

# Urban Deer Management Status within the United States: A Synthesis of State Wildlife Agencies' Urban Deer Management Resources

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*Abstract:* Across the U.S., the presence of white-tailed deer (deer; *Odocoileus virginianus*) in urban areas can create conflicts with residents (e.g., ornamental plant damage). State wildlife agencies approach urban deer management differently from traditional deer management due to diverse community groups, urban stakeholder viewpoints about deer, and other aspects of wildlife management in urban environments. With this variation in mind, we reviewed deer management resources across the U.S. to understand the current state of urban deer management. Of the 46 states with deer populations, 21 had publicly available deer management plans (DMPs; 46%), 22 had only online urban deer management resources available (48%), and three had no urban deer-related information available even though deer were present (7%). Our synthesis revealed that public input was incorporated in all DMPs including input from traditionally under-represented stakeholders. Of 21 DMPs, 16 (76%) incorporated urban deer management-related programs. Eighteen DMPs (86%) expressed deer impacts on people as a major issue. Subsequently, 13 DMPs (62%) contained focused goals addressing damage and conflict management. Lethal control remained the most common urban deer management tool. States' online urban deer management resources varied in content, quality, and ease of navigability. Overall, states lacked strategies, protocols, and supplemental resources to effectively address site-specific urban deer management. Our research identified urban deer management gaps in deer management resources, and we provide state wildlife agencies with eight recommendations for integrating urban deer management information. Managers can use our recommendations to help stakeholders address urban deer-related concerns, improve urban deer management materials, and facilitate state wildlife agency-stakeholder collaboration.

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White-tailed deer (*Odocoileus virginianus*; hereafter, deer) overabundance in urban, suburban, and semirural areas (hereafter, urban) has been an ongoing problem in the U.S. After extirpation in many regions during the late 1800s through the early 1900s (Warren 2011), deer populations recovered in much of the U.S. (Decker and Connelly 1989). In the southeastern U.S., deer population densities have recovered to levels comparable to pre-Euro-American settlement of 54.3–59.7 deer km<sup>-2</sup> (21–23 deer mi<sup>-2</sup>; Hanberry and Hanberry 2020), but instances of greater deer densities ( $\geq 77.7$  deer km<sup>-2</sup> [ $\geq 30$  deer mi<sup>-2</sup>]) are also common in urban

areas across the U.S. (DeNicola and Williams 2008, Urbanek and Nielsen 2013). Human populations in metropolitan areas across the U.S. increased 9% from 2010–2020 (U.S. Census Bureau 2021) while urban and agriculture development simultaneously increased (Kim 2000, Hanberry and Hanberry 2020, Lichter et al. 2020). These alterations to the human-deer interaction interface have supported increased negative interactions between deer and humans, often resulting in deer populations exceeding social carrying capacity in urban areas (Decker and Chase 1997, Parsons 1998, Warren 2011, Hanberry and Hanberry 2020). Additionally,

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deer often experience high survival and fecundity (Etter et al. 2002, Storm et al. 2007) in developed areas because of nutritious food resources and lack of predation and hunting pressure (Butfiloski et al. 1997, Stout et al. 1997, Lauber and Knuth 2000, Curtis 2020). Larger deer populations come with associated drawbacks such as vehicle collisions (Huijser et al. 2009, IIHS 2019), damage to landscape plantings (Connelly et al. 1987, Kilpatrick and LaBonte 2003, Urbanek et al. 2013), agricultural depredation (Conover 1995, West and Parkhurst 2002), and concerns about deer impacts to human health (Kilpatrick and Walter 1997, Stout et al. 1997, Rudolph et al. 2011). Therefore, the negative impacts of overabundant deer populations in urban landscapes justify urban deer management actions that effectively reduce deer-human conflicts.

Managing urban deer is complicated. Under the public trust doctrine, state wildlife agencies (hereafter, SWAs) are entrusted to sustainably manage deer for all potential beneficiaries (Rudolph et al. 2011, Westerfield et al. 2019, Stinchcomb et al. 2022). While SWAs have traditionally managed deer populations with regulated hunting (Doig 1995, Geist et al. 2001), hunting is restricted in urban areas due to limited access, legal constraints, human safety concerns, and non-consumptive social values (Butfiloski et al. 1997, Messmer et al. 1997b, Stout et al. 1997, Rudolph et al. 2011, Curtis 2020). Social factors add complexity to urban deer management because stakeholder groups hold diverse views on wildlife making it difficult to reach a consensus on proposed management solutions (Decker and Enck 1996, Messmer et al. 1997a, Baker and Fritsch 1997, Parsons 1998, West and Parkhurst 2002). Regardless of social complexities, previous research has recommended that SWAs incorporate urban stakeholders into deer management decisions (Decker and Chase 1997, Messmer et al. 1997a, Koval and Mertig 2004, Urbanek et al. 2012, Curtis 2020). As a result, several SWAs have begun to integrate urban stakeholder input into deer management planning processes (Anderson 1997, Raik et al. 2003, Raik et al. 2006, Rudolph et al. 2011, Baumer and Pomeranz 2017).

How SWAs incorporate urban deer management into their publicly available white-tailed deer management plans (hereafter, DMPs) has been unclear (Messmer et al. 1997a, Urbanek et al. 2011). Messmer et al. (1997a) and Urbanek et al. (2011) reported that most SWAs acknowledge that urban deer issues exist; however, few SWAs have developed urban deer management resources, and even fewer have incorporated stakeholder input. In the mid-1990s, some SWAs began engaging with communities and other stakeholder groups, in a process commonly known as community-based deer management, to collaboratively formulate site-specific deer management (i.e., municipality level) rather than statewide urban deer management planning (Raik et al. 2003, Decker et al. 2004, Lauber 2010, Curtis 2020). The effectiveness of community-based

deer management can depend on several factors. A community's capacity to learn, lead, and gather for a collective purpose are important dimensions to achieve successful community-based deer management (Raik et al. 2005, Raik et al. 2006). The level of SWA involvement in decision making has also been suggested to play a role in the effectiveness of community-based deer management (Decker and Chase 1997, Raik et al. 2003). Rudolph et al. (2011) and Baumer and Pomeranz (2017) proposed that if deer management plans in general have defined clear, practical, and relevant topic categories (e.g., goals, objectives, management actions, budget, timetable, etc.), then community-based deer management has a higher likelihood of progressing effectively.

Community-based deer management is an important first step in SWAs' involvement in urban deer management. However, a research gap exists in identifying the status of state-specific urban deer management planning and ascertaining the type, content, and quality of available resources related to urban deer management. Our research aims to 1) characterize the status of SWA urban deer management across the U.S.; 2) describe best-management practices available for urban deer management; 3) increase the understanding of stakeholder involvement in decision-making for urban deer management; and 4) provide recommendations on how SWAs can incorporate stakeholder input and urban deer management practices into urban deer management planning. Understanding the current state of urban deer management will enable SWAs to evaluate their resources, identify where resources are underperforming, and identify best management practices available to ensure urban deer management efforts are effective.

## Methods

From January 2022 through January of 2023, we searched for digitized DMPs using internet search engines, a list of general keywords (e.g., "management plan," "deer") and specific phrases (e.g., "Minnesota white-tailed deer management plan," "Deer management in Ohio"), SWA employee contacts, and by directly accessing SWA websites. In each DMP, we noted specific details to characterize the current state of urban deer management (Table 1). We categorized SWA issues related to urban deer including: 1) deer impacts on people (e.g., property damage, deer vehicle collisions, human health); 2) impacts on deer (e.g., diseases, non-hunting mortality events, supplemental feeding); 3) deer impacts on ecosystems (e.g., damage to ecosystem structure and function, impacts to biodiversity, invasive species spread); 4) hunters and hunting (e.g., opportunities to hunt, decreased access to private lands, retaining hunters); 5) changing views and land uses (e.g., conflicting stakeholder views, urbanization, support for hunting); 6) rules and regulations (e.g., local firearm ordinances, changing

**Table 1.** Ten standardized factors noted from publicly available state white-tailed deer management plans to better understand the status of urban deer management in the U.S.

Plan detail	Definition	Example(s)
State issues	Specifically mentioned problems that states are facing when managing deer.	Deer impacts on people
Stakeholder input	Public input utilized for decision-making and plan creation.	Stakeholder comments taken after a public meeting
Urban deer management section	A major section heading focusing on urban deer management topics in a respective state.	Georgia's 17-page urban deer management section
Goals	Broad statements about an agency's aim to manage specific resources related to urban deer management.	Be responsive to public concerns and maintain open communication with the public regarding deer-related issues <sup>a</sup>
Objectives	Statements about what an agency plans to achieve in relation to an urban deer management-related goal.	Provide assistance to the public regarding deer-human conflicts <sup>a</sup>
Strategies	Statements about what actions will be taken to achieve an urban deer management-related objective.	Use various media outlets to distribute information which addresses deer-human conflicts <sup>a</sup>
Notable details	Unique urban deer-related information not contained in goal, objective, or strategy sections.	Programs available to resolve urban deer-human conflict
Supplemental materials	Additional resources listed to educate the public about, or help resolve, urban deer-related issues.	Damage prevention technical guides
Available staff	State wildlife agency employee(s) designated to help resolve deer-human conflicts.	An urban deer biologist
Management techniques	Methods used by state agencies, or residents, to manage urban deer.	Lethal control, repellents, and exclusion

a. AGFC 2019.

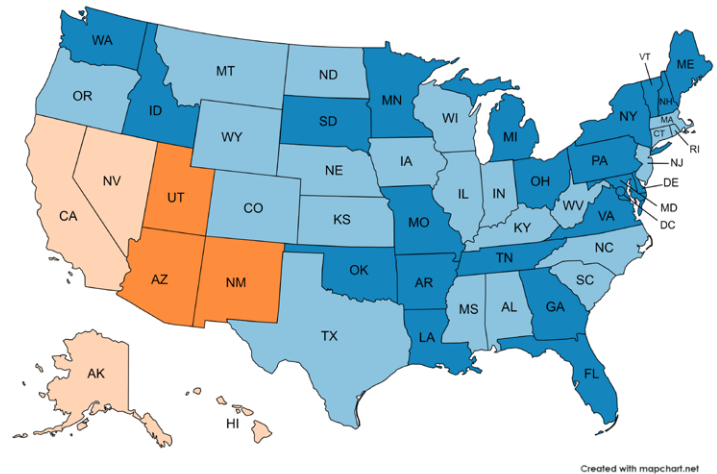
hunting seasons and limits); and 7) education (e.g., educating the public about deer and deer management).

We searched for additional urban deer management resources by examining SWA websites. We only considered additional resources that were linked on respective SWA websites and that were directly related to resolving deer-human conflicts in urban settings. For example, technical guides and SWA deer management websites were considered official additional resources. Technical guides provided steps for urban communities to understand and resolve urban deer issues, and SWA deer management websites provided methods to minimize deer-human conflicts. Additionally, we contacted two SWA employees from Alabama and West Virginia for help locating respective online urban deer management-related resources. Using information from DMPs and additional SWA resources, we characterized the current state of SWA urban deer management.

## Results

Of the 46 states with deer populations, 21 (46%) SWAs had DMPs (Figure 1). All urban deer management-related information was included within DMPs, and no SWA had a stand-alone urban deer management plan. Nineteen DMPs (90%) discussed issues that managers face in their respective states (e.g., deer impacts on people; Table 2), as well as common goals (e.g., hunting and deer-related recreation; Table 3). Deer population management was the most frequently mentioned goal in all 21 DMPs, and 13 DMPs (62%) noted damage management and conflict management as important goals.

Among DMPs, several themes for urban deer management



**Figure 1.** State designations of publicly available urban deer management-related resources across the U.S. as of 9 January 2023. Dark blue: urban white-tailed deer management considered in state white-tailed deer management plan; Light blue: only online urban white-tailed deer management resources available; Dark orange: no white-tailed deer plan or urban white-tailed deer management resources available; Light orange: no white-tailed deer populations in the state.

approaches emerged. First, all DMPs noted that technical assistance is a standard practice for urban deer management (e.g., in-person assistance to a homeowner's association, technical guidance over the phone to a property owner experiencing damage). Second, all DMPs incorporated public input from both non-traditional (e.g., non-hunters, animal activists) and traditional (i.e., hunters and farmers) stakeholder groups in some capacity. For instance, Maryland hosted public meetings to solicit feedback from stakeholders and formally surveyed 2200 of its residents (i.e., 800 from the public, 800 deer hunters, and 600 landowners) in 2018

**Table 2.** Publicly available state white-tailed deer management plans in the U.S. ( $n = 21$ ) that note having management issues that fall into seven issue categories as of 9 January 2023. “X” marks a state that acknowledged a particular issue in their plan.

State plan	Changing views and land uses	Impacts on deer	Deer impacts on people	Hunters and hunting	Deer impacts on ecosystems	Rules and regulations	Education
Arkansas	X	X					X
Delaware	X	X	X	X	X		X
Florida	X	X	X		X		X
Georgia	X	X	X	X	X	X	X
Idaho	X	X	X	X			
Louisiana	X	X					
Maine	X	X	X	X	X	X	
Maryland	X		X	X	X		
Michigan	X	X	X	X	X		X
Minnesota	X	X	X	X	X		
Missouri	X	X	X	X			
New Hampshire	X	X	X	X	X		
New York	X	X	X	X	X	X	X
Ohio	X	X	X	X			
Oklahoma							
Pennsylvania		X	X		X	X	
South Dakota	X	X	X	X			
Tennessee	X	X	X		X		
Vermont	X	X	X	X	X		
Virginia	X	X	X	X	X	X	
Washington	X	X	X	X		X	
Number (%) of plans	19 (90)	19 (90)	18 (86)	15 (71)	13 (62)	6 (29)	6 (29)

**Table 3.** Publicly available state white-tailed deer management plans in the U.S. ( $n = 21$ ) that have goals in seven frequently mentioned goal categories as of 9 January 2023. “X” marks a state that acknowledged a particular goal in their plan.

State plan	Deer population management	Hunting and deer-related recreation	Communication and education	Damage and conflict management	Habitat	Achieving stakeholder satisfaction	Operational resources
Arkansas	X		X		X	X	
Delaware	X	X	X	X	X		X
Florida	X				X	X	
Georgia	X	X	X	X			
Idaho	X	X		X	X		
Louisiana	X	X	X	X	X	X	
Maine	X	X	X			X	
Maryland	X	X	X	X			X
Michigan	X	X	X	X	X		
Minnesota	X		X	X	X	X	X
Missouri	X	X	X				
New Hampshire	X			X			
New York	X	X	X	X	X		X
Ohio	X	X	X				
Oklahoma	X	X	X		X	X	
Pennsylvania	X	X	X	X			
South Dakota	X				X	X	
Tennessee	X		X	X		X	X
Vermont	X	X		X	X	X	
Virginia	X	X		X	X		
Washington	X	X			X		
Number (%) of plans	21 (100)	15 (71)	14 (67)	13 (62)	13 (62)	9 (43)	5 (24)

**Table 4.** Publicly available state white-tailed deer management plans in the U.S. ( $n = 21$  plans) that noted deer management techniques in the context of urban deer management as of 9 January 2023.

Technique	State Plan	Number (%) of plans
Lethal control	Arkansas, Delaware, Florida, Georgia, Idaho, Louisiana, Maine, Maryland, Michigan, New York, Ohio, Oklahoma, Pennsylvania, South Dakota, Tennessee, Vermont, Virginia, Washington	18 (86)
Modifying human behavior	Arkansas, Delaware, Florida, Georgia, Louisiana, Maryland, Michigan, New York, Oklahoma, Pennsylvania, South Dakota, Tennessee, Vermont, Virginia	14 (67)
Exclusion	Delaware, Georgia, Idaho, Maryland, Michigan, Minnesota, South Dakota, Vermont, Virginia	9 (43)
Repellents	Delaware, Georgia, Maryland, Michigan, Minnesota, South Dakota, Virginia	7 (33)
Fertility control	Delaware, Georgia, Maryland, Pennsylvania, South Dakota, Vermont, Virginia	7 (33)
Harassment or scare devices	Delaware, Idaho, Michigan, Minnesota, South Dakota, Virginia	6 (29)
Relocation	Delaware, Georgia, Maryland, Pennsylvania, South Dakota, Vermont	6 (29)
Changing regulations	Georgia, Idaho, Maryland, Oklahoma, South Dakota	5 (24)
Habitat modification	Georgia, Michigan, South Dakota	3 (14)
Predator reintroduction	Delaware, Georgia, Maryland	3 (14)
Changing infrastructure	Delaware, South Dakota	2 (10)

to ascertain their views on deer management issues. Other states scientifically surveyed public viewpoints on deer and deer management by creating surveys through their SWA (e.g., Minnesota) or through a third-party (e.g., Georgia contracting with Responsive Management Inc.). Additionally, states such as South Dakota created citizen task forces to provide public input-based deer management recommendations. The last theme shared across all DMPs was that their respective SWAs were actively developing plans, policies, and/or programs, as well as training their staff, to effectively manage urban deer-related issues. Sixteen DMPs (76%) specifically listed developing or currently available urban deer management programs. Vermont, for instance, used the Landowner-Hunter Connection program to match landowners experiencing deer damage with hunters to reduce locally overabundant populations. Additionally, Louisiana was developing urban archery hunt programs to reduce urban deer populations. Minnesota and New York were, in some areas, monitoring the outcomes of deer population reductions using a program called Assessing Vegetation Impacts from Deer (Curtis et al. 2021), which monitors deer browsing pressure on woodland vegetation to determine if deer population reductions have improved vegetation growth over time.

Georgia, Idaho, Pennsylvania, and South Dakota (19%; 4 DMPs) were the only SWAs to incorporate a specific urban deer management section in their DMPs. The other 17 SWAs only included aspects about how they planned to address urban deer management through other sections of their plans. Delaware, Idaho, New Hampshire, New York, Pennsylvania, and Virginia (29%) were the only SWAs to provide urban deer management supplemental materials (e.g., hyperlinks to deer-human conflict resolution resources) in their DMPs. However, few hyperlinks to supplemental

materials were functional and some supplemental materials did not have associated hyperlinks. Delaware, Maryland, and New York (14%) were the only SWAs to note staff designated to help resolve deer-human conflicts in their DMPs. For example, New York's Big Game Team offered educational resources, recommendations, and strategies for communities to manage deer. Deer management plans often mentioned management techniques proposed for urban deer management (Table 4). Lethal control was the most common urban deer management technique encouraged by 18 of the 21 DMPs (86%). Some DMPs mentioned management techniques such as fertility control (33%; 7 DMPs), relocation (29%; 6 DMPs), and predator reintroduction (14%; 3 DMPs) but discouraged SWA personnel and stakeholders from using these techniques because of practicality, safety concerns, cost restraints, time considerations, disease transmission potential, legal constraints, and other factors.

Of the 46 states with deer populations, 25 (54%) SWAs did not have a DMP. Of these states, 22 (88%) had online urban deer management resources available (e.g., technical guides and SWA deer management websites). However, the amount of information available, ease of locating the information, and type of information available were highly variable. Five of the 22 states (23%) had technical guides available (e.g., Connecticut, Indiana, New Jersey, Rhode Island, Texas), and all 22 states had SWA deer management websites (e.g., Alabama, Colorado, Connecticut, Illinois, Indiana, Iowa, Kansas, Kentucky, Massachusetts, Mississippi, Montana, Nebraska, New Jersey, North Carolina, North Dakota, Oregon, Rhode Island, South Carolina, Texas, West Virginia, Wisconsin, and Wyoming), which included nuisance deer websites, living with deer websites, deer damage websites, and conflict control websites.

## Discussion

Based on our results, SWAs have improved how they approach urban deer management compared to previous studies. In 2011, only 33 SWAs considered urban deer an issue in their state (Urbanek et al. 2011). At the time of this study, 43 SWAs had resources available to address urban white-tailed deer issues. In 1997, only 6 of 21 state urban deer management programs were developed with public input (Messmer et al. 1997a), while all 21 DMPs during the time of our synthesis integrated public input formally (e.g., human dimensions surveys), informally (e.g., holding a public meeting), or a combination thereof. Throughout DMPs, lethal control remains the most encouraged urban deer management technique, but DMPs highlighted that SWAs are frequently encouraging their staff and stakeholders to also utilize non-lethal management techniques (e.g., exclusion, repellents, scare devices, changing laws and ordinances, and modifying infrastructure and habitat resources) to mitigate deer-human conflicts. Researchers have encouraged SWAs to use social science methods (e.g., surveys, focus groups, citizen task forces, workshops) to improve the effectiveness of urban deer management techniques, better understand stakeholder perceptions of deer-human conflicts, and enhance the quality of public input (Decker and Enck 1996, Decker et al. 2002, Urbanek et al. 2012, Curtis 2020). Our research demonstrates that SWAs are incorporating more social science methods into their public input and planning processes.

Even though SWAs are making improvements in urban deer management resources, many still fall short in specific areas. For instance, 22 of the 46 states with deer populations were missing DMPs, and only 4 DMPs included urban deer management sections. Other DMPs were missing hyperlinks, or provided non-functional hyperlinks, to urban deer management-related supplemental materials which could provide stakeholders additional opportunities to learn more about minimizing deer-human conflicts. Lastly, 18 DMPs did not list specific staff designated to help resolve deer-human conflicts. Furthermore, the DMPs that did have staff listed did not include sufficient contact information (i.e., phone numbers, email addresses) for those individuals. Shortfalls with SWA urban deer management resources leave stakeholders struggling to locate resources and make it difficult to interpret available information. Improving urban deer management resources would assist SWAs in meeting expectations set by the public trust doctrine to sustainably manage deer for all potential beneficiaries.

Most SWAs have opportunities to improve the structure and content of urban deer management information in DMPs. State wildlife agencies should aim to proactively address urban deer management issues but recognize if their agency can, or has enough justification to, allocate sufficient resources to urban deer manage-

**Table 5.** Eight recommended characteristics that state wildlife agencies can include in urban deer management resources to help improve state urban deer management.

Recommendations
Provide background information on urban deer management in their state (e.g., how deer-human conflicts have changed in urban areas over time, economic costs and benefits, review of urban deer management literature, stakeholder views).
Articulate goals, objectives, and strategies directly related to how a state plans to address urban deer management.
Describe urban deer management techniques that are available, encouraged, discouraged, and commonly used by stakeholders and state wildlife agency staff.
List specific contact information for staff, or external contractors, specifically trained to resolve deer-human conflicts.
Include links to other urban deer management supplemental materials (e.g., deer-human conflict resolution websites).
Describe programs available in the state used to assist in urban deer management (e.g., urban deer hunter certification programs).
Articulate strategies for community-based deer management that can be implemented across the state.
Provide anonymous community-based deer management plan examples detailing what prompted each community to act, challenges they faced, outcomes they experienced, how they built community support, and how they managed negative publicity.

ment (McMullin et al. 1993, Doig 1995, Hewitt and Messmer 1997). One option that SWAs can use to begin improving their urban deer management resources is to designate a specific urban deer management section in their DMP. We recommend that urban deer management sections should include the eight characteristics detailed in Table 5. Regarding recommendation seven, community-based deer management strategies should include four elements. First, strategies should address how SWAs can collaborate with communities to build partnerships, local leadership, credibility, common purpose, and knowledge (Raik et al. 2003, Raik et al. 2005, Curtis 2020). Second, strategies should address how communities can establish clear, practical, and relevant objectives (Rudolph et al. 2011). Third, strategies should articulate what should be included in a community-based deer management plan (e.g., budgets, timetables, how to measure and evaluate outcomes, establish who is responsible, identify permitting requirements; Baumer and Pomeranz 2017, Westerfield et al. 2019, Curtis 2020). Finally, strategies should address how a SWA plans to follow-up with collaborating communities once plans have been implemented.

State wildlife agencies can scale and adapt our eight recommendations based on their staffing resources, financial capacity, time allocation ability, general SWA culture, potential for litigation, stakeholder needs, and other factors. For instance, if a SWA has sufficient resources and few urban areas with deer-human conflicts, it may choose to focus on creating an urban deer management section within its DMP, conducting community-based deer management, and providing on-site technical assistance. Conversely, if a SWA has limited resources and numerous urban areas with deer-human conflicts, that SWA may choose to create online,

self-help type resources focusing on certain recommendations that stakeholders may deem important (e.g., recommendation 3, 5, and 6; Table 5). Furthermore, if a SWA does not have the capacity to create online, self-help type resources, that SWA can point stakeholders to preexisting urban deer management resources such as Cornell University's Community Deer Advisor website (<https://deeradvisor.dnr.cornell.edu/>). If stakeholder groups or individuals challenge a SWA on lethal deer management techniques, that SWA may choose to focus on collecting additional public input to explore management techniques (e.g., fencing, education) that could be used to reduce deer-human conflicts instead of focusing on reducing deer populations through lethal control. If SWAs scale and adapt our eight recommendations to fit their capabilities and the needs of their stakeholders, then they should have sufficient urban deer management resources to address deer-human conflicts in their region.

### Management Implications

Traditional resource management has often been seen as reactive (Decker et al. 1983, Lal et al. 2001). However, we found several DMPs that indicated SWAs are transitioning to proactive deer management (e.g., FFWCC 2008, VDGIF 2015, SDDGFP 2017, IDFG 2019, TWRA 2019). Our recommendations (Table 5) will allow SWAs to take the necessary steps to proactively manage deer. When SWAs provide stakeholders with the proper tools, contacts, background information, strategies, and resources, stakeholders are empowered to manage localized deer conflicts themselves. If stakeholders need additional assistance, our recommendations provide SWAs with the foundation to create protocols to assist. Establishing clear guidelines for urban deer management will enable SWAs and stakeholders to navigate their way through community-based deer management together.

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