general U.S. population, (middle) big game hunters, and (bottom) difference between big game hunters and general population. Big game hunters are older than the general population and aging out of the hunting population faster.

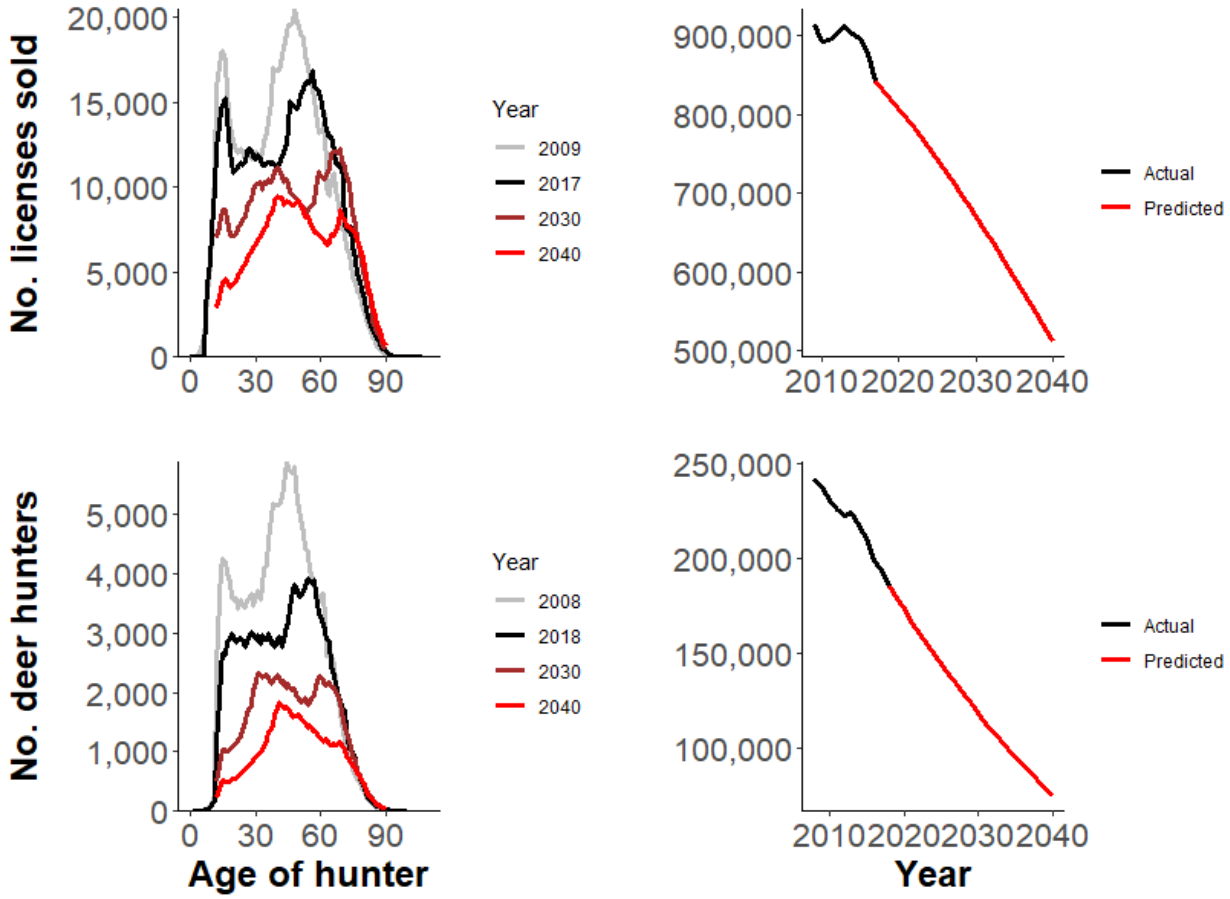

Figure 21.2. Age distribution and number of actual (pre-2019) and predicted (2030 and 2040) deer hunters in Virginia, USA (bottom) and hunting license buyers in Pennsylvania, USA (top).