The role, size, and effectiveness of safety zones for creating refuges for white-tailed deer

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Abstract: White-tailed deer (Odocoileus virginianus) are overabundant in many areas, particularly in more developed landscapes where refuges may provide additional challenges for deer managers. Refuges have been widely used to sustain breeding stock in harvested populations and to mitigate other sources of mortality. As the landscape becomes more urbanized, local municipalities and states have implemented safety zones to reduce the probability of a hunter’s projectile from accidentally striking a building or its inhabitants. I evaluated if mandated safety zones in Delaware may constitute unintentional refuges. I used Delaware’s land-cover data to created buffers (i.e., 46, 91, and 183 m) around each building to mimic current state regulations (i.e., 46 and 91 m) and those in northern New Castle County (i.e., 183 m). I overlaid these buffers on deer habitat coverage to determine the amount of deer habitat not available for harvest, which I assumed would act as a refuge because hunting was prohibited in these areas. The amount of deer habitat available for harvest was 39, 71, and 92% for the 183-, 91-, and 46-m safety zones, respectively. For land in public ownership, the amount of deer habitat available for harvest was 55, 81, and 96% for the 183-, 91-, and 46-m safety zones, respectively. The amount of deer habitat available for harvest on private land was 34, 67, and 91% for the 183-, 91-, and 46-m safety zones, respectively. My results suggest that allowing archery and carefully evaluating actual safety concerns will reduce the influence of inadvertent refuges on deer management.

Key words: Delaware, human–wildlife conflicts, Odocoileus virginianus, refuge, safety, urban deer, white-tailed deer, zone

White-tailed deer (Odocoileus virginianus) were extirpated from much of their range, but deer populations have rebounded to overabundance in many areas (McShea et al. 1997). Because white-tailed deer are keystone herbivores (Waller and Alverson 1997), overabundant deer populations affect various trophic levels of these ecosystems (DeCalesta 1994, McShea et al. 1997, Waller and Alverson 1997, Augustine and McNaughton 1998). Several authors have discussed the implications of overbrowsing by deer on plant communities (McShea et al. 1997, Waller and Alverson 1997, Augustine and McNaughton 1998). Additionally, DeCalesta (1994) and McShea and Rappole (1997) documented reduced songbird abundance in areas of high deer densities. Economic impacts associated with overabundance are also a concern (Stout et al. 1993, Romin and Bissonette 1996, Conover 1997, Scanlon 1998).

Overabundant deer populations have gained national attention, especially in suburban and urban landscapes (DeNicola et al. 2000). Development patterns have provided a habitat mosaic ideal for white-tailed deer. Often, undeveloped land is interspersed among subdivisions and industrial areas, providing habitat for deer. Deer management in these landscapes provides new challenges for wildlife agencies, which have typically focused on wildlife management in rural landscapes. Suburban and urban landscapes provide not only new challenges from a biological standpoint, but also from a human dimension perspective. Attitudes about wildlife in urban landscapes typically are highly polarized (Porter 1997, Swihart and DeNicola 1997). As a result, deer management in these landscapes has focused on the political and sociological aspects (Green et al. 1997, Kilpatrick et al. 1997, Messmer et al. 1997, Stout et al. 1997).

Lethal control is the most common management technique implemented in suburban and urban areas to reduce deer populations (DeNicola et al. 2000) and the most cost-effective method (Ishmael and Rongstad 1984). Although lethal control is cost-effective, land ownership patterns in these landscapes make implementing lethal control complicated because they can create deer refuges (Messmer et al. 1997, Brown et al. 2000). One of the challenges to the use of harvest in these landscapes is the presence of refuges
because these areas protect deer from harvest and reduce the efficacy of harvest to control deer populations (Brown et al. 2000, Rhoads 2006). Refuges are caused either by landowner attitudes preventing harvest (Messmer et al. 1997, Storm et al. 2007) or by state or local regulations that prevent or limit harvest in certain areas (Brown et al. 2000, Rhoads 2006). One of the greatest concerns for managers is protecting public safety while allowing for the management of deer populations. One of the primary methods for achieving this goal in the Northeast is the use of safety zones, which are areas around an inhabited building where it is illegal to hunt.

Refuges have been used to protect a segment of harvested populations to ensure sustainability (Powell et al. 1996, Slough and Mowat 1996). Although protection from harvest can be valuable in some instances, the use of refuges may limit the management of some species. Elk (Cervus elaphus) have been documented moving onto private land refuges as a result of pressure from hunting (Burcham et al. 1999, Conner et al. 2001). Rhoads (2006) documented white-tailed deer increasing the use of refuges during controlled hunts on a public park in Maryland. When deer have access to refuges, management efforts (i.e., harvest) to reduce the population may be mitigated by the protection that these refuges provide.

Safety zones are intended to provide protection to landowners but may be inhibiting the management of white-tailed deer populations by creating refuges. The high density of homes and buildings in the Northeast coupled with highly restrictive safety zones may limit the amount of deer habitat available for management. Although safety zones are intended to protect the nonhunting public, hunting accidents involving these individuals are extremely rare (Smith et al. 2005). Most states do not have safety zones even in highly developed areas (e.g., Virginia and North Carolina). Although permitting firearm hunting in close proximity (<200 m) to houses may not be feasible, the use of archers might be an alternative. Pennsylvania and Delaware recently reduced their safety zone to 46 m for archers. My objectives were to investigate the impact of variations in the safety zones in northern New Castle County, Delaware, on the amount of deer habitat available to deer management.

**Study area**

My study area was northern New Castle County, Delaware. This area was bounded by Pennsylvania to the north, Maryland to the west, Interstate 95 to the south, and Interstate 495 to the east. This part of Delaware has the greatest amount of development in the state and is typical of urbanized areas on the East Coast of North America. Property sizes were variable (<0.1 ha to >100 ha), with most properties <0.2 ha. Northern New Castle County (387 km²) was 70% development, 18% forestland, 7% agricultural areas, 2% open water, 2% wetlands, and 1% open fields. Deer habitat (i.e., forestland, agricultural areas, wetlands, and open fields) comprised 28% of the study area. The deer population on our study area was 45 to 51 deer/km² (Bowman 2006).

**Methods**

Safety zones are common in the Northeast and are implemented to reduce the probability of a hunter’s projectile (i.e., bullet or arrow) from accidentally striking a building or its inhabitants (Table 1). Within these zones, hunting and or the discharge of firearms is prohibited.

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**Table 1. Safety zone regulations for firearm and archery hunting in the Northeast in 2010.**

<table>
<thead>
<tr>
<th>State</th>
<th>Firearm (m)</th>
<th>Archery (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delaware¹</td>
<td>91</td>
<td>50</td>
</tr>
<tr>
<td>Connecticut</td>
<td>152</td>
<td>152</td>
</tr>
<tr>
<td>Maine</td>
<td>91</td>
<td>91</td>
</tr>
<tr>
<td>Maryland</td>
<td>137</td>
<td>137</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>152</td>
<td>152</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>91</td>
<td>91</td>
</tr>
<tr>
<td>New Jersey</td>
<td>137</td>
<td>137</td>
</tr>
<tr>
<td>New York</td>
<td>152</td>
<td>152</td>
</tr>
<tr>
<td>Ohio</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>137</td>
<td>46</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>152</td>
<td>61</td>
</tr>
<tr>
<td>Vermont</td>
<td>152</td>
<td>152</td>
</tr>
<tr>
<td>Virginia</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>West Virginia</td>
<td>152</td>
<td>152</td>
</tr>
</tbody>
</table>

¹1183 m, north of Interstate 95 and west of Interstate 495
Although the safety zone established by the state wildlife agency for most of Delaware was 91 m for firearms and 46 m for archery, the safety zone for our study area established by county law was a more restrictive 183 m. Within the boundaries of my study area, county law prohibited the discharge of any firearm within the safety zone. Because the law included all types of weapons that are legal for deer hunting, no deer harvest was permitted within these areas.

I used ArcView 3.2 (ESRI Inc., Redlands, Calif.) for all geospatial analyses. I used the 2002 Delaware land-use coverage to determine the distribution of deer habitat (i.e., forestland, agricultural areas, wetlands, and open fields). No digital source of building locations was available for Delaware, so, I used a combination of the 2002 Delaware land-use coverage and 2002 digital orthophotos to create coverage with the location of each building. To reduce the time required for digitizing the location of buildings, I created a 200-m buffer around all deer habitat within the study area. The largest safety zone was 183 m, so, I used a 200-m buffer to be conservative and to ensure that I did not miss any buildings that could have safety zones overlapping deer habitat. Using ArcView, I displayed the digital orthophotos with the above buffer overlaid on the photos. My research assistant (A. Reid) then digitized the location of each building. To reduce the time required for digitizing the location of buildings, I created a 200-m buffer around all deer habitat within the study area. The largest safety zone was 183 m, so, I used a 200-m buffer to be conservative and to ensure that I did not miss any buildings that could have safety zones overlapping deer habitat. Using ArcView, I displayed the digital orthophotos with the above buffer overlaid on the photos. My research assistant (A. Reid) then digitized the location of each building. She did this by placing a point on the edge of the structure closest to deer habitat. These points became the buildings’ coverage. I created buffers (i.e., 46, 91, and 183 m) around each building to mimic current safety zone regulations. I overlaid these buffers on our deer habitat coverage to determine the amount of deer habitat not available for harvest. I assumed that areas within a safety zone would act as a refuge because harvest would be prohibited in these areas. Harvest is the most important mortality cause for white-tailed deer, so, removing the major cause of mortality will cause the area to be a refuge (Bowman 2011).

In northern New Castle County, most of the larger patches (>100 ha) of deer habitat are publically owned. I expected safety zones to have less impact on large patches of habitat because these patches have a smaller edge to area ratio compared to smaller habitat patches (<100 ha). I overlaid the same buffers (i.e., 46, 91, and 183 m) over a deer habitat coverage that was classified by land ownership. This technique allowed me to determine impact of safety zones on public versus private lands. I assumed that areas within a safety zone would act as a refuge because harvest would be prohibited in these areas.

**Results**

Our study area had 10,883 ha of deer habitat (Figure 1). The amount of deer habitat available for harvest was 4,232, 7,686, and 10,037 ha for the 183, 91, and 46 m safety zones, respectively. The 183 m safety zone made 61% of deer habitat a refuge (Figure 2). Reducing the safety zone by half (i.e., 91 m) reduced amount of deer habitat in refuges to 29% (Figure 3). If the safety zone was reduced by 75% (i.e., 46 m), the amount of deer habitat in refuges was reduced to 8% (Figures 4 and 5).

Our study area had 2,680 ha (25%) of deer habitat in public ownership, whereas the remaining 8,203 ha (75%) of deer habitat were privately owned. The amount of deer habitat available for harvest on public lands was 1,477 (55%), 2,177 (81%), and 2,559 ha (96%) for the 183, 91, and 46 m safety zones, respectively. The amount of deer habitat available for harvest on private lands was less than on public lands. Private lands had 2,755 (34%), 5,509 (67%), and 10,037 ha (91%) open to harvest for the 183, 91, and 46 m safety zones, respectively.

**Discussion**

My results support the hypothesis that refuges may limit deer management (Brown et al. 2000, Rhoads 2006). The current safety zone regulation on our study area caused 61% of the deer habitat to be closed to hunting. With this amount of refuge, most of the deer on the study areas were protected from harvest, which will prevent the desired population reduction from occurring (Bowman 2006). Because the safety zone regulation on our study area was more restrictive than the rest of the state, I also considered the impact of reducing the safety zone to 91 m, which is the regulation for firearms in the rest of Delaware. This reduction doubled...
the amount of deer habitat that would be open to hunting, but still caused 29% of deer habitat to be in refuges. If the safety zone was reduced to 46 m for archery as in Pennsylvania and the rest of Delaware, only 8% of deer habitat would be refuges. This size safety zone would provide the greatest flexibility to wildlife managers.

The discrepancy in the safety-zone size for Delaware is dictated by variation in state and county regulations. The safety-zone regulation for Delaware is 91 m for firearms (or 46 m for archery), but New Castle County passed an ordinance that dictated a more stringent regulation (i.e., 183 m) in northern part of the county. This discrepancy may cause confusion for the public because it is unclear why it is safe to hunt within 91 m of a building in most of Delaware but not in northern Delaware.

The size of the safety zone should be dictated by the weapon used by hunters. The range of archery equipment is much less than that of firearms, so, to have different safety zone sizes for different equipment types is appropriate. Delaware, Pennsylvania, and Rhode Island are the only states that have reduced safety-zone sizes for archery equipment. These reduced zones likely reduce the area of refuges substantially. In addition to equipment type, elevation of the hunters may allow for reduced safety zone sizes. Requiring hunters to hunt on elevated stands would force them to fire their projectiles downward, reducing the probability of the projectiles traveling long distances (MountainTop Technologies 2007). The size of safety zones needs to be more carefully evaluated and tied to actual safety data.

One of the assumptions of safety zones is that these regulations make hunting safer.
for the nonhunting public. The name safety zone is likely a misnomer because unsafe behavior is not prevented by these regulations. Safety zones reduce the probability only that unsafe behavior will result in injury to the public. Focusing on safe behavior is likely more important to public safety than these regulations. Hunting accidents are very rare (<7 per 100,000 hunters) and almost always involve other hunters (Smith et al. 2005). The threat of hunters accidentally injuring nonhunters is likely overstated. In contrast, deer are actually a greater threat to public safety. Conover et al. (1995) estimated that deer caused >200 fatalities and injuries to approximately 29,000 people each year. Although safety zones are intended to protect public safety, these regulations should be evaluated for their impact on deer abundance, which may be of greater concern for public safety.

Currently, the impact of the safety-zone regulations is greater for private land than for public land. Over half of the public land was available for hunting compared to about a third of the private land. Although private landowners can decide not to allow harvest with the current regulations, most cannot allow harvest even if they were supportive of it. Reducing the size of safety zones would allow for greater freedom of private landowners to manage deer on their properties. Storm et al. (2007) documented that most landowners did not permit harvest on their property, so landowners will need to be educated that reducing deer abundance is necessary and important. Many researchers have suggested that preventing hunter access on private lands is inhibiting the effectiveness of harvest for reducing deer abundance by creating refuges (Messmer et al. 1997, Brown et al. 2000, Storm et al. 2007)

Management implications

The size of safety zones in northern Delaware should be reduced to control white-tailed deer populations in northern New Castle County. I recommend reducing the size of the safety zone to 91 m for firearms and 46 m for archery equipment so that it is consistent with the rest of the state. I encourage all states to evaluate carefully the size of their safety zones and ensure that these regulations are consistent with the type of weapon used for harvest. Finally, to moderate the misconceptions formed by the title safety zones, buffered areas should simply be called no-hunting zones.

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