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Massachusetts

Monitoring Moose Status and Relative Abundance from Sighting Surveys during the Quabbin Controlled Deer Hunts

2006-2015 Results

August 2016

Massachusetts Department of Conservation and Recreation
Division of Water Supply Protection
Office of Watershed Management
Natural Resources Section

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Principal participants were: for DCR Dan Clark, Kiana Koenen, Ken MacKenzie, and Jillian Whitney; and for USGS CFWRU Stephen DeStefano and Dave Wattles. We thank the large number of DCR staff and volunteers who made the Quabbin moose survey possible. A very special thanks to the Quabbin deer hunters, whose participation, cooperation, and enthusiasm were invaluable.

SUGGESTED CITATION

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Monitoring Moose Status and Relative Abundance from Sighting Surveys during the Quabbin Controlled Deer Hunt

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INTRODUCTION

The forests are back in Massachusetts and so are the moose.

Both forests and moose (*Alces americanus*) started disappearing from the landscape of southern New England in the early 1800s with the advent of European settlement. By the late 1800s, the habitat changed drastically from mostly forests to mostly agricultural fields. The much smaller, more adaptable and versatile browser, the white-tailed deer (*Odocoileus virginianus*), persisted through this period, but the much larger moose was extirpated; only remnant populations remained in northern New England.

As farms were abandoned and settlers moved further west, the forest started to recover. A mix of young brushy growth and second-growth forest was ideal for deer; they responded positively to this change in habitat, and their populations increased. During this time – in the 1930s – the Quabbin reservoir and reservation were created and established. The early goal for the reservoir was to fill it to capacity so that it could supply the growing human population of eastern Massachusetts with clean water.

Concern over water yield occurred in the 1960s and 1980s with extended periods of drought and demand that regularly exceeded supply. Fields were created to increase yield and high deer densities were seen as a positive thing. The thought at this time was that deer browsing could be beneficial, in that it reduced vegetation and thereby helped to increase yield. As such, for over 50 years hunting was not permitted on the Reservation and the deer herd was unmanaged. During this time, however, the deer population grew and deer were having a bigger and more noticeable effect on understory vegetation, to the point where managers were now concerned with negative impacts to the watershed and the overall health of the forest as a natural filtration system (Barten et al. 1998).

In response to growing concerns over the detrimental impacts of an “overabundance” of white-tailed deer browsing on forest trees and ground vegetation, the Metropolitan District Commission (now Department of Conservation and Recreation [DCR]), Division of Water Supply Protection (DWSP) initiated a limited, controlled public deer hunt on the Quabbin Reservation in 1991. Since the late 1990s, more and more hunters reported sightings of moose. Overall interest in the expanding moose population was growing for many reasons, including the

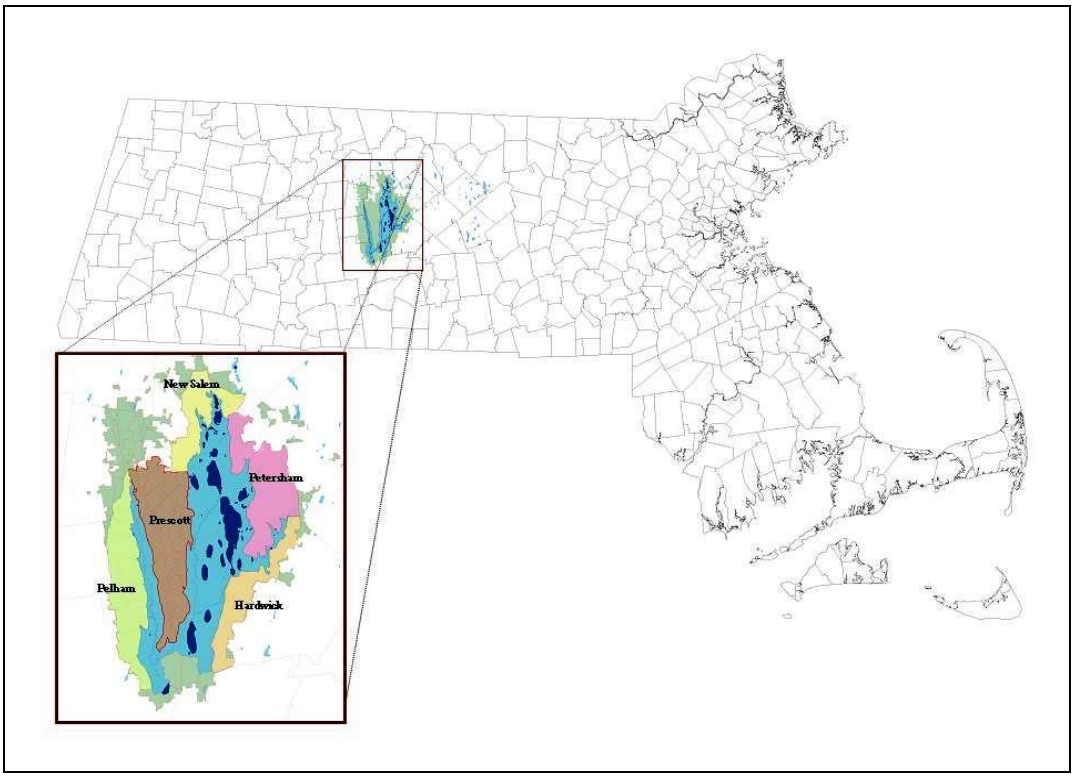
potential impact of this heavy browser on forest vegetation and regeneration. This concern led to the establishment of an informal Quabbin moose count in early 2000s, conducted by DCR staff and hunters, during the deer hunt season on the watershed. The goal of the count was to provide a mechanism for tracking the moose population and an index to abundance and changes in numbers over time.

In 2006, a formal Quabbin moose sighting survey began, during which hunters would report the number, type (e.g., bull, cow, cow with calf), and location of moose sightings. The moose survey has taken place each year since 2006 in the zones that are hunted. This report summarizes 10 years of information collected from deer hunters on moose sightings on the Quabbin Reservation.

METHODS

The controlled hunt area of the Quabbin Reservation is approximately 63 mi^2 and is divided into 5 deer management units or hunt blocks: Hardwick (8.8 mi^2), New Salem (10.7 mi^2), Petersham (10.9 mi^2), Pelham (13.3 mi^2), and Prescott (18.8 mi^2) (Fig. 1).

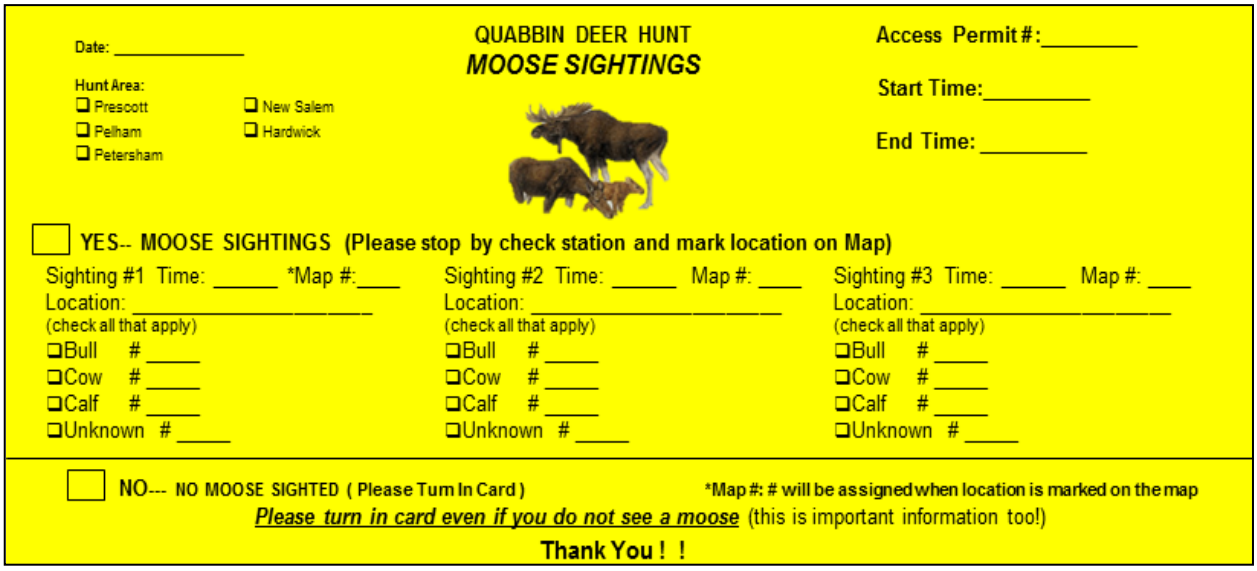
Figure 1. Location of the 5 management units used in the Quabbin Reservation controlled deer hunt.



Each year 4 of the 5 blocks are hunted, totaling approximately 50 mi^2. The hunts take place on 4 days during the 2-week statewide shotgun hunting season. Two blocks are hunted each week for 2 days (Thursday and Friday), from sunrise to 4 pm. The moose survey is done on the first day of the hunt in each active hunting block.

Every hunter is given a moose survey card before they check into their hunt area, and each card has room for at least 3 group or individual moose sightings (Fig. 2).

Figure 2. Example of a moose survey card.


Date: _____

QUABBIN DEER HUNT
MOOSE SIGHTINGS

Access Permit #:_____

Hunt Area:
❑ Prescott ❑ New Salem
❑ Pelham ❑ Hardwick
❑ Petersham

Start Time:_____

End Time: _____

☐ YES-- MOOSE SIGHTINGS (Please stop by check station and mark location on Map)

Sighting #1 Time: _____ *Map #:____
Location: _____
(check all that apply)
❑Bull # _____
❑Cow # _____
❑Calf # _____
❑Unknown # _____

Sighting #2 Time: _____ Map #: ____
Location: _____
(check all that apply)
❑Bull # _____
❑Cow # _____
❑Calf # _____
❑Unknown # _____

Sighting #3 Time: _____ Map #: ____
Location: _____
(check all that apply)
❑Bull # _____
❑Cow # _____
❑Calf # _____
❑Unknown # _____

☐ NO--- NO MOOSE SIGHTED (Please Turn In Card)

*Map #: # will be assigned when location is marked on the map

Please turn in card even if you do not see a moose (this is important information too!)

Thank You ! !

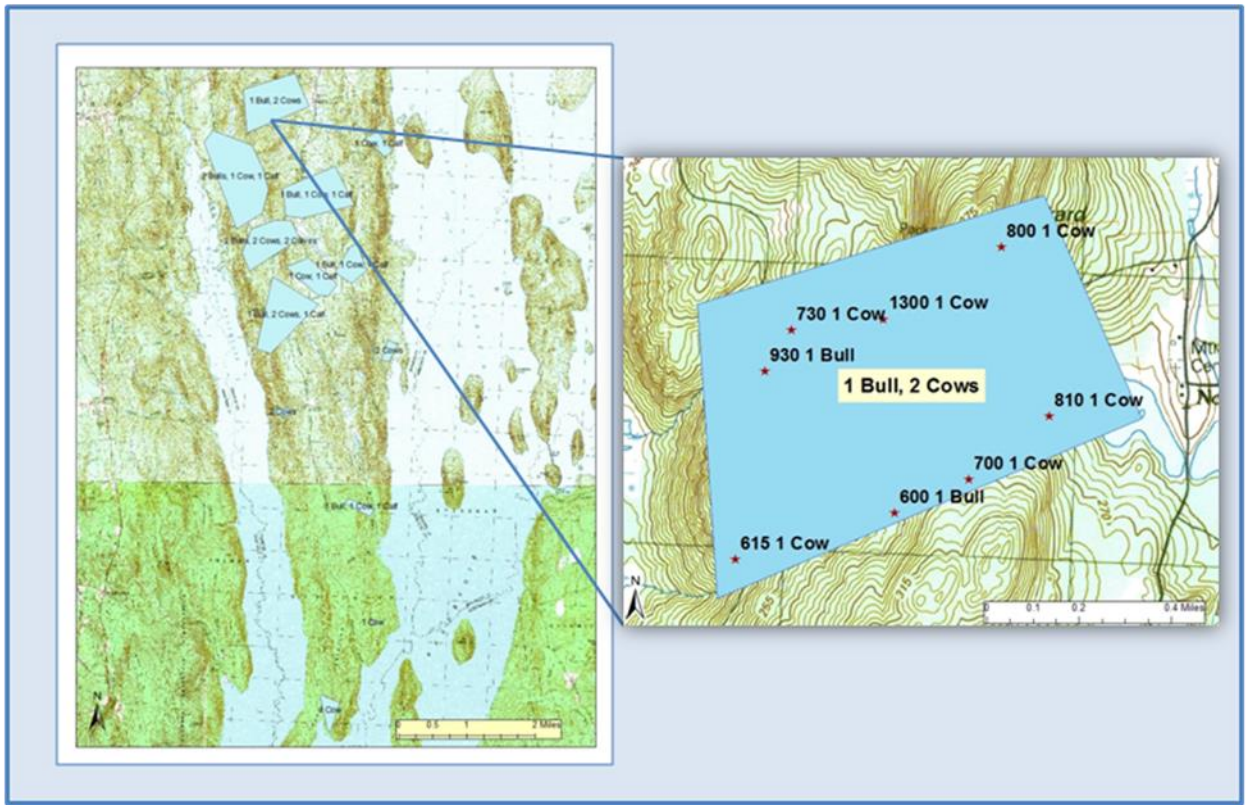
Hunters are asked to record time, sex, and number of individual moose observed at each location. Prior to the deer hunt, each hunter is given detailed maps with all the roads and cross road locations (all locations are clearly marked in the field and on the detailed maps). They are also encouraged to scout their areas and are given 2 days the weekend before Thanksgiving to drive around the hunt area. In addition, many of the hunters have hunted the Quabbin before and are familiar with the lay of the land. It is illegal to hunt moose in Massachusetts, and violators can be prosecuted, lose hunting privileges and equipment, and encounter stiff fines. Hunters are required to keep track of time because they cannot start hunting until the posted legal hunting time and must check out at a designated exit promptly at 4:00 pm.

Moose survey cards are collected as hunters exit the reservation. If a hunter has a moose sighting they are asked to stop and mark each location on the survey map. Each unique sighting is assigned an individual Map Number that is recorded on the card and referenced at the location on the map.

Moose Survey Maps

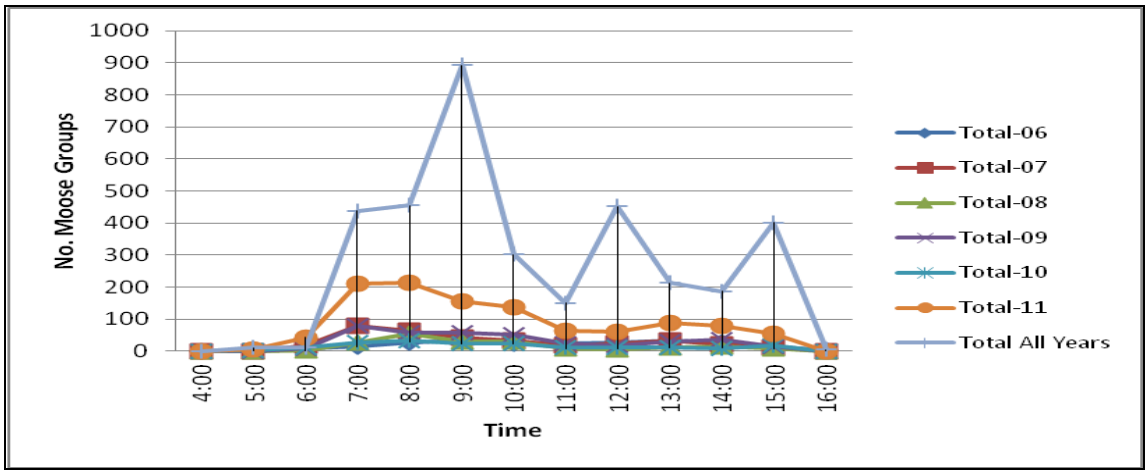
All map locations with individual moose sighting information were digitized into the ArcMap, Geographic Information System (GIS) mapping program. The maps for each survey area (1:15,000) were printed and labeled with the unique map location number, time, and moose grouping (e.g., 1 bull, 2 bulls and 1 cow, cow and calf). Each map was reviewed and moose groupings were determined by looking at time and locations marked on the map (Fig. 3).

Figure 3. Example of moose groupings, based on time and location of individual sightings, Prescott Peninsula, 2014.



Surveys were done on the first day of the 2-day hunt only. To try to reduce chances of double counting (i.e., possibly the same moose seen at 6:00 a.m. moving to a new location and reported as another moose at 10:00 a.m.), the day was divided into 3 time periods. We used the first 6 years of data to determine time periods based on peak observation times (Fig. 4), which represented a maximum (10 hour), moderate (6 hour), and minimum (3 hour) time period for determining the number of individual moose observed. Periods were: All Day (6 am – 4:00 pm), Noon (6 am - 12 pm), and 9 am (6 am – 9 am).

Figure 4. Peak times that moose were observed during the 2006-2011 moose observation surveys.



The totals were then pooled from each time period to calculate a mean number of moose for each survey area. Minor adjustments were made to include individuals when one time period did not record a particular sex/age composition of moose seen in other periods. For example, in the case where no calves were seen during the first 3 hours (9 am period) but seen in the other 2 time periods, the mean number of calves was calculated for those 2 time periods when they were observed. Twins were determined only when there was 1 cow present with the 2 calves.

RESULTS

Four out of 5 hunting blocks were surveyed each year from 2006 through 2015, and during this time period each block was surveyed a total of 8 times. Moose survey cards were handed out to 9,954 hunters and 8,893 cards were collected over the 10 year survey period. Return rates ranged from 84% to 95%, and averaged 89% overall. Approximately 23% of hunters reported seeing 1 or more individual moose or groups of moose (Table 1).

Table 1. Moose observation card returns and cards with moose sightings on the Quabbin Reservation, MA, 2006-2015.

Year	Hunters	Cards returned	Cards with moose
2006	1150	962 (84%)	254 (26%)
2007	1065	907 (85%)	254 (28%)
2008	928	813 (88%)	178 (22%)
2009	1149	1042 (91%)	327 (31%)
2010	1023	938 (92%)	189 (20%)
2011	1186	1021 (86%)	303 (30%)
2012	914	826 (90%)	175 (21%)
2013	769	710 (92%)	88 (12%)
2014	923	872 (95%)	180 (21%)
2015	847	802 (95%)	126 (16%)
Mean	**995**	**889 (89%)**	**207 (23%)**

Survey Periods Moose Counts

The 10 year average number of individual moose estimated for each time period ranged from 94 using observations made for all day (6 am to 4 pm), 86 moose for a partial day (6 am to 1200 pm), and 58 moose for sightings made only from the first 3 hours of the survey day (6 am to 9 am) (Fig. 5). The moose count data from survey times pooled and averaged for all time periods ranged from a high of 115 in 2007 to a low of 50 in 2015 (Fig. 6).

Figure 5. Number of moose observed in 3 time periods (all day, noon, 9 am) from 2006-2015.

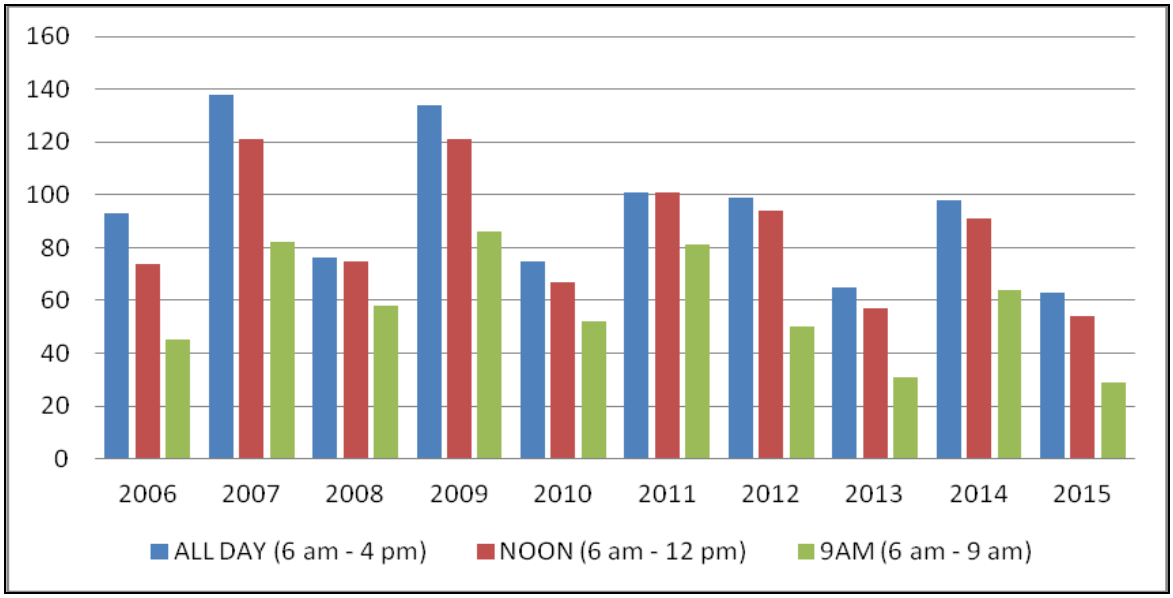
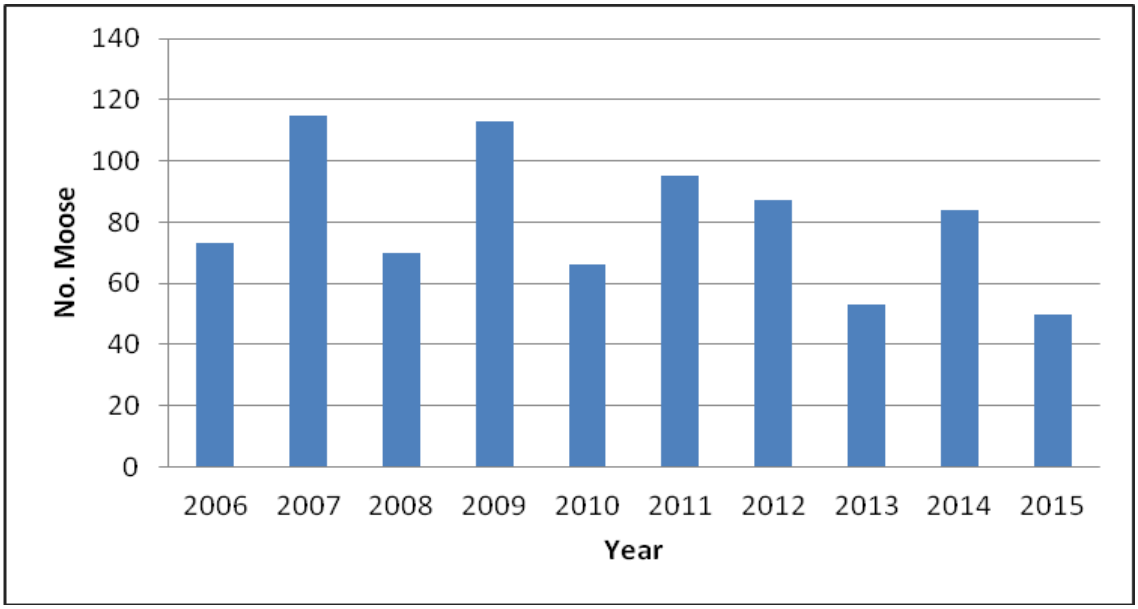


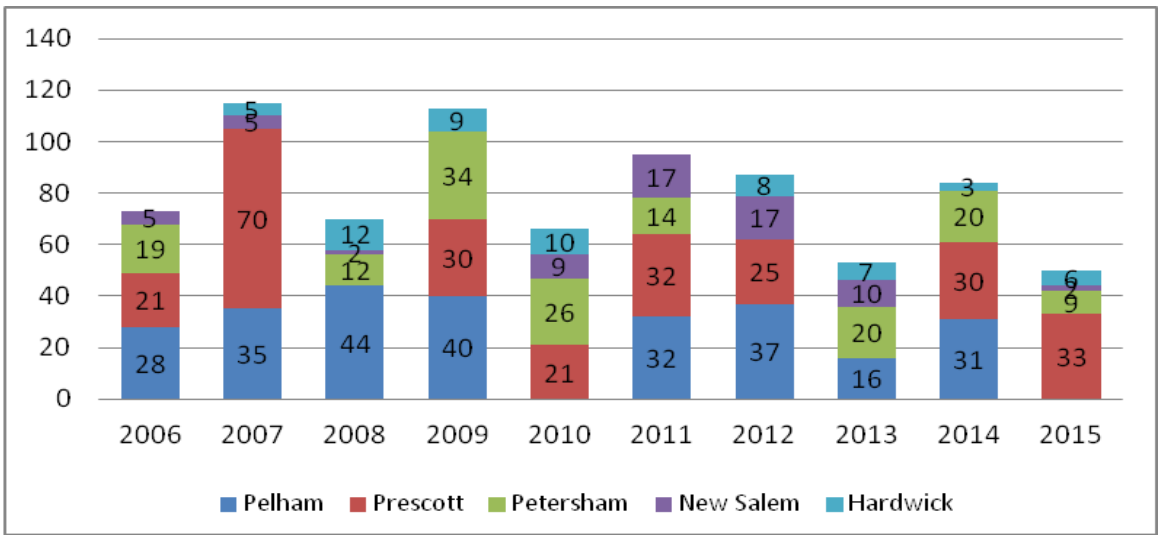
Figure 6. Mean number of moose observed for the 3 time periods (All Day, Noon, 9 am) on Quabbin survey areas, 2006-2015.



Survey Area Moose Counts

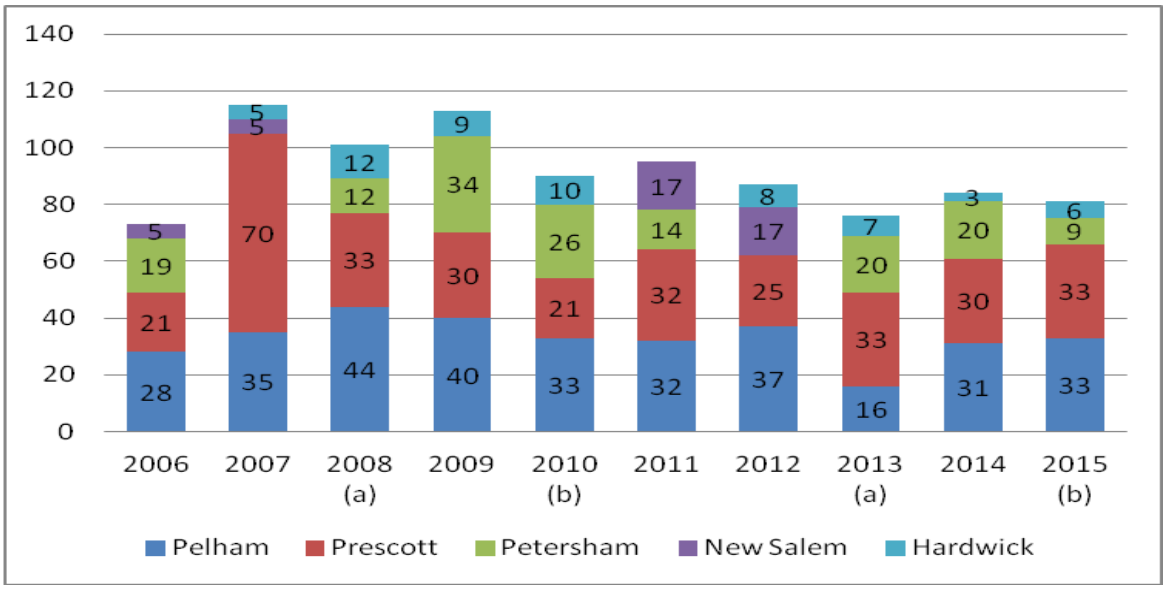
Moose were observed in each hunt block in every one of the 8 years surveyed. The highest number of moose was consistently seen in the 2 largest hunt blocks, Pelham and Prescott, with both averaging 33 moose and mean sighting densities of 2.47 moose/mi^2 (SE 3.0 moose) and 1.74 moose/mi^2 (SE 5.6 moose), respectively (Fig. 7a). Petersham had an 8 year average of 19 moose and 1.47 moose/mi^2 (SE 3.9 moose). Hardwick and New Salem averaged 8 moose with 0.85 moose/mi^2 (SE 1.0) and 0.99 moose/mi^2 (SE 3.5 moose), respectively. It should be noted that in years when either the Prescott or Pelham blocks were not hunted, the total moose count tended to be low. The 10 year average number of all moose sighted was 81 moose (SE 7.1 moose). Group size ranged from a single animal up to 7 individuals. Moose sighting density ranged from 0.87 to 1.99 moose/mi^2 for all years (Table 2). The mean sighting density of moose for all years was approximately 1.6 moose/mi^2.

Figure 7a. Mean number of moose counted in each survey area, 2006-2015.



To take into account years when the Prescott or Pelham blocks were not hunted, we deleted the New Salem block (for consistency) and substituted the average count (33 moose) for Prescott or Pelham (Fig. 7b). This stabilized the moose count over time, and highlighted the contributions that the Prescott and Pelham blocks made to the overall moose count.

Figure 7b. The adjusted mean number of moose for each year if larger Prescott or Pelham survey blocks were included in the survey and the smaller New Salem block was deleted, 2006-2015.



(a) Prescott added (b) Pelham added

Table 2. Mean sighting density of moose/mi² for all survey areas, 2006-2015.

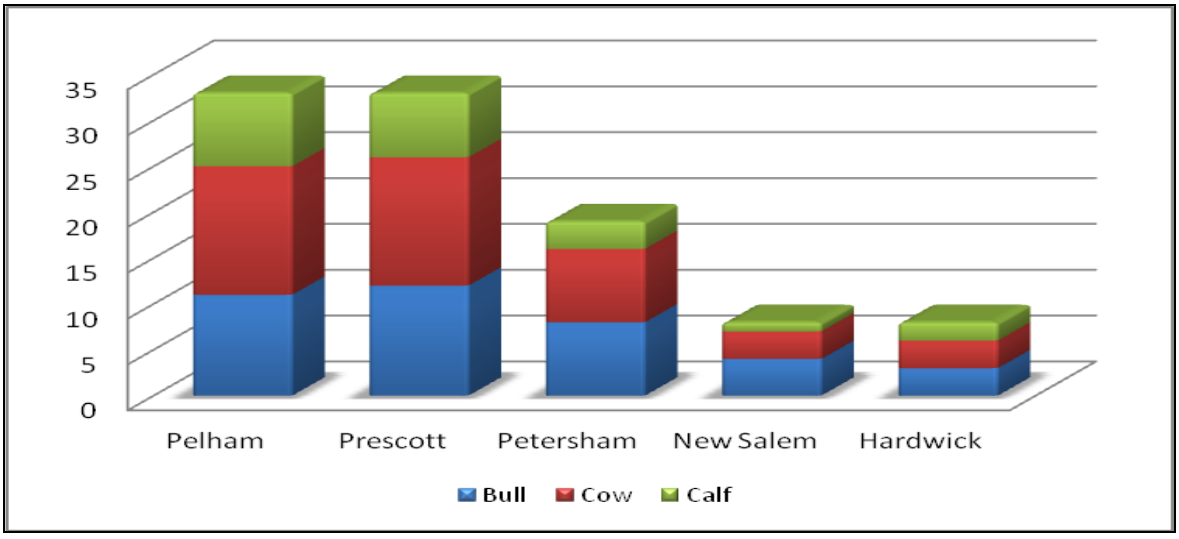
	Survey Years (moose/mi²)										
Survey Area	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	$\bar{x}$
Pelham	2.11	2.63	3.30	3.01	-	2.41	2.78	1.20	2.33	-	2.47
Prescott	1.12	3.72	-	1.60	1.12	1.70	1.33	-	1.60	1.76	1.74
Petersham	1.31	-	0.83	2.34	1.79	0.97	-	1.83	1.83	0.83	1.47
New Salem	0.70	0.70	0.28	-	1.27	2.39	1.59	0.93	-	0.19	1.01
Hardwick	-	0.57	1.36	1.02	1.14	-	0.91	0.8	0.34	0.68	0.85
$\bar{x}$ moose/mi²	1.31	1.91	1.44	1.99	1.33	1.86	1.65	1.19	1.53	0.87	
SE	0.30	0.77	0.66	0.43	0.16	0.40	0.40	0.23	0.42	0.33	

- (Year not surveyed)

Age and Sex Composition

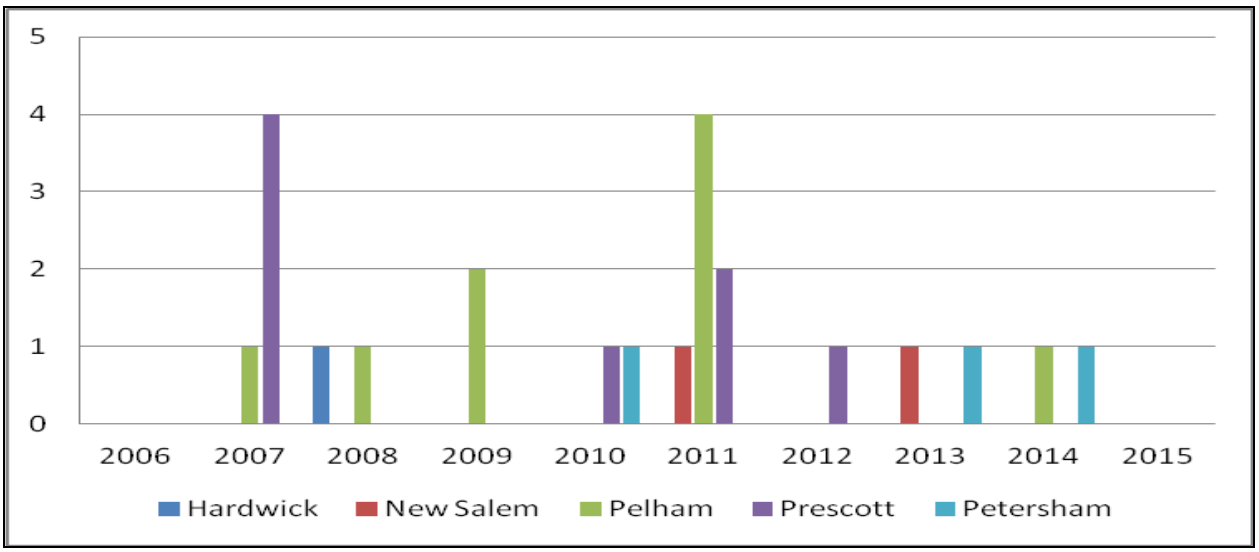
The number of bulls to cows (sex ratio) ranged from 1.3:1.0 to 0.6:1.0 over the 10 years of surveys. For the 10 years combined, the overall bull to cow ratio was approximately 0.9:1, and the calf to cow ratio was 0.5:1.0 (Fig. 8). A more even sex ratio can occur in moose populations that are not hunted (e.g., bulls are not removed by selective harvesting), as is the case for Massachusetts (Laurian et. al 2000, Milner et.al 2007). The relatively high calf-to-cow ratio occurs in areas of good habitat and food resources, as well as low predation rates, especially when wolves (*Canis lupus*) or grizzly bears (*Ursus arctos*) are at very low densities or where they do not occur, as in Massachusetts (Ballard and Van Ballenberghe 2007).

Figure 8. Mean number of moose by age and sex within each survey area, 2006-2015.



Moose calves were recorded in all survey areas at least 1 year or more (Fig. 9). Hardwick, Prescott, and Pelham had ≥1 calf every year surveyed; Petersham had calves 7 out of 8 years and New Salem had calves 3 out of 8 survey years. Cows with twin calves were recorded in all the survey areas in at least one year. New Salem had confirmed twins 2 years, Hardwick 1 year, Petersham 3 years with 1 year (2007) also having 1 set of triplets, Prescott 4 years with 1 year (2007) having 4 sets of twins and 1 year (2011) having 2 sets. Pelham had 5 years with twins; 1 year with 2 sets (2009) and 1 year with 4 sets (2011).

Figure 9. Number of sets of moose calf twins observed in each survey area, 2006-2015.



DISCUSSION

The Quabbin moose survey provides an index to relative abundance as one way of monitoring the population. It is an inexpensive and efficient way to keep track of moose population levels; minor changes in the relative number of moose are difficult to detect with almost any survey technique, but the Quabbin moose survey is capable of detecting larger movements in moose levels (increases or decreases), and as such provides managers with a mechanism to determine changes in the population over time. For the period covered by the first 10 years of the moose count (2006-2015) we can see that numbers have been relatively stable, and perhaps decreasing slightly over time, but there has yet to be a dramatic drop in moose numbers as has been reported in other areas along the southern edge of the geographic range.

It is important to be cautious when extrapolating from this count to density or abundance estimates (i.e., actual population size). However, providing rough estimates of sighting densities is useful for comparative purposes (i.e., to other states or areas and over time) and provides some quantitative basis for watershed and statewide population estimates besides our "best guesses". The moose count has translated into a low density estimate (about 1.6

moose/mi^2) on the watershed, which is reasonable compared to density estimates from elsewhere in the Northeast. The Quabbin may represent some of the best moose habitat in the Commonwealth, although timber management in other parts of the state, such as the Berkshire Mountains and Worcester highlands, provides good habitat for moose as well. Results from the GPS study (Wattles and DeStefano 2013a,b) indicate that there is occupied moose habitat throughout much if not all of the forested portions of central and western Massachusetts.

The survey also provides demographic data that would otherwise be restricted to anecdotal reports. Bull:cow and cow:calf ratios are useful indicators of population structure, and consistent reports of twin (and in one case triplet) calves indicate that the population is reproducing and that much of the habitat, and thus resources such as food and cover, is good.

Reports from hunters show that many of the moose seen are in relatively good shape, as determined by their apparent weight and coat condition. Parasites and disease can be limiting factors on moose survival but comments regarding condition of moose seen during the survey were generally positive; few reports of sickly moose or individuals in poor condition were given. The impacts that winter ticks (*Dermacentor albipictus*) and parasite loads can have on a population are related to density (i.e., a density-dependent phenomenon); individuals are likely less susceptible when their population densities are low, as is the case in southern New England. Brain worm (*Parelaphostrongylus tenuis*) mortality in New Hampshire has been found in areas where deer density exceeds 10 deer/mi^2 (Rines 2015), and some mortality likely occurs in Massachusetts.

Moose are hunted in New Hampshire, Vermont, and Maine where moose densities are highest; they are not currently hunted in New York, Massachusetts, and Connecticut where moose have become more recent residents. Because moose are not harvested in Massachusetts, pregnancy rates, weights, and bull rack spread measurements, which are often used as indices of habitat quality and food resources (Van Ballenberghe and Ballard 2007), are not generally available for southern New England and New York.

The moose count is also supported enthusiastically by the Quabbin deer hunters, who have been extremely interested and cooperative throughout the survey. The interchange between wildlife managers and the hunting public has been enhanced by this relationship, and it has created an atmosphere in which the hunters feel a part of the survey and the efforts to keep track of the moose population.

A Perspective on Relative Abundance and Density Estimates

Knowing the number of individuals for any wildlife species is always of interest, but accurate estimates of population size are usually fraught with problems and uncertainty. Even tested

methodology (e.g., capture-recapture, distance sampling, aerial surveys) that can produce reliable results have challenging issues and demanding assumptions; and they can be very expensive to conduct. These more formalized methods are impractical and cost-prohibitive for moose in Massachusetts. Other indices, such as number of moose collisions with motor vehicles, pellets counts, or general observations by hunters or other members of the public provide some useful information, but their efficacy in accurately tracking numbers needs to be considered critically.

The same is true of using sighting surveys during the Quabbin controlled deer hunt. Potential issues include missed sightings, duplicate sightings of the same animal, and a limited spatial scope of inference (i.e., limited to Quabbin reservation). It could also be true that there is more of a tendency to over-estimate moose numbers (by double-counting) during years of high moose populations, and under-estimate numbers (by missing animals) during years of low moose numbers. However, our concerted efforts to develop a rigorous protocol that is carried out on a consistent basis over time improves our confidence in the Quabbin sighting survey as an index to relative moose abundance over time. As such, we believe that the information provided by the Quabbin moose survey provides important data that would otherwise not be available, and should remain a part of moose monitoring and management in the state well into the future.

Comparisons to Other Areas

It is difficult to compare moose densities with other areas because often these estimates are broken down by management units and can vary from state to state. Currently, the Northeast states of Maine, New Hampshire, Vermont, Massachusetts, Connecticut, and New York have resident moose populations (Wattles and DeStefano 2011). Each state's wildlife agency uses a combination of surveys to estimate moose densities based on hunter observation rates; these approaches often combine averaging the number of moose seen per hundred hunting hours with aerial moose surveys (Bontaites et al. 2000).

In 2015, New Hampshire moose density ranged from 0.10 moose/mi^2 in the Southeast Region to 2.2 moose/mi^2 in the northern Connecticut Lakes Region (Rines 2015). In Maine, moose densities from south to north ranged from 7 - 10.4 moose/mi ^{2} (Kantar and Cumberland 2013). Statewide moose population estimates for Vermont are around 1,750 animals (Vermont Department of Fish and Wildlife, 2017 Moose Season Proposal), for Connecticut are around 100 moose (Connecticut Department of Energy and Environmental Protection [DEEP], Wildlife Division unpublished data), and for New York are from 500 to 800 moose (New York State, Department of Environmental Conservation [NYSDEC] unpublished data). Massachusetts estimates it moose population to be relatively stable at around 1,000 individuals (Wattles and

DeStefano 2011; D. Stainbrook, Massachusetts Department of Fisheries and Wildlife [MDFW], pers. Comm.). Our moose density of 1.6 moose/mi^2 is moderate relative to other moose density estimates in the Northeast and lower than many other North American populations, which range from 0.1– 24.1 moose/mi^2 (Karns 2007).

CONCLUSIONS

It is important to note that our survey is a snapshot in time and does not take into account annual variation and moose movement on and off the Quabbin watershed. The moose count only takes place on the first day of a 2-day hunt and annual results are dependent on the size of the areas surveyed, habitat, weather, and hunt conditions. The larger hunt blocks (Pelham, Prescott) accounted for the largest number of moose seen during our surveys, and when one of those areas was not surveyed the number of moose counted that year was less. Also weather, such as extreme fog, wind, or rain events during the survey day, could have affected the number of moose observed, such as during the 2013 Pelham hunt when there was heavy fog.

In conjunction with our moose sighting survey in 2006, the U.S. Geological Survey's Massachusetts Cooperative Fish and Wildlife Research Unit at the University of Massachusetts-Amherst began a research project in Massachusetts to fit moose with global positioning system (GPS) collars to track their habitat use and movements (Wattles and DeStefano 2013a,b). Researchers collared over 30 moose, at least 7 of which were known to move on and off the Quabbin Reservation hunt areas. Six of the 7 collared moose were observed during the survey in areas verified by GPS locations and 1 moose was known to be in the area during a survey day but was never sighted by hunters (CFWRU 2008, unpublished data). In 2007 DWSP hired a private contractor to use aerial infra-red technology to search for moose, and in 2010 collaborated with a researcher from Mt. Holyoke College to survey for moose and deer on the watershed. Neither of the surveys was able to detect the known collared moose on the watershed, and all results were inconclusive.

In the future we hope to explore the possibility of using GIS modeling and analysis, combining our moose sighting location information with known movements from the GPS collared moose sighted during our surveys, to further refine our population estimates. We will continue to explore ways to address the opposing potential biases of missed sightings of moose that are present during the hunt, versus double-counting or counting the same individuals more than once. Also, in 2015 a pilot project was started to estimate deer and moose densities on study sites within Division lands using pellet-group counts. This project will continue and explore appropriate pellet-group deposition rates for moose to further refine these relative abundance estimates (D. Clark 2015, 2016 DCR, DWSP unpublished report).

Estimating moose abundance using hunter observation information during the Quabbin controlled deer hunt proved to be a consistent and viable way of collecting information on moose in the forested habitat of the Quabbin watershed. Hunter response was high (~90%) and moose were observed in every block in every year surveyed. As such, we believe that the Quabbin moose survey has become an invaluable and unique source of information to monitor the status of the moose population and as an index to moose abundance that would otherwise not be available. The information that the survey provides is critical because of the relatively recent re-establishment of moose in southern New England during the past few decades – after 2-3 centuries of absence – and because of the dramatic and disturbing declines in moose numbers seen in other areas along the southern edge of their geographic range in the U. S. and Canada. Also, this survey may likely provide the best indication of changes in the moose population related to climate change or increases winter tick mortality.

Our survey is a limited look at moose, but our data indicate that the moose population is relatively stable, reproducing successfully, and apparently healthy. We hope to continue to monitor moose populations on the Quabbin Watershed by using hunter participation during the white-tailed deer hunt. Future population estimates will be refined as new information on the moose population in Massachusetts becomes available.

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