

PROGRESS REPORT: MOVEMENTS AND LANDSCAPE PATTERN USE OF A COLONIZING MOOSE POPULATION IN MASSACHUSETTS

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INTRODUCTION

The moose (*Alces alces*) is the largest member of the deer family (Cervidae). Moose are circumpolar in distribution, being found throughout the boreal forest in North America and Eurasia (Franzmann 1981). In North America, moose are distributed from the Maritime Provinces of Canada to Alaska and south to southern New England, northern New York, the Great Lake States, the northern edge of North Dakota, and south into the central Rocky Mountains (Franzmann and Schwartz 1997).

In the northeastern United States, moose historically ranged throughout New England and New York and as far south as Pennsylvania (Allen 1870, Goodwin 1936, Franzmann and Schwartz 1997). In Massachusetts, the moose population was essentially extirpated with large-scale clearing of forests for agriculture and subsistence and commercial hunting during the time of European settlement.

Over the past several decades moose have recolonized Massachusetts from expanding populations in northern New England into what, despite their historical presence, many biologists considered marginal moose habitat. Current research on moose temperature tolerances suggests that it is too warm in Massachusetts for moose to be demographically viable. Despite this the state moose population has grown and is apparently thriving. Browse species such as trembling aspen (*Populus tremuloides*),

various willow species (*Salix* spp.), and balsam fir (*Abies balsamea*), important to moose in other portions of their range, have been reduced in abundance and distribution, are entirely absent, or are regionally restricted in Massachusetts. Regeneration of second- or multiple-growth mid-aged hardwood forest and the loss of early successional stage habitats affect several species of wildlife and is a major conservation issue in southern New England. The browse that has fueled the rapidly increasing phase of irruptive population fluctuations often exhibited by moose in places such as Isle Royale National Park is relatively rare in Massachusetts. Clearcutting, which promotes young woody regrowth, has been virtually eliminated due to political and economic constraints.

The establishment of a growing and apparently viable moose population in Massachusetts also coincides with an increase in urban and suburban development. Massachusetts has among the highest densities of people of any state in the country. Although portions of the landscape are relatively undeveloped, and some are protected from development in the form of state forests, wildlife management areas, and other conservation areas, natural areas in Massachusetts are distributed in a more patchy arrangement than in most other portions of the moose's geographic range in North America.

The proximity of such a large ungulate to high densities of people raises human-wildlife issues. Chief among them are moose-vehicle collisions (MVC). Moose-vehicle collisions have been increasing and occurring frequently in Massachusetts during the past several years. In 2004, about 50 such accidents occurred. Two human fatalities resulting from MVC have been recorded to date. Moose-vehicle accidents constitute a threat to public safety in certain areas, which will likely decrease public tolerance for the species.

Beginning in the spring of 2006, the Massachusetts Cooperative Fish and Wildlife Research Unit, in conjunction with the Massachusetts Division of Fisheries and Wildlife, began studying the movements and landscape pattern use of moose in Massachusetts, using global positioning system (GPS) equipped collars, to determine just how moose were adapting to this unique environment.

The results in this report represent preliminary data and are the property of the USGS Massachusetts Cooperative Fish and Wildlife Research Unit and the Massachusetts Division of Fisheries and Wildlife. The report can be cited as:

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OBJECTIVES

In light of the unique setting of Massachusetts and given its differences in forest communities compared to northern moose range, limited early seral stage forest, high temperatures, and high level of human development and density of roads, our objectives are to (1) determine home range size and seasonal home range use by moose, (2) document movement patterns, pathways, and distances moved across the landscape, (3) determine landscape pattern and resource use, including documenting interactions with roads and development, identifying landscape features that may function as movement corridors or may be barriers to movement, and identifying moose use of key habitat features (early seral stage forest, thermal cover, areas of timber harvest, wetlands); (4) document the timing of occurrence and behaviors associated with life

history characteristics, such as breeding (rut), births, and dispersal of young in Massachusetts and compare those to other parts of the range; and (5) contribute to the collection of demographic data, such as age-sex structure, survival, and cause-specific mortality.

STUDY AREA

Our study takes place throughout most of Massachusetts, and could extend into border areas of the surrounding states of Vermont, New Hampshire, New York, and Connecticut. Our capture operations, however, will focus in the northern portions of the Massachusetts, and include parts of the Coastal Plain, Worcester-Manadnock Plateau, Connecticut River Valley, Vermont Piedmont, and Berkshire-Vermont Upland ecoregions. These same ecoregions have been classified into the Northeast Coastal Plain, Worcester Plateau, Connecticut Valley, and Berkshire Highland Forest Management Zones by MDFW.

Massachusetts falls between 41° 14' and 42° 53', N latitude and 69 ° 55' and 73 ° 31', W longitude. Elevation in Massachusetts ranges from sea level in the east to 1,064 m above sea level at the state's highest point in the Berkshire Mountains of the west. Elevations range between 100-400 m above sea level across the main study area in central Massachusetts, where topography is dominated by glaciated rolling hills and stream valleys. Elevation and relief increase to the west of the Connecticut River in the Berkshire Highlands.

Forests in Massachusetts are typically regenerating second- or multiple-growth mid-aged mixed hardwoods and conifers, which have resulted from regeneration of farm fields abandoned in the mid-late 1800s. The forest is characterized by relatively even-

aged, mid-aged trees with limited early seral stage woody growth.

The forests of the central portion of the state are of the Transitional Hardwood-White Pine Region. This area is transitional between the Northern Hardwoods to the north and Central Hardwood-Hemlock-White Pine Forest Regions to the south. The major hardwood species include yellow and paper birch (*Butela alleghaniensis* and *B. papyrifera*), beech (*Fagus grandifolia*), and sugar and red maples (*Acer saccharum* and *A. rubrum*). Oaks (*Quercus* spp.) and hickories (*Carya* spp.) occur on warmer and drier sites, while hemlock (*Tsuga canadensis*) is found on cooler sites in the region. White pine (*Pinus strobus*) occurs on well-drained sandy sites and red maple and black ash (*Fraxinus nigra*) can be found on more poorly drained sites (DeGraff and Yamasaki 2001).

The forests of the Berkshire Highland Ecoregion are composed of the Northern Hardwood and Northern Hardwood-Spruce forest communities. Beech, white and yellow birch, and sugar maple are the main hardwood species in these communities. Quaking and bigtooth aspen (*Populus tremuloides* and *P. grandidentata*) and paper birch are early successional species in the Northern Hardwood community. In the Northern Hardwood-Spruce forest type, hemlocks are the conifer found at lower elevations, being replaced by red spruce (*Picea rubens*) and balsam fir at higher elevations. Spruce (*Picea* spp.) and fir stands are found on mountaintops, poorly drained sites, and north facing exposures (DeGraff and Yamasaki 2001).

Early successional habitat is limited across the state, typically occurring only in small patches of 0.4-40 ha (<1-100 acres), on state-managed public lands or resulting from small scale logging on private holdings.

METHODS

Capture

Due to the closed nature of Massachusetts forest and the lack of large openings, we are unable to use helicopters to capture moose, which is the common practice in other portions of moose range. Our primary means of capture is to approach and dart the moose from the ground. General ground searches for moose are made in areas of recent sightings, areas where moose are known to frequent due to habitat preferences, or where we can track moose that have been marked previously with conventional (VHF) telemetry collars.

A second general approach involves capture and relocation of “problem” moose. We assist with the capture of moose in urban and other areas of high public use, necessitating darting and removal by the Massachusetts Large Animal Response Team composed of MDFW personnel and Massachusetts Environmental Police (MEP). We take advantage of some of these opportunities to place GPS collars on moose.

Moose are immobilized with xylazine hydrochloride in concentrations of 300 and 450 mg/ml (concentration of drug expressed as amount of drug in mg per volume of liquid in ml). The drug is delivered by dart syringe shot from a dart gun. Tolazoline is used as an antagonist used to reduce recovery time in moose that have been immobilized with Xylazine. The tolazoline is delivered via hand injection into the muscle in the front shoulder.

Home Range

We used minimum convex polygon (MCP) and 95% adaptive kernel estimators to calculate home ranges for all moose collared with GPS collars in Massachusetts.

Seasonal home ranges were also calculated using MCP methods. MCP home ranges were calculated using the Create Minimum Convex Polygon tool in the Hawth Tools program for ArcGIS 9.2, while 95% volume kernels were created using the Home Range Tools ArcGis9 toolbox in ArcGIS 9.2 (Bayer 2004). A 0.5 href smoothing factor and adaptive kernel estimation were used to create the 95% kernel home ranges.

Road Crossings

We conducted an analysis of moose road crossings in central Massachusetts. GPS positional datasets from 4 GPS-collared moose were examined to determine the timing of road crossings. Moose movement path layers were created from GPS location data using the Convert Locations to Path tool in the Hawth Tools program for ArcGIS 9.2 (Bayer 2004). Paths were examined to find where moose crossed roadways. At each crossing of public roadways the date and time of the position before and after the road crossing were recorded to determine the time interval of the crossing, the road name, and road class were also recorded. Road crossings were tabulated and put into 1 of 6 4-hour time intervals: 2:00-6:00, 6:00-10:00, 10:00-14:00, 14:00-18:00, 18:00-22:00, and 22:00-2:00. Moose crossings of forest roads were also counted but no timing of the crossings were recorded.

Habitat Use

We completed a preliminary analysis of habitat use by 4 GPS-collared moose in central Massachusetts. Positional data from GPS collars recovered from 2 bull and 2 cow moose were mapped on the most current, 2005 series, orthophotos from MassGIS. Additionally, Department of Environmental Protection (DEP) wetlands layer, a Massachusetts Forestry layer (Harvard Forest Reference), and a Past Harvests (Mass.

Department of Conservation and Recreation [DCR]) layer were mapped with the data. Each data point was given a 20 m diameter buffer to approximate the error in the datapoints, calculated from data derived from GPS collar performance tests (Mass. CRU unpublished data). Each data point was inspected to determine the habitat type it was found in.

We used 9 habitat categories: regenerating forest (forest growth from previously logged sites), deciduous (pure, mixed, and deciduous dominated stands), conifer (pure and conifer dominated stands), wetlands (shrub swamp, conifer wetland, deciduous wetland, mixed tree wetland, grassy fen wetland, deep water swamp, open water), streams (which were combined with the dominant habitat type they were found in), powerline right-of-way, open, development, and active logging.

Habitat use was calculated for each animal for the duration of the time it was collared. The data was also split seasonally into Fall (16 Aug - 30 Nov), Winter (1 Dec - 31 Mar), Spring (1 Apr - 31 May), and Summer (1 Jun - 15 Aug).

Movement Rates

We calculated seasonal daily movement rates for 4 moose (3 bulls and 1 cow) by 2 methods. In the first method we compiled all of the movements made by a moose during a season. We calculated the mean, median, and range of those values for each moose and season. We then took the seasonal GPS collar performance calculated from each of the deployed collars, which is the number of successful fixes divided by the total number of attempts for that season, and multiplied it by 10.67, which is the average number of fixes per day based on our 135 minute sampling interval. This number gave us the daily fix rate for that season for each animal. We then multiplied this daily fix rate by

the mean and median movement lengths for each animal in each season, which gave us the mean and median daily movement rates.

In the second method we used a random number generator to select 3 points in each season for each animal. We compiled all the distances moved by that animal for the day and the following day for that random point in time. These movements were summed to create a 2-day total distance moved. We then took the mean of the 3 trials for each animal for each season to get a 2-day seasonal movement rate. Finally, we then divided by 2 to get the daily seasonal movement rate for each animal.

Fate of Relocated Moose

We summarized the 6 month post capture survival data we have from the 45 moose captures (22 relocations and 23 free ranging) during and just before the initiation of this study. Each capture was examined and the length of moose survival following the capture was calculated. The fate of relocated animals was compared to those of free ranging moose.

RESULTS

Capture and Marking

Since 2006, we have collared 25 moose with GPS collars throughout central and western Massachusetts (Fig. 1). Of the 25 collared moose, 21 have resulted in either data sets with at least several hundred GPS locations or are currently collared, 3 moose died shortly after being relocated or rescued as problem moose, and 1 collar failed and the fate of that animal is unknown. Thirteen of the 25 moose were male and 12 female. The 25 moose include 14 free-ranging moose, 8 relocations of problem or rescued animals, and 3

recollars of moose previously collared with VHF radio collars. Eight moose have been recaptured and had their original collar replaced with a second GPS collar.

We are using G2000 series GPS collars from Advanced Telemetry Systems, Inc. (ATS, Isanti, MN) and TWG-3790 collars from Telonics, Inc. (Mesa, AZ). To date we have recovered 17 ATS GPS collars with complete data sets from 12 moose. These collars have given us datasets with between 890 and over 3,100 moose locations per collar. We can periodically download data from the Telonics collars, and have successfully downloaded 5,000-6,000 locations from 2 collars deployed in October 2007, which are still deployed. We have another 3 Telonics collars deployed, from which we can download approximately 500 locations per month.

Home Range

Home ranges for moose were calculated using both minimum convex polygon and 95% volume adaptive kernel estimators (Table 1). Five cows and 7 bulls were used in these calculations; 3 of the bulls had multiple years of data. Cow and bull moose had mean home ranges of 73.5 and 78.6 km², respectively, using MCP methods. Cow home ranges ranged between 41.6 and 103.4 km². Bull home ranges had a range of 34.1 to 124.3 km². Home range size decreased sharply with 95% volume adaptive kernel estimators. Female home ranges were between 23.8 and 53.68, with a mean of 37.74 km². Males ranged between 21.82 and 69.22, with a mean of 40.94 km².

Seasonal home ranges were also calculated using MCP methods. Mean seasonal home ranges for cows were 41.26, 24.32, 41.47, and 35.41 km², respectively for fall, winter, spring, and summer. For bulls mean seasonal home ranges were 52.17, 23.27, 30.20, and 30.33 km².

Road Crossings

Road crossing data were compiled by examining all road interactions by moose throughout the periods they were collared. We examined the datasets from 4 moose (2 bulls and 2 cows). The bulls were collared in Pelham and Royalston, and the cows were collared in the northeast portion of the Quabbin Reserve and in Barre Falls Wildlife Management Area (WMA). The bull in Pelham crossed 182 public roads, including 30 state highway (Route 202) crossings, and 230 forest roads in 11 months. The bull in Royalston crossed 203 public roads, including 65 crossings of state Route 68 and 115 forest roads, in 15 months. The north Quabbin cow crossed Routes 202 and 122 24 times out of 89 total public road crossings in 15 months. She also crossed 330 forest roads. The cow in the Barre-Rutland area crossed 62 public roads and 51 forest roads, with 21 crossing of Routes 56 and 68.

Compiling road crossings by time of day revealed increased road crossing at night. Moose almost universally had fewer road crossings during the daylight time periods of 6:00-10:00, 10:00-14:00, and 14:00-18:00 (Fig. 2).

Habitat Use

We performed preliminary habitat use analysis on 4 animals (2 bulls and 2 cows) in central Massachusetts. One bull used habitat almost entirely within the east side of the Quabbin Reserve, between Gates 39 and 45, while the other bull split its time between the west side of the Quabbin Reserve and areas of Pelham south of the Amherst-Pelham Road and north of Rte 9. These bulls are referred to as the Gate 40 Bull and the Cadwell Bull, respectively, according to their capture locations. One of the cows was captured inside Gate 26 of the Quabbin and spent the majority of her time between Gate 30 and

Gate 22. However, she also spent considerable time outside of the Quabbin, as far away as the center of the town of Wendell. That cow is referred to as the Gate 26 cow. A second cow, Barre Cow 2, was collared in Barre Falls WMA. She split her time between the WMA and large blocks of forest between state highways 68 and 56 in Rutland, spending more time outside the WMA than in.

We documented moose use of the 9 habitat categories for each of 4 seasons (Figs. 3-6) and for all seasons combined (Fig. 7). Regenerating forest was the dominant habitat type used by moose in all seasons, with the exception of wetlands use by the Barre Cow 2 during the summer (Fig. 4). For all 4 moose over all 4 seasons, regenerating forest encompassed 42-69% of habitat use. Males used regenerating forest to a greater degree than females (61% and 69% for the 2 males, 42% and 55% for the 2 females). If active logging sites are included in the use of regenerating forest by the Gate 26 cow, her overall use of regenerating forest increases to 64%. Use of regenerating forest was greatest for the 2 males during the summer, when it comprised 77% and 79% of habitat use.

Wetlands were not used as heavily by bulls as compared to cows, representing the 4th most heavily used habitat class for both bulls and approximately 5% of overall use for both animals. The Gate 26 cow also had a surprisingly low percentage of wetland use overall, despite wetlands representing 26% of her overall use in summer. Wetlands, however, represented nearly 25% of the Barre Falls cow's overall habitat use, being the most heavily used habitat type during summer and a close second to regenerating forest during fall.

Movement

Estimation of mean daily movements was similar for the 2 methods we used for spring, summer, and winter (about 1,560, 1,800, 1,224 m per day, respectively).

Estimation of mean daily movements was different for the 2 methods in the fall, with 1,950 and 1,325 m per day based on our first and second method, respectively. Overall, mean movement rates were the highest in the summer and fall, and lowest in the winter. Seasonal median daily movement rates were about half of the mean rates (690, 880, 725, and 550 m per day for spring, summer, fall, and winter, respectively). However, median rates did show the same pattern as mean rates, with the greatest daily movements occurring during the summer and fall, and the lowest during the winter.

Fate of Relocated Moose

We compared the 6 month post capture survival of relocated and free ranging moose captured during and just before this study. Of the 22 problem moose relocated or rescued in large animal response situations, 12 moose survived at least 6 months, 1 moose was relocated less than 2 months ago and is still living, 5 moose died within 6 months of release, the fate of 3 moose are unknown either because they were not collared or the collar failed, and 1 moose died due to complications during handling. Of the 5 moose that died after relocation all 5 died in less than 3 months, 4 of the 5 died after about 1 month. Of the 23 captures of free ranging moose we are only considering the 14 original captures and not the captures involving recollaring the same animals. All 14 of the free-ranging moose captured during this study survived at least 6 months.

DISCUSSION

Home range sizes were large and varied considerably when calculated using minimum convex polygons. Recalculation of home ranges using adaptive kernel estimators reduced the size of home ranges as well as their variability. Home range size has more meaning when calculated with adaptive kernel home ranges than MCP methods because it more accurately represents habitat or landscape use and the areas that are being used by the animals, rather than simply the area encompassed by all of the animal's movements. Minimum convex polygons can vastly overestimate areas being used by moose by incorporating large chunks of land or water that are not being used by the animal but fall between two areas that are being used. Because of this, the measures of home range should be interpreted differently based on the method used. The 73.5 and 78.6 km² mean home range sizes for females and males (based on MCP) should be interpreted as the entire area a moose moved during a year, while the 37.7 and 40.9 km² mean home ranges (based on kernel method) should represent the area the animal used to meet its resource needs. The larger areas represented by MCP home ranges should not be discounted because the moose may need to move through "blank" habitats to link the more important habitat patches, especially in highly fragmented landscapes or landscapes with patchy distribution of resources.

Male seasonal home range was greatest during the fall when males were moving within and outside of their usual home range in search of females. We have documented several instances where bulls made large movements outside of their home range, presumably in search of or following mates, only to return to their home range shortly after. These areas of travel are then not used for the rest of the year. In most cases bulls

and cows have almost complete overlap of their season home ranges, but in one instance a bull had a distinct fall season home range, separate from the remainder of the year.

Winter home sizes are typically smaller than the rest of the year. At this time of year habitat use is concentrated in small habitat patches of regenerating forest, conifer, or mixed forest. Movement rates are lower at this time of year with limited movement within patches punctuated by larger between patch movements. Movement and habitat use during the rest of the year (i.e., outside of winter) tends to encompass the home range of the moose, with more large movements throughout the home range and less time spent in any one patch before moving on.

Habitat use by moose in Massachusetts is dominated by the use of regenerating early seral stage forests. These habitats provide the abundant young woody shoots and stems favored by moose throughout the year and succulent leaves accessible to browsing during the growing season. The concentrated nature of regenerating vegetation growth that results from logging or other disturbances provides concentrated food sources that moose can browse on for long periods without having to move. This concentration of food allows moose to maximize their nutrient intake while minimizing energy expenditure. The food resources in most other forested habitats in Massachusetts do not provide such a concentration of food resources.

Wetland use by moose in Massachusetts is lower than expected. Wetland use makes up a small percentage of male habitat use. Use of wetlands appears to be greater by females, especially cows with calves. The Barre Cow had a calf in the spring of 2007 and she used wetland habitats significantly more than the other moose we evaluated.

Initial inspections of other datasets from cows with calves, indicates similar levels of wetland use and supports this theory.

Use of deciduous and conifer sites varied among the 4 animals, both overall and seasonally, and was not as concentrated as the use of either regenerating forests or wetlands. This more dispersed use was likely due to the lower concentration of resources in these habitats. We know from snow tracking moose that they will often move through these habitats, browsing selectively on important food plants, but doing so as they move through on the way to another more concentrated patch of food.

Use of conifers especially during the warm summer months and during warm periods in the spring and fall, when it was hypothesized that conifer cover would provide thermal relief for the moose, was not seen as much as expected. A more fined-grained inspection of the data may be required to determine its use, especially in instances where clumps of conifer are found within forest harvest units or other habitat types that moose are using. A more detailed comparison of habitat use with respect to temperature must also be performed. We have deployed clusters of ibutton temperature dataloggers (Embedded Data Systems, LLC, Lawrenceburg, KY) in hemlock, deciduous, and regenerating forest stands to detect any differences in temperature that these different forest types may exhibit and how that may influence moose habitat to reduce thermal stress.

Based on our unpublished data from GPS collars performance tests, we also believe that the use of conifers could be under-represented in the moose collar data sets. The habitat use described in this report has not yet been weighted to reflect the biases caused by unequal observation rates by GPS collars in different types of forest habitat.

As expected our analysis of moose road crossings showed that moose are more likely to cross roads from dusk to dawn than during the day. We have not yet performed a detailed analysis of the locations of moose road crossings, but initial review of the data show that those crossings are not random and tend to be clustered and often associated with regenerating forest patches or wetlands close to the roadway. A further analysis of the data will be performed to determine if there are any habitat, landscape, or roadway features that influence moose road interactions. In conjunction with this analysis we are hoping to perform a similar analysis of MDFW moose vehicle collision records.

The comparison survival following capture of relocated and free-ranging moose showed that moose from problem situations are more likely to die after capture than free-ranging moose. However, we believe that this has as much to do with the animal's health prior to capture as it does with the capture itself. Four of the 5 moose that died within 6 months of capture showed signs of poor physical condition and in one instance the moose was likely involved in a moose vehicle collision before relocation, which may have made their deaths inevitable. Since 2004 twice as many moose have lived at least 2 years following relocation as died shortly after release. As a result, we believe that relocation of moose in problem animal situations continues to be a viable option to euthanasia when the immediate risk to the public can be minimized.

RESEARCH ACTIVITY FOR 2009

The fall of 2009 will represent our final capture season. We will attempt to capture as many animals as possible west of the Connecticut River during the period around the rut in September and October, when during the past 3 seasons we have been able to capture 3 or 4 moose each year. Additionally, we will continue to take advantage

of as many problem moose relocations as we can over the next 9 months; hopefully this will result in another 3 to 4 collars deployed, and push our overall sample size close to 30 different individuals. By concentrating west of the Connecticut River, we hope to have a balanced sample in the western and central portions of the state. We currently have 12 moose collared with GPS collars and will continue to monitor those animals over the next year. We will periodically download data from collars with remote download capabilities and recover collars that have dropped off animals. Over the next year we hope to make significant progress with the analysis of existing data sets and writing papers.

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Table 1. Home range size (in km² [SE, *n*]) for female and male moose fitted with GPS collars in central Massachusetts, based on minimum convex polygon (MCP) and adaptive kernel approaches.

	MCP					Kernel
	Spring	Summer	Fall	Winter	Annual	Annual
Female	41.5 (10.2, 4)	35.4 (11.9, 6)	41.3 (4.2, 5)	24.3 (8.9, 4)	73.5 (10.5, 5)	37.7 (5.5, 5)
Male	30.2 (4.9, 10)	30.3 (7.1, 7)	52.2 (8.1, 11)	23.3 (5.4, 8)	78.6 (9.5, 10)	40.9 (5.0, 10)

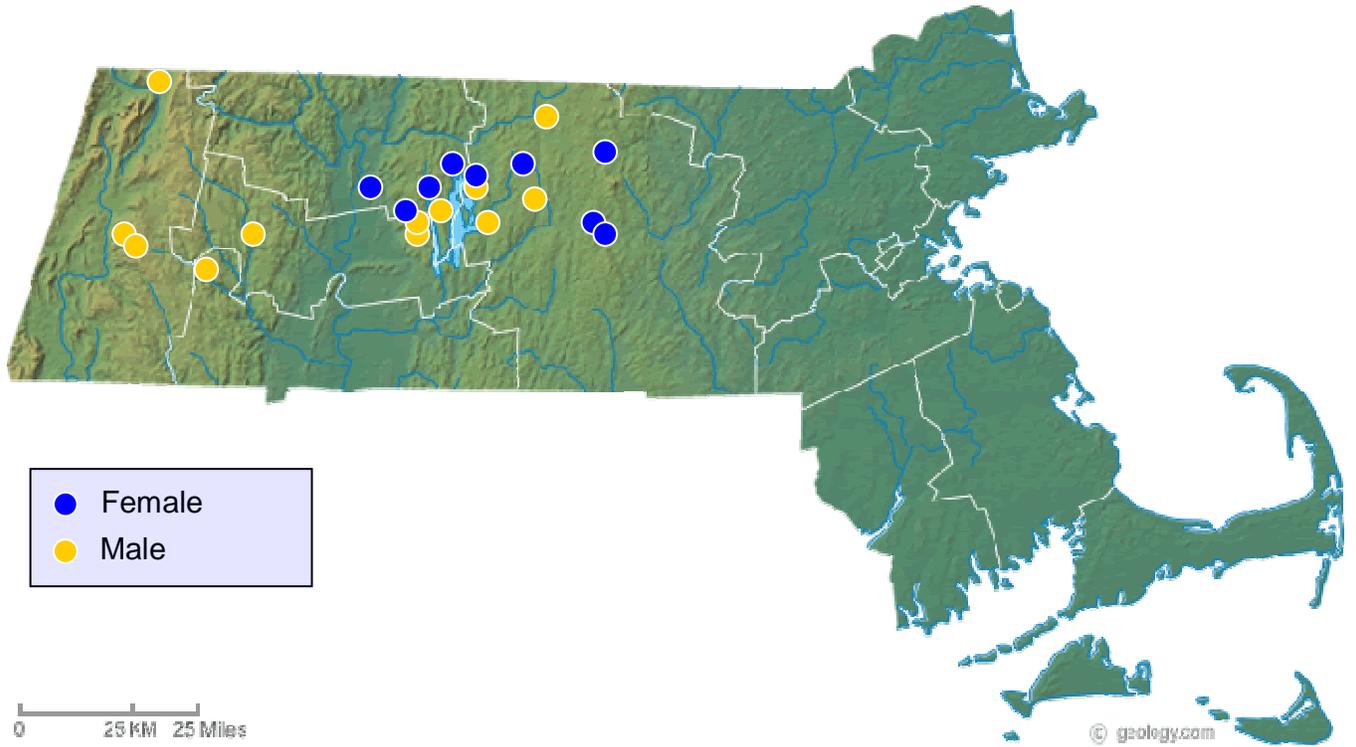


Fig 1. Distribution of GPS collared moose in Massachusetts.

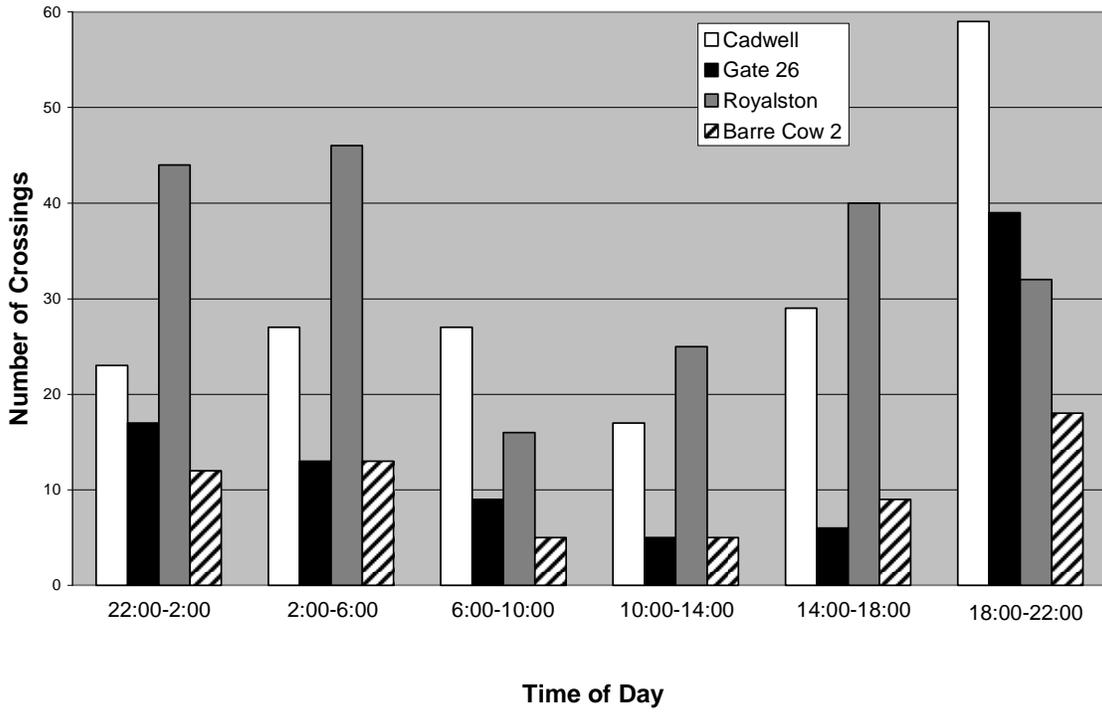


Fig 2. Timing of road crossings by four GPS collared moose in central Massachusetts

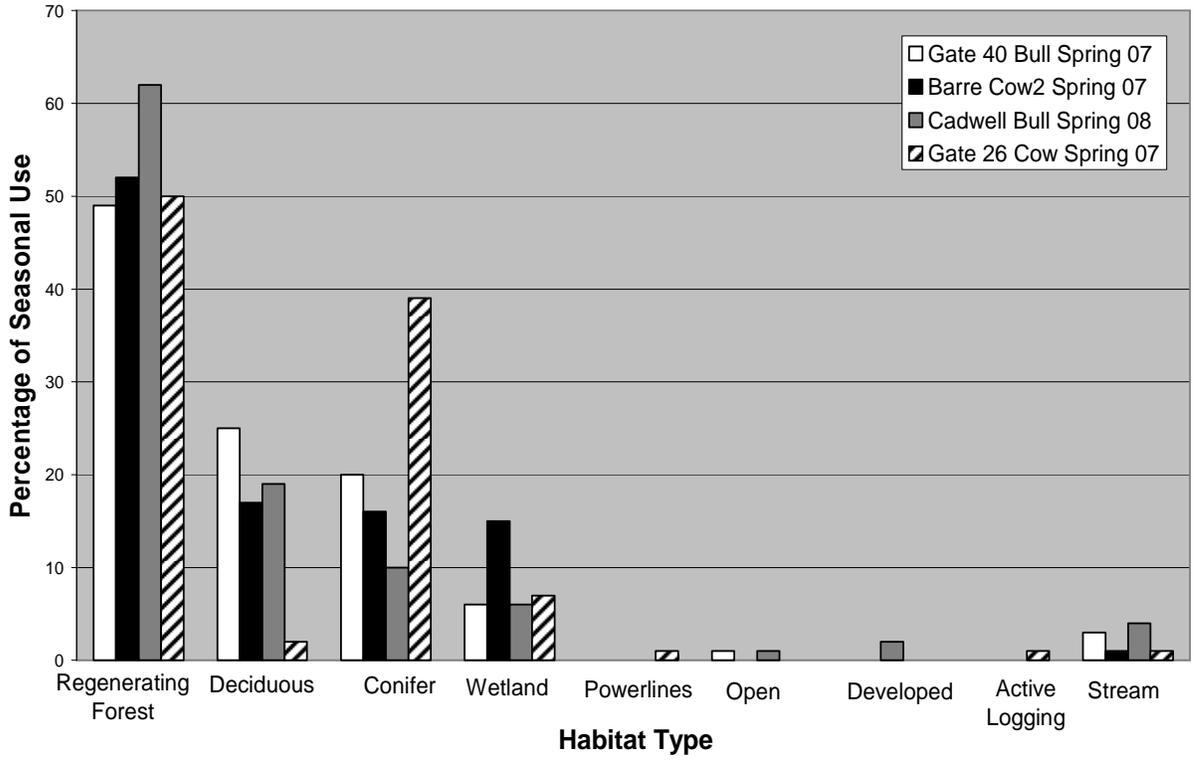


Fig 3. Spring habitat use by four GPS collared moose in central Massachusetts.

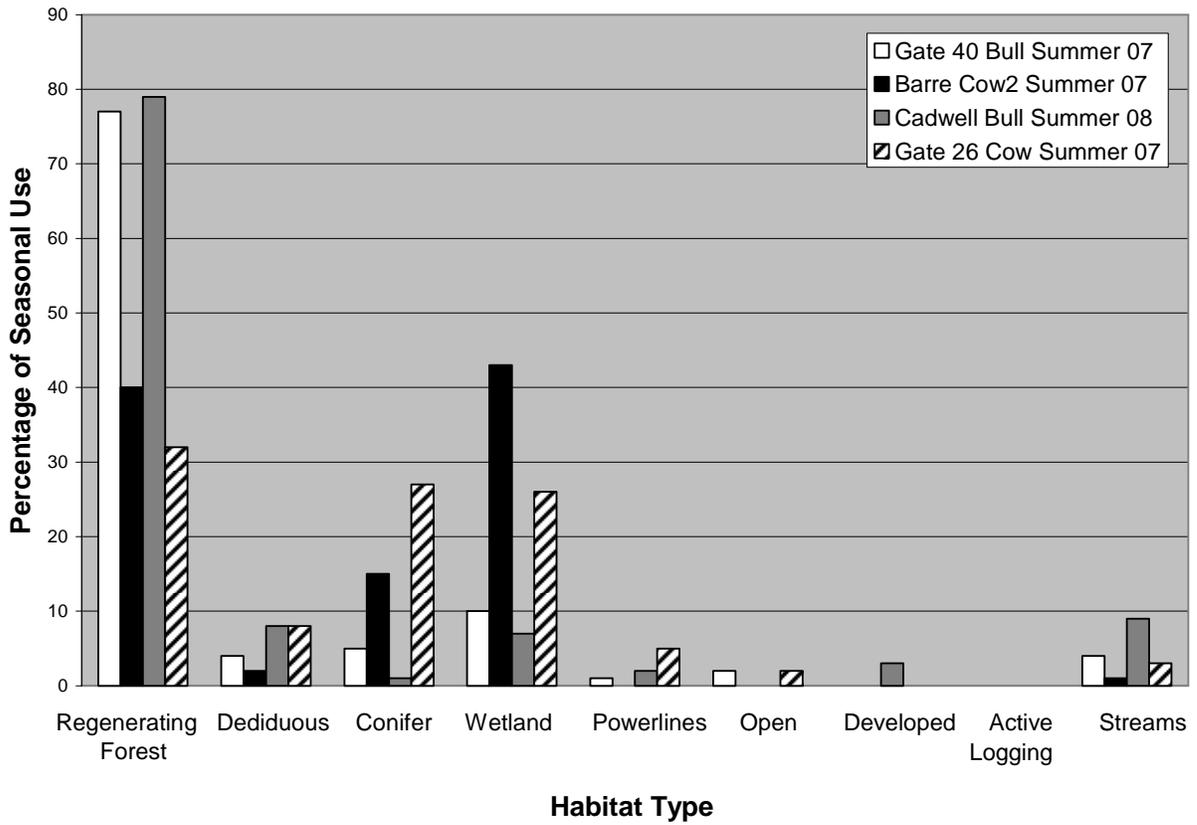


Fig 4. Summer habitat use by four GPS collared moose in central Massachusetts.

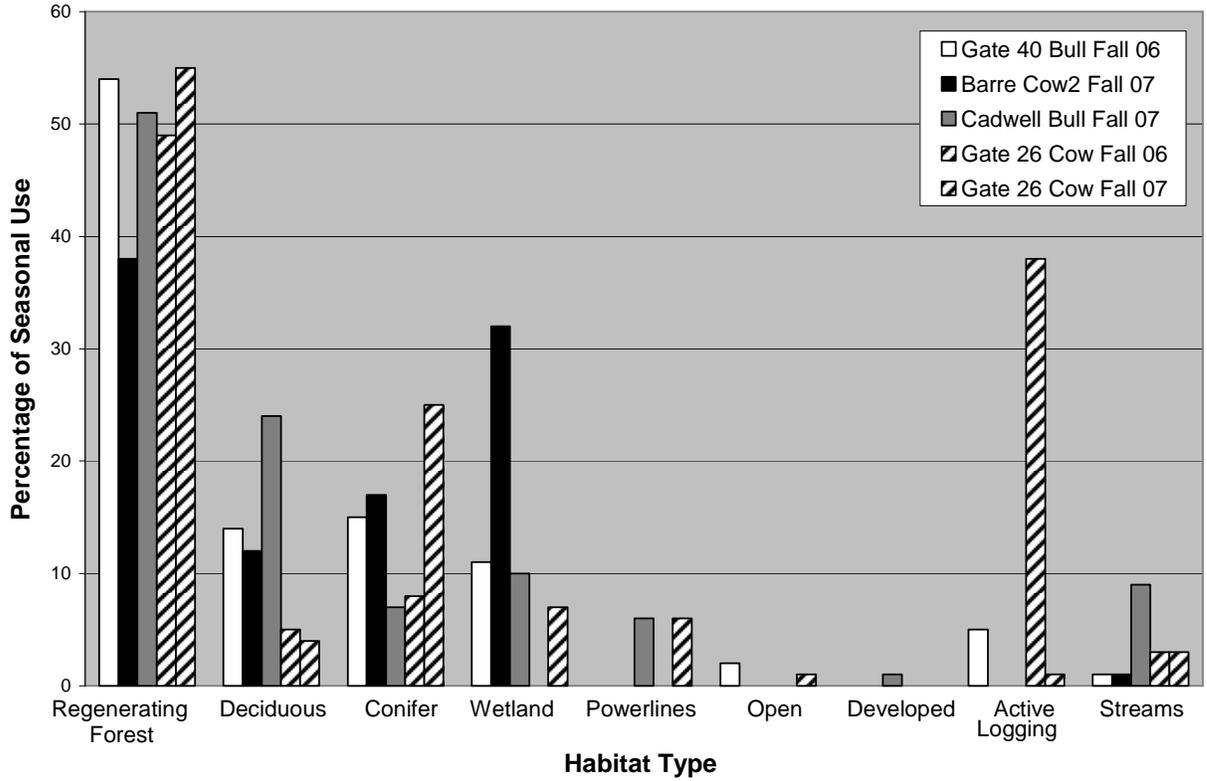


Fig 5. Fall habitat use by four GPS collared moose in central Massachusetts.

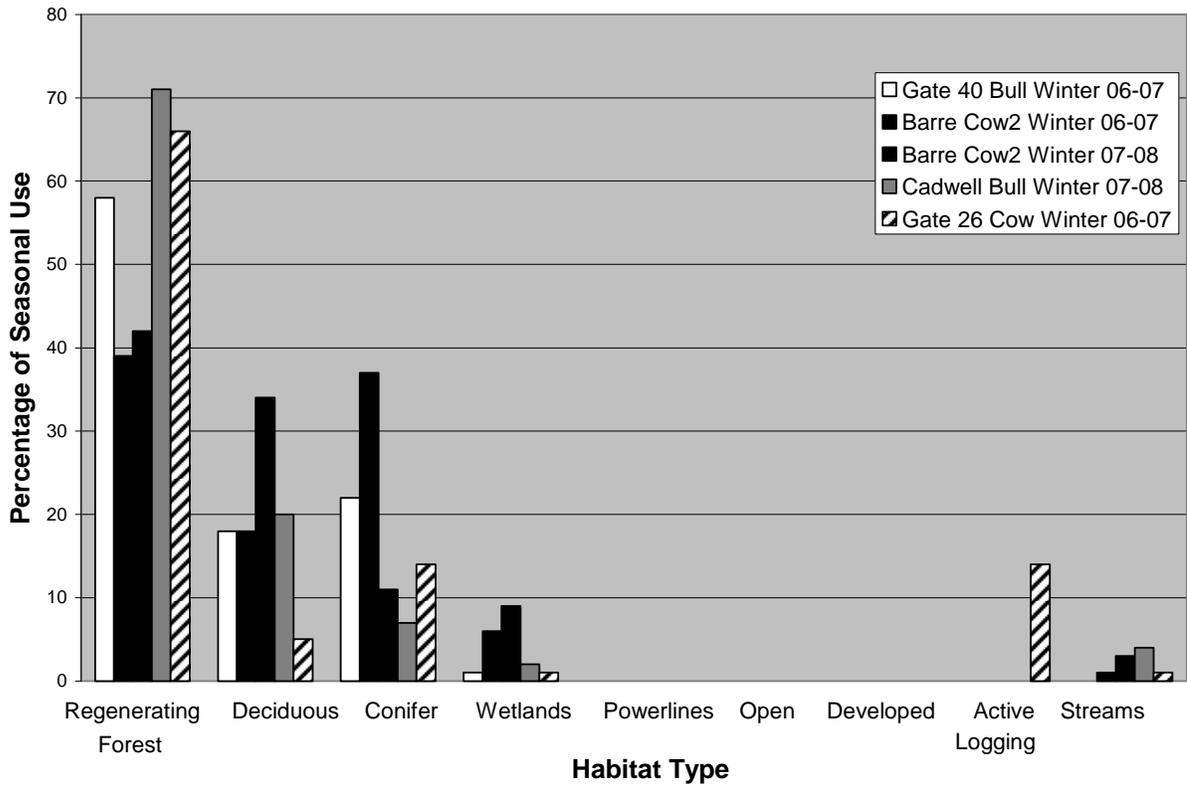


Fig 6. Winter habitat use by four GPS collared moose in central Massachusetts.

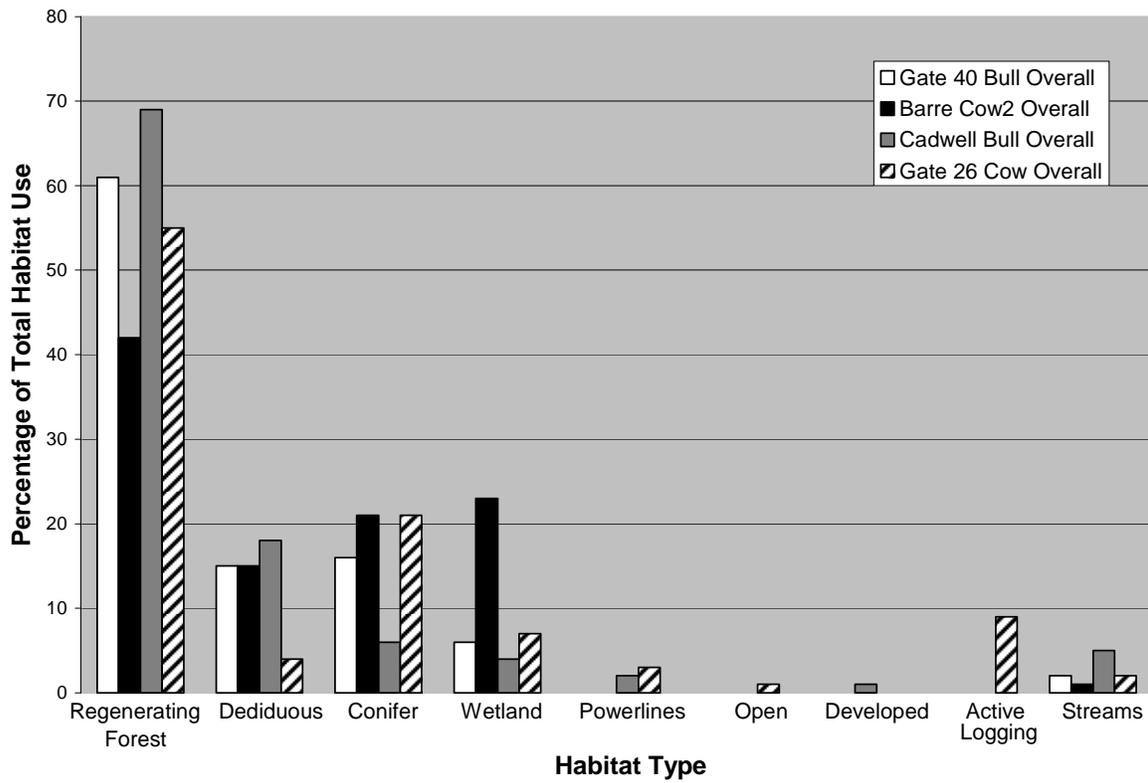


Fig 7. Overall habitat use by four GPS collared moose in central Massachusetts.