Estimating Deer and Moose Densities on DCR Division of Water Supply Protection Lands using Pellet-Group Counts

2016 Results[1]

INTRODUCTION

Estimating free-ranging deer and moose populations in a forested landscape can be a challenging task. Since the Quabbin white-tailed deer hunts began in 1991, the Division of Water Supply Protection (Division) has relied almost exclusively on annual deer harvest data to track changes in Quabbin's deer population, age structure, etc. The Division has investigated (and in some cases used) other methods to independently assess the Quabbin deer herd, including aerial infra-red surveys, distance sampling, mark-recapture techniques, and trail cameras. In 2007, the Division hired a contractor to survey deer and moose populations on Quabbin Reservation using aerial infra-red technology. Unfortunately, the results of the study were inconclusive; the contractor didn't observe enough deer or moose to calculate an estimate. In 2010, the Division made another attempt to use aerial infra-red technology and collaborated with a researcher from Mt. Holyoke College. This attempt also provided no useable information. The Division has successfully used distance sampling to estimate deer densities in Quabbin Park, but this technique becomes impractical at deer densities less than 20/mi^2 and could not be used over most of the Reservation. Trail cameras have been used in small landscapes with success, but they are cost prohibitive (Curtis et al. 2009). Based on camera densities in a published study, the Division would need at least 150 cameras to sample an area the size of Prescott Peninsula (Curtis et al. 2009). Finally, mark-recapture studies can provide an unbiased estimate of deer densities but would require the Division to capture and mark a number of deer prior to the Quabbin hunts.

While infra-red surveys proved unsuccessful in estimating moose populations, the Division has successfully used Quabbin hunter sighting data to estimate moose numbers on the Reservation. This technique provides a reasonable estimate of moose but is dependent on hunter accuracy and interpretation of the data. In addition, for several years, Division staff sampled fixed plots at the Ware River to record moose sign. While this technique did not provide a specific estimate of moose density, it did allow for generalizations about moose population trends in the Ware River watershed.

Recent anecdotal observations (browsing levels) in the Wachusett watershed suggest that deer densities may be higher than desired, specifically on Division lands that are not hunted. No formal assessment of deer densities have ever been made in the Wachusett watershed. White-tailed deer hunting has always been allowed on Division lands in the Ware River watershed. However, no attempts have ever been made to assess deer densities using harvest data or through an independent method.

[1]DAN CLARK, *Massachusetts Department of Conservation and Recreation, Division of Water Supply Protection, Natural Resources Section, West Boylston, MA 01583*

Counting deer or moose droppings instead of individuals has several distinct advantages. First, droppings are easy to see, don't move, and can be counted over a longer period of time. In addition, counting droppings is relatively straight forward and can be done with a minimal amount of equipment or personnel. Further, a recently published paper has provided a solid framework for conducting this type of survey over large forested areas (DeCalesta 2013).

METHODS

Sampling protocol

Division properties were divided into 12 study sites based on current hunting zones or other delineations. In the Quabbin watershed, 6 areas were identified: Pelham, Prescott, New Salem, Petersham, Hardwick, and Quabbin Park. All division lands in the Ware River and Sudbury watersheds were study sites. In the Wachusett watershed, 4 areas were identified. Two areas allow hunting: Poutwater and Justice Brook, and two do not allow hunting: French Hill and Boylston. During the 2015 pilot study, 3 of these areas were chosen to be sampled: Pelham, Quabbin Park, and Ware River. In 2016, the Petersham, Prescott, Sudbury and all four sites in the Wachusett watershed were sampled. At each site, a grid of points 1,610 m (1 mile) apart was laid out in a north-south and east-west direction. Depending on the size of each study area, 3-9 points were randomly selected. At each selected point, a second grid was constructed comprised of 5 transects 1,610 m (1 mile) long and spaced 300 m (1000 feet) apart. Each originally selected point formed the mid-point of the middle transect. All points and lines were generated in ArcGIS and transferred to hand-held GPS units that were used for navigation. In some cases, the total 1,610 m line could not be created because the line left Division property, entered the reservoir, etc. All transects were laid out in true north/south orientation (Figure 1).

In 2015, most transects were walked by at least 2 observers. The lead observer used a GPS and compass to identify the start and end of each transect and walk a straight line. The lead observer paced out 30.5 m (100 feet) intervals and established a plot center by placing a wire flag at their feet. The second observer followed the lead person and counted pellet groups (both deer and moose) within 1.2 m (4 feet) radius plots centered on the wire flag. Pellet groups were tallied if there were ≥10 pellets in a group and at least half of the pellets in a group were within the plot boundary. Second observers carried a 1.2 m (4 foot) pole to identify the edges of a plot. Approximately 52 plots/transect were surveyed. However, observers kept an accurate record of how many plots per transect were actually sampled. In 2016, many transects were walked by a single observer. The protocol was the same, but this technique was more efficient.

Calculating density from pellet-group counts

Unadjusted deer and moose densities (#/km^2) were calculated using the following formula:

Deer or Moose/km^2 = $\sum$number of pellet groups counted/(pellet-group deposit rate x deposition period x $\sum$ plot area in m^2/1,000,000 m^2)

To convert this estimate into deer or moose/mi^2, the estimate was divided by 0.386.

Based staff observations, a leaf-off date of 11 November, 2015 was used. The deposition period was determined by calculating the number of days between leaf-off and the survey date. The sum of the plot area was the area of an individual plot (4.52 m^2) multiplied by the number of plots.

The pellet-group deposit rate can be the most challenging variable to determine and can influence the final density estimate. A range of defecation rates have been reported on both captive and free-ranging white-tailed deer and moose (Table 1, Table 2). Some studies have suggested picking a single rate (i.e., 25 for deer), but unless there is local knowledge of the herd, this can lead to an over or under estimate of density. An alternative to picking a single defecation rate is to use an average rate. We averaged the reported defecation rates for moose and deer into a single value (Table 1, Table 2). We then calculated three unadjusted density estimates using three defecation rates: 1. the average defecation rate 2. one standard deviation above the average and 3. one standard deviation below the calculated average. An overall unadjusted density estimate was calculated by averaging the density estimate obtained for each of the 3 defecation rates (average rate + 1 standard deviation above + 1 standard deviation below).

Table 1. Reported defecation rates for white-tailed deer from different studies. M: Males, F: Females; Defecation rate is pellet-groups/individual/day.

Defecation Rate	Study Site	Environment	No. deer/sex	Reference
34.0	USA	Free Ranging	7F	Rogers, 1987
26.9	USA	Captivity	1M, 3F	Sawyer et al. 1990
19.6	USA	Captivity	4F	Rollins et al., 1984
13.6	USA	Semi-captive	?	McCullough, 1982
12.0	USA	Captivity	18M, 1F	Eberhardt and Van Etten, 1956
13.2	USA	Captivity	?	Van Etten, 1959
Avg. **19.8**				
Std. Dev. **8.9**				

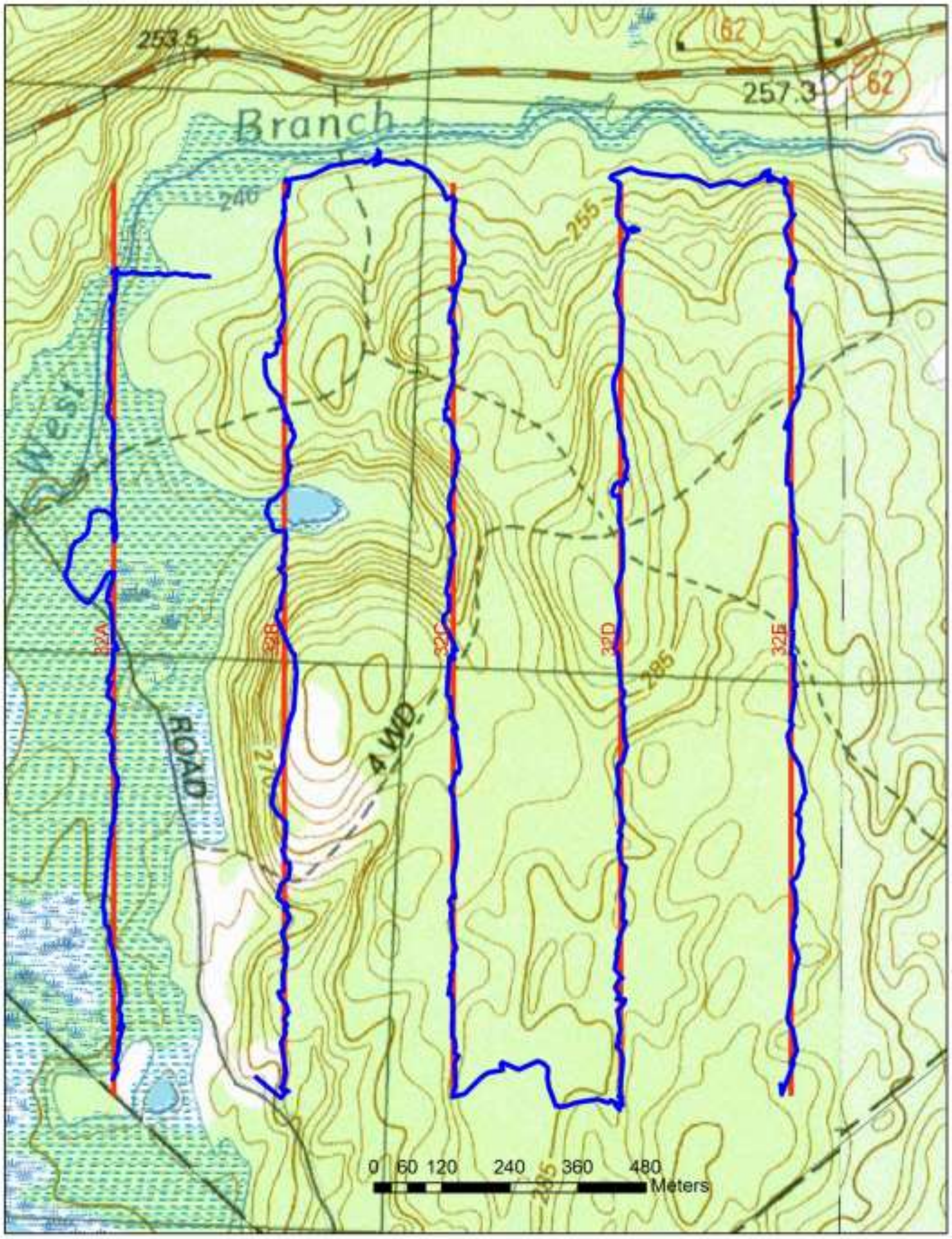
Table 2. Reported defecation rates for moose from different studies. Defecation rate is pellet-groups/individual/day.

Defecation Rate	Study Site	Season	Reference
18.6	Norway	Winter	Andersen et al. 1992
17.6	USA	Winter	Franzmann & Ameson, 1976
16.7	USA	Winter	Oldemeyer & Franzmann, 1981
14.0	Soviet Union	Winter	Baskin & Lebedeva, 1987
13.0	Canada	?	Edwards 1963
13.0	Sweden	Winter	Lavsund 1975
12.7	Canada	Winter	Joyal & Ricard, 1986
11.2	USA	Summer	Miquelle, 1983
10.9	Canada	Summer	Miquelle, 1983
Avg. **14.2**			
Std. Dev. **2.8**			

However, the unadjusted density estimate doesn't account for deer or moose that were killed or died during the period after leaf-off but before the transects were completed. The unadjusted estimates represent average overwinter densities. To calculate spring densities, the number of pellet groups produced by deer and moose that died before spring surveys was subtracted from an estimate of all pellet groups (across the study area, not just the ones counted) deposited by deer and moose that died and deer and moose that survived until spring. For this estimate, average deposit rates for deer and moose of 19.8 and 14 per animal per day, respectively were used. If adjusted density estimates were ≤0.05% of the unadjusted estimate, then the unadjusted estimate was used.

Confidence intervals (95%) were calculated for the Prescott, Petersham, Boylston, Poutwater, and Sudbury study sites. At least five replicate samples were drawn from each study site by assigning each transect within each grid a number from 1 to 5. Replicate one consisted of all the transects assigned number one and so on. Mean deer and moose density estimates, standard deviations, and confidence intervals were calculated from the 5 replicates. No estimates of precision were calculated for the French Hill or Justice Brook study sites.

Figure 1. A sampling grid in the Ware River showing the 5 north-south transects (in red) and the survey route walked (in blue).



RESULTS

Transects were walked between 4 February and 15 April, 2016. Eleven individuals participated in the study and collectively walked over 187 km (Table 3). Deer pellets were counted in each study area, while moose pellets were only seen in Prescott, Petersham, Poutwater, and Justice Brook. Very few dead deer (n=1) were encountered on transects.

Table3. Survey effort and number of pellet-groups seen in each study area, 2015-2016.

Year	Watershed	Study Site	Size of Study Site (km^2)	# Transects	# km walked	# Plots sampled	# Pellet Groups Deer	Moose
2016	Quabbin	Prescott[2]	49.0	42	67.8	2181	47	61
		Petersham[2]	28.9	31	46.7	1500	116	30
2016	Wachusett	French Hill[1]	4.8	9	9.5	304	61	0
		Boylston[1]	13.1	28	21.5	678	74	0
		Poutwater[2]	6.9	20	14.5	454	11	1
		Justice Brook[2]	4.3	8	10.2	326	7	5
2016	Sudbury	Sudbury[1]	15.6	24	17.5	549	97	0
2015	Quabbin	Pelham[2]	37.8	34	63.9	1659	112	50
		Park[1]	11.8	15	19.6	572	95	0
	Ware River	Ware River[2]	94.6	44	86.9	2239	174	64

[1] Public hunting not allowed; [2] Public hunting allowed

Deer Densities:

Unadjusted deer densities were calculated averaging the three deposition rates (average from Table 1 ± one standard deviation) and ranged from a low of 3.7 deer/mi^2 in Prescott to a high of 81.8 deer/mi^2 on French Hill in Wachusett (Table 4). Deer densities were much lower in areas that have been hunted historically (Poutwater, Justice Brook) or have been hunted for many years (Prescott, Petersham) than those areas where public hunting is not allowed. Adjusted deer densities were calculated for Prescott and Petersham to account for deer harvested during the annual Quabbin controlled deer hunt. However, adjusted deer density estimates were almost identical to unadjusted densities, so unadjusted densities are presented. Since no accurate estimate of overwinter or harvest mortality existed for the other study sites, no estimate of adjusted density was calculated.

Table 4. Unadjusted deer densities expressed as # deer/mi^2 (km^2) and 95% Confidence Intervals.

Year	Watershed	Study Site	Density estimate (km^2)	95% Confidence Interval (km^2)
2016	Quabbin			
		Prescott	3.7 (1.4)	2.2 (0.8) – 5.2 (2.0)
		Petersham	20.7 (8.0)	15.5 (6.0) – 25.9 (10.0)
2016	Wachusett			
		French Hill	81.8 (31.6)	N/A
		Boylston	31.8 (12.3)	24.6 (9.5) – 39.1 (15.1)
		Poutwater	6.6 (2.5)	3.5 (1.4) – 9.6 (3.7)
		Justice Brook	8.8 (3.4)	N/A
2016	Sudbury			
		Sudbury	42.5 (16.4)	32.0 (12.4) – 53.1 (20.5)
2015	Quabbin			
		Pelham	13.7 (5.3)	11.1 (4.3) – 16.3 (6.3)
		Park	35.6 (13.7)	N/A
2015	Ware River			
		Ware River	13.1 (5.0)	10.4 (4.0) – 15.8 (6.1)

Moose Densities:

Moose pellet groups were seen in Prescott, Petersham, Poutwater and Justice Brook study sites. However, moose density estimates were only calculated for Prescott, Petersham, and Justice Brook; only one pile of moose droppings was seen in the Poutwater site. Moose densities were similar across study sites and ranged from around 7-10 moose/mi^2 (Table 5). Moose densities in the Prescott study site were estimated to be higher than white-tailed deer.

Table 5. Unadjusted moose densities expressed as # moose/mi^2 (km^2) and 95% Confidence Intervals.

Year	Watershed	Study Site	Density estimate (km^2)	95% Confidence Interval (km^2)
2016	Quabbin	Prescott	9.7 (3.8)	8.3 (3.2) – 11.2 (4.3)
		Petersham	6.7 (2.6)	5.4 (2.1) – 8.0 (3.1)
2016	Wachusett			
		Justice Brook	7.7 (3.0)	N/A
2015	Quabbin			
		Pelham	7.6 (3.0)	6.3 (2.4) – 9.0 (3.5)
2015	Ware River			
		Ware River	6.7 (2.6)	5.3 (2.0) – 8.1 (3.1)

Pellet-group Distribution

Deer and moose populations are not randomly distributed across the landscape, and this is reflected in the survey results. Many transects contained no pellet groups, while others contained multiple piles of pellets both inside and outside plots. Figures 2-8 show the distribution of pellet groups along the 2016 transects for each study site.

Figure 2. Distribution of pellet-groups on Prescott Peninsula

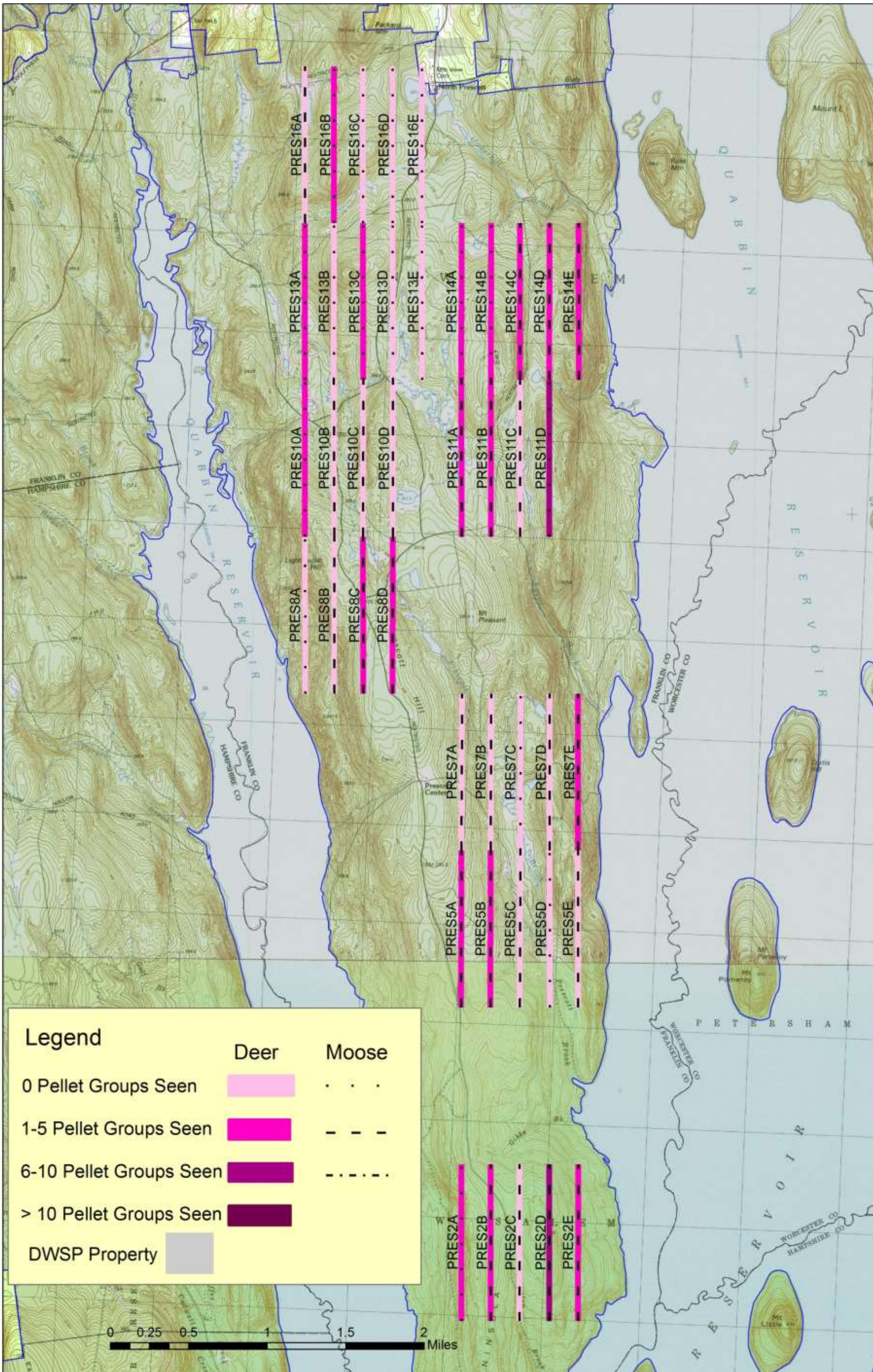


Figure 3. Distribution of pellet-groups on Petersham study site.

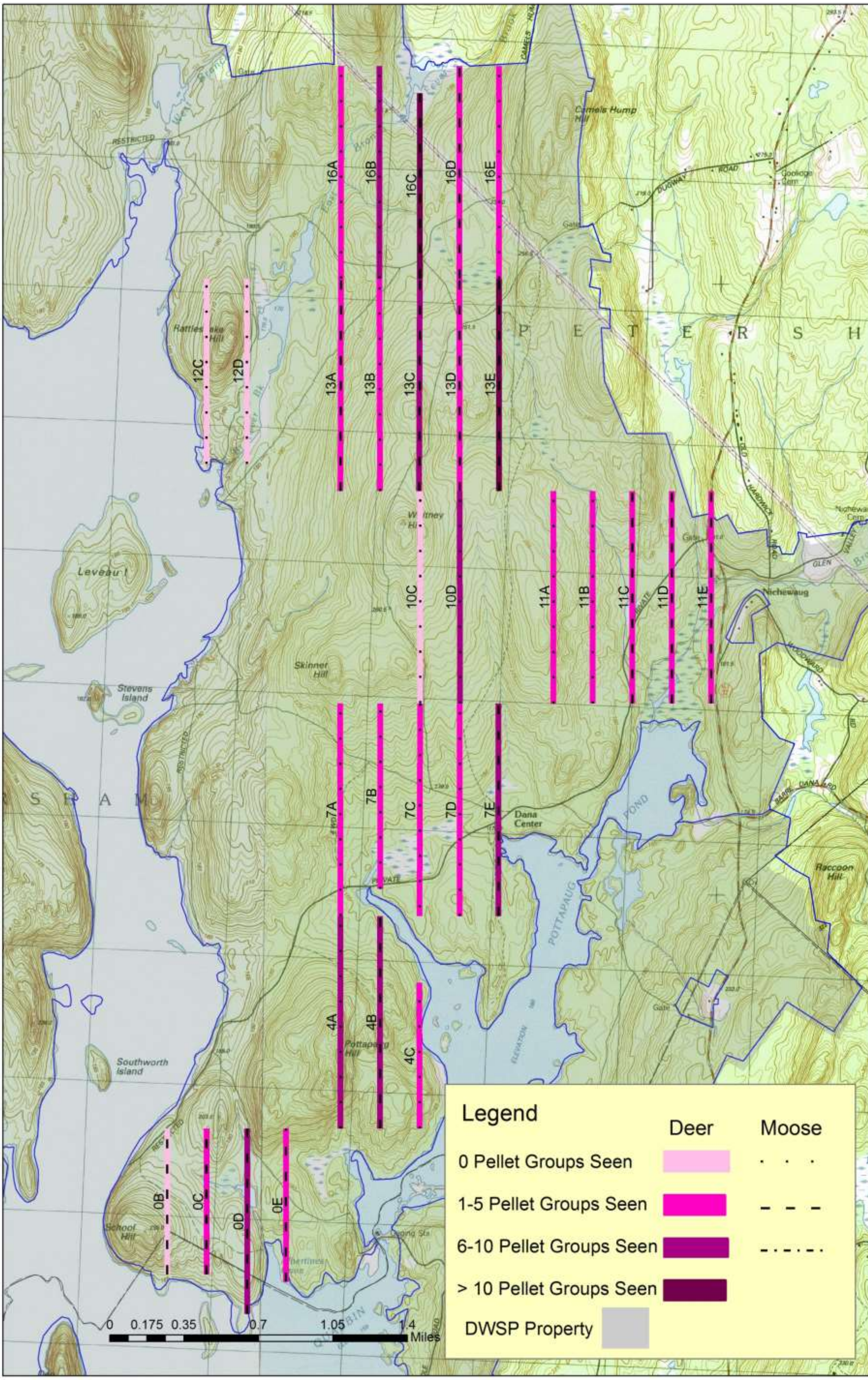


Figure 4. Distribution of pellet-groups on Poutwater study site.

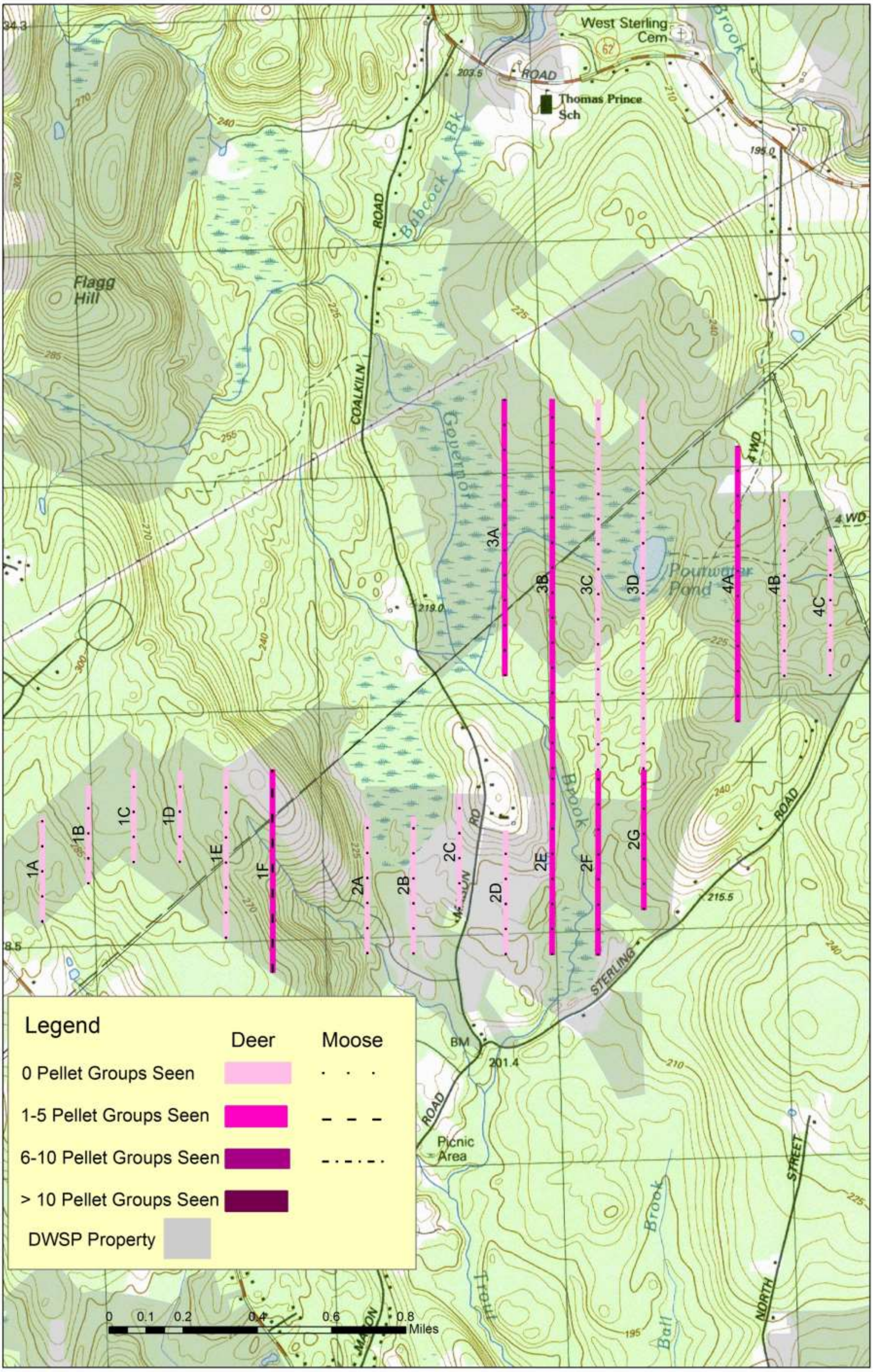


Figure 5. Distribution of pellet-groups on Justice Brook study site.

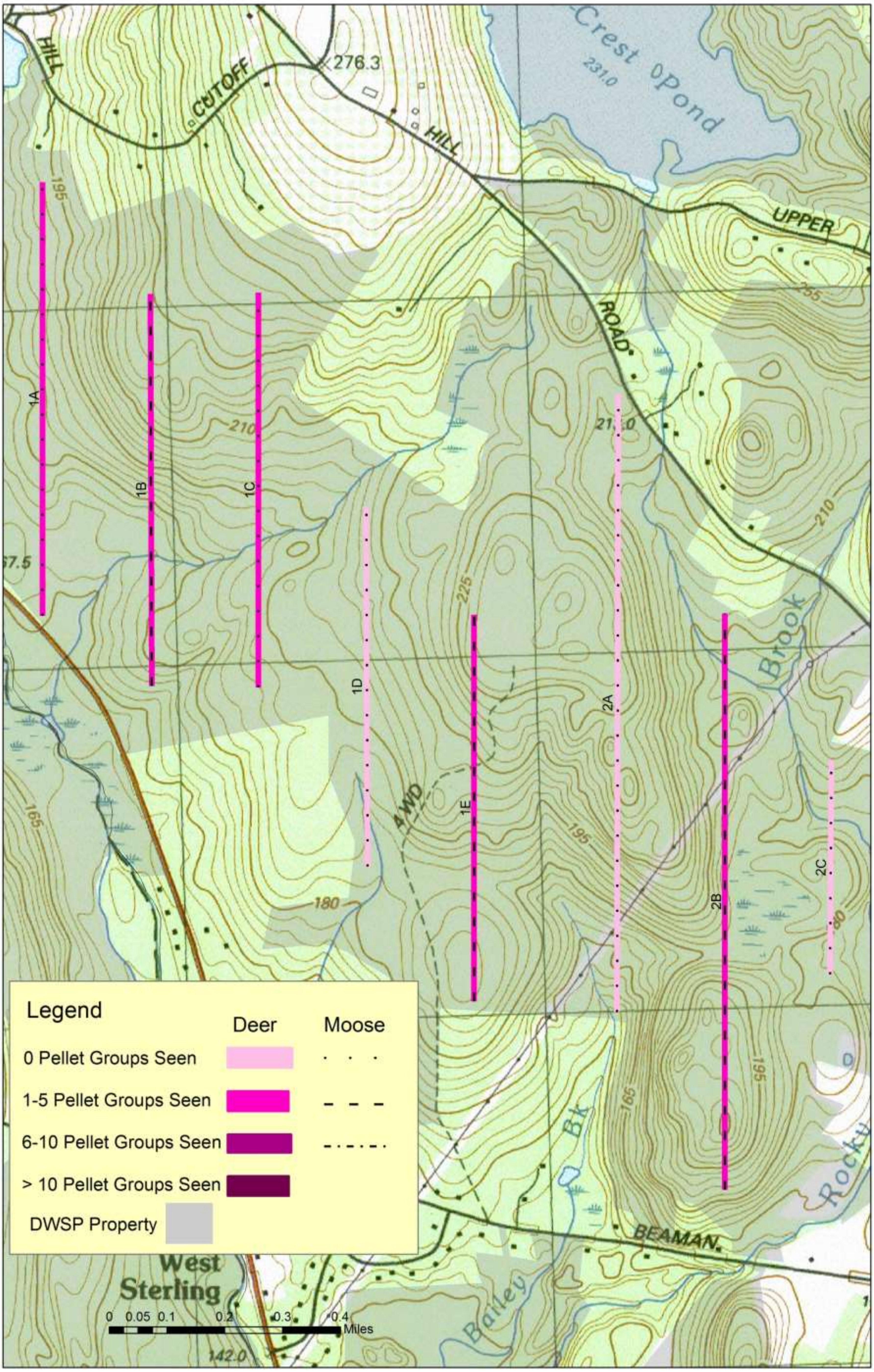


Figure 6. Distribution of pellet-groups on French hill study site.

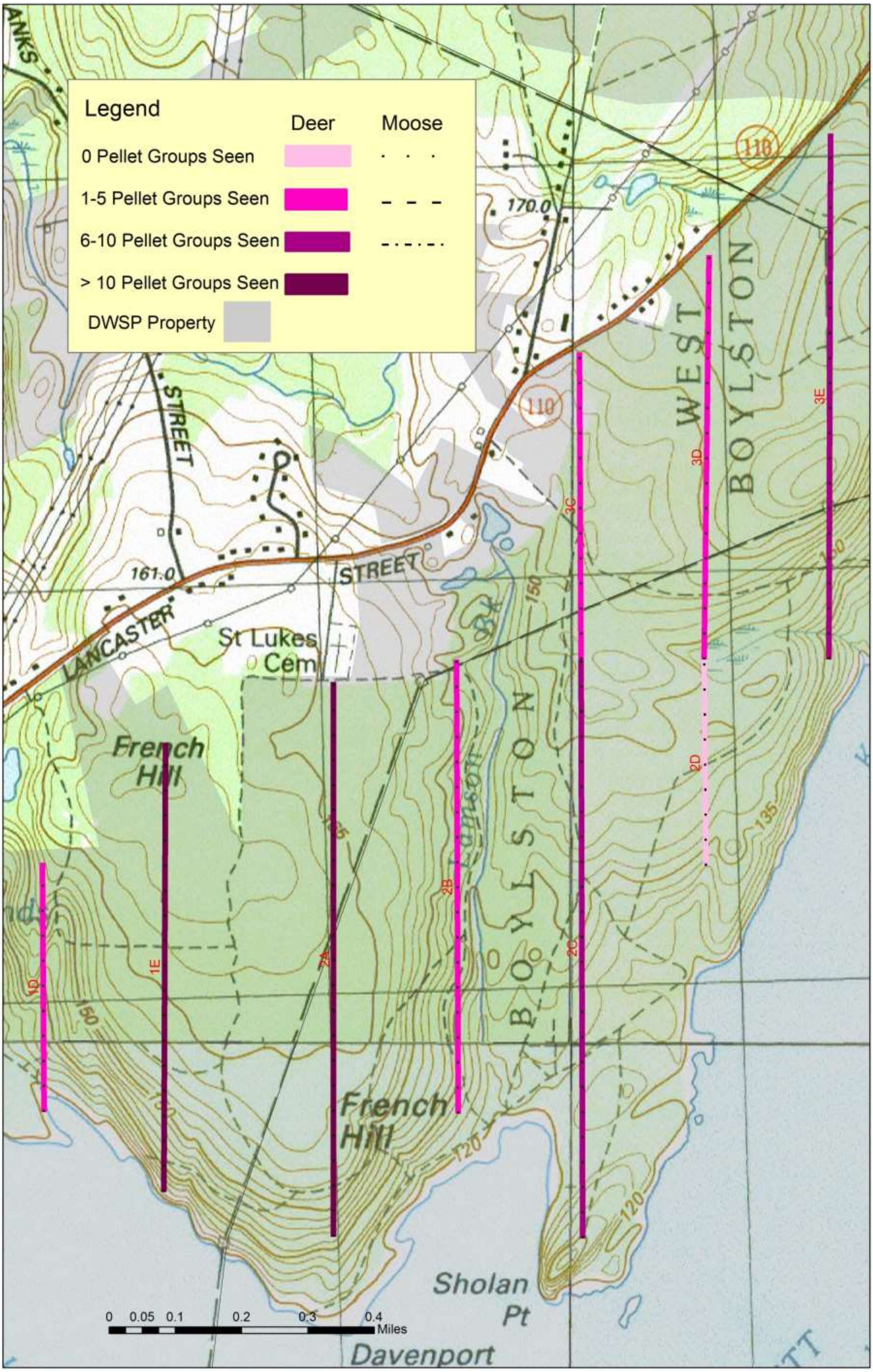


Figure 7. Distribution of pellet-groups on Boylston study site.

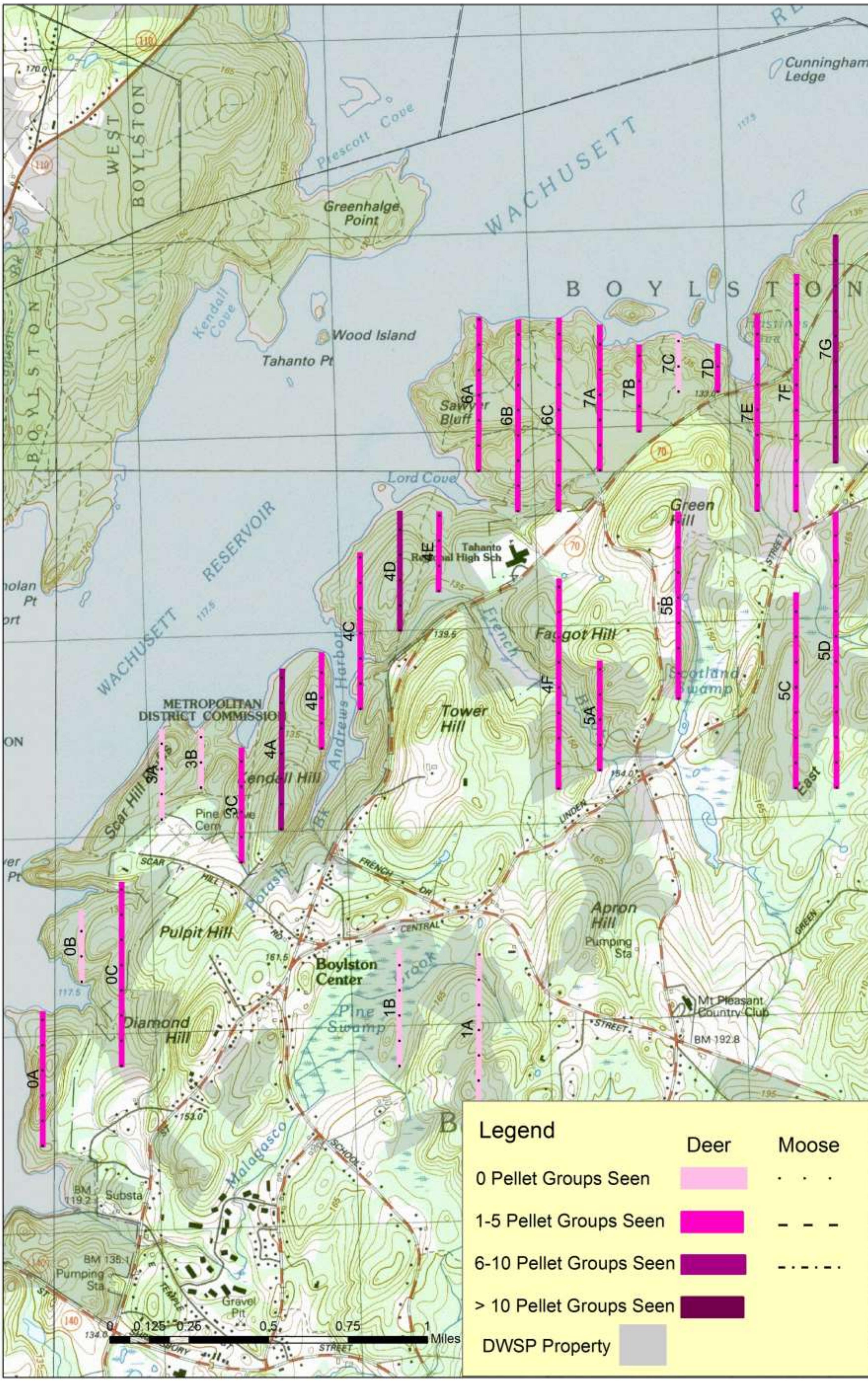
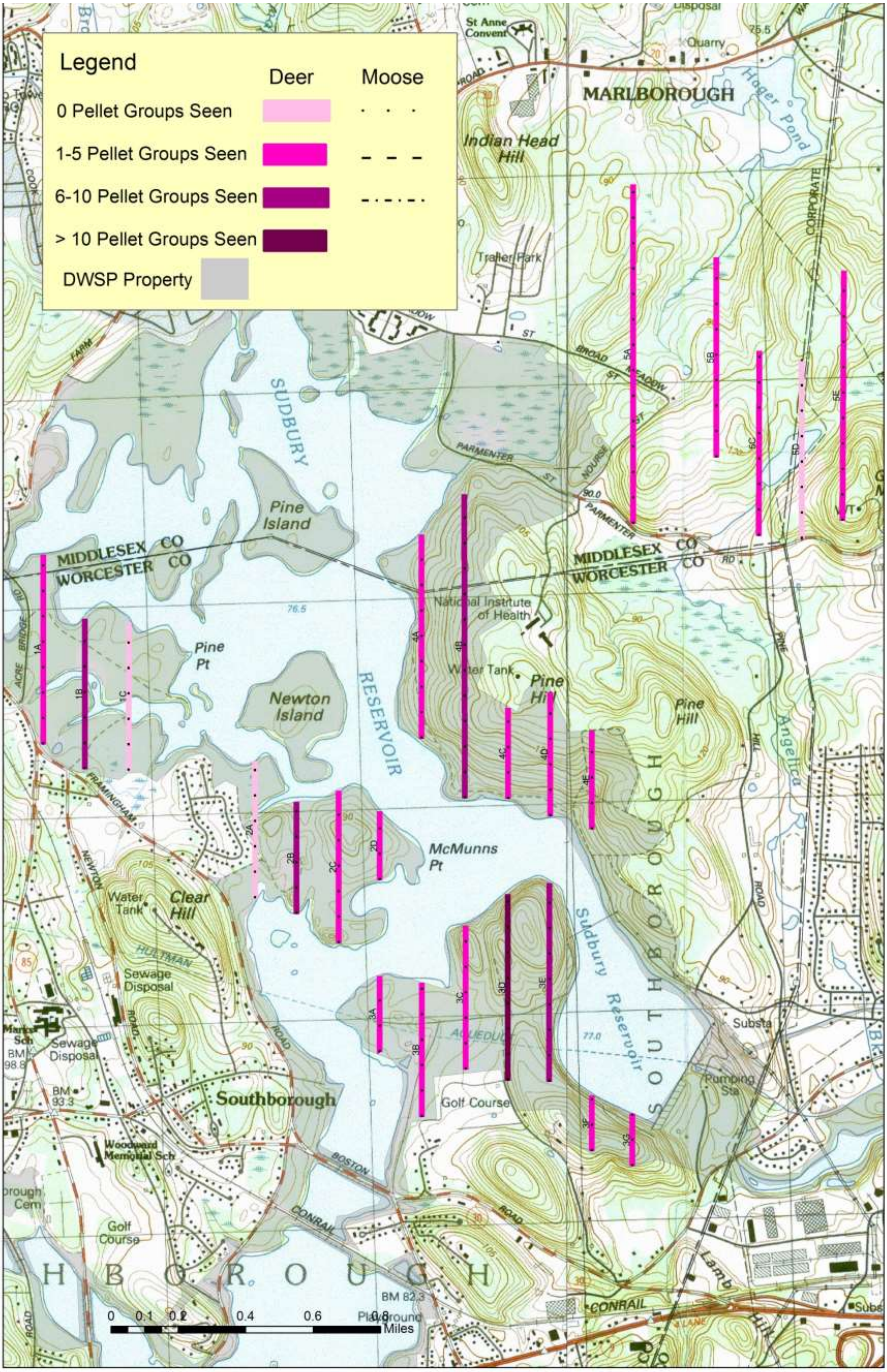


Figure 8. Distribution of pellet-groups on Sudbury study site.



DISCUSSION

Collecting deer and moose pellet-group data was relatively straightforward and simple. Because the actual sample plots (4.52 m^2) were small, and only pellets on top of the leaves were counted, it is unlikely that any pellet-groups were missed. Most transects were easy to locate and walk. However, there were a few transects that bisected large wetlands, areas of thick invasive species, or steep slopes. In 3 cases, the whole transect (1,610 m) was removed from sampling because it was nontraversable. In other cases, short detours were necessary when observers were walking the lines in order to avoid open water or deep wetlands.

The biggest potential influence on deer and moose estimates is the pellet-group deposit rate. While published literature provided useful guidance, these studies were conducted outside Massachusetts. As a result, deposit rates for moose and deer in Massachusetts may be different, and deposition rates may vary throughout the winter. Using the average deposition rate ± one standard deviation provides a reasonable alternative when the exact deposition rate is unknown.

Our deer density estimates were highly variable from site to site. At Quabbin, deer density estimates were very low for Prescott and much higher for Petersham. This information will be useful when making year to year management decisions on antlerless permit allocation. Density estimates for Wachusett were also very different, but the differences were likely attributed to current management practices. Estimates in areas where hunting has traditionally occurred were well below the accepted limit of 20 deer/mi^2 that is needed for adequate tree regeneration and growth. In areas where hunting is currently not allowed and has been historically absent, deer densities were much higher. Deer densities sustained at levels above 20 deer/mi^2 can lead to concerns about forest regeneration and tree species composition.

Our moose density estimates were much higher than reported elsewhere. Reported moose densities in Maine ranged from 0.8-3.4 moose/mi^2 and densities in New Hampshire were estimated at 3 moose/mi^2 (Morris 1999). In Alaska, densities estimated from aerial surveys ranged from 0.19-0.31 moose/mi^2 (Lawler et al. 2006). Our estimates were 2 to 8 times higher than those reported from New Hampshire. However, estimates in these other states were determined using aerial surveys and may not be comparable to our technique. Continued monitoring of moose populations on Division lands should provide useful information as the state continues to discuss moose management.

LITERATURE CITED

Andersen, R., O. Hjeljord, and B. E. Saether. 1992. Moose defecation rates in relation to habitat quality. Alces 28:95-100.

Baskin, L. M., and N. L. Lebedeva. 1987. Moose management in USSR. *In* Goransson, G. and S. Lavsund (eds.), Swedish Wildlife Research, Proceedings. Second International Moose Symposium, Uppsala 519-634.

Curtis, P. D., B. Bazartseren, P. M. Mattison, and J. R. Boulanger. 2009. Estimating deer abundance in suburban areas with infrared triggered cameras. Human-Wildlife Conflicts 3:116-128.

DeCalesta, D. S. 2013. Reliability and precision of pellet-group counts for estimating landscape-level deer density. Human-Wildlife Interactions 7(1):60-68.

Franzmann, A. W., and P. D. Arneson. 1976. Daily pellet groups and beds of Alaskan moose. Journal of Wildlife Management 40:375-376.

Joyal. R., and J. G. Ricard. 1986. Winter defecation output and bedding frequency of wild, free-ranging moose. Journal of Wildlife Management 50:734-736.

Lavsund, S. 1975. Investigations on pellet groups. Research notes 23. Department of Vertebrate Ecology, Royal College of Forestry, Stockholm, Sweden. 47pp.

Lawler, J. P., L. Saperstein, T. Craig, and G. Stout. 2006. Aerial moose survey in upper game management unit 24, Alaska, Fall 2004, including state land, and lands administered by the Bureau of Land Management, Gate of the Arctic National Park and Preserve, and Kanuti National Wildlife Refuge. Report NPS/AR/NR/TR-2006-55. 33pp.

Miquelle, D. 1983. Summer defecation, urination rates and volumes of moose. Journal of Wildlife Management 47:1230-1233.

Morris, K. I. 1999. Moose assessment. Maine Department of Inland Fisheries and Wildlife. 92pp.

McCullough, D. R. 1982. White-tailed deer pellet-group weights. Journal of Wildlife Management 46:829-832.

Oldemayer, J. L., and A. W. Franzmann. 1981. Estimating winter defecation rates for moose, *Alces alces*. Canadian Field Naturalist 95:208-209.

Persson, I-L., K. Danell, and R. Bergström. 2000. Disturbance by large herbivores in boreal forests with special reference to moose. Annales Zoologici Fennici 37:251-263.

Rogers, L. L. 1987. Seasonal changes in defecation rates of free-ranging white-tailed deer. Journal of Wildlife Management 51:330-333.

Rollins, D., F. C. Bryant, and R. Montandon. 1984. Fecal pH and defecation rates of eight ruminants fed known diets. Journal of Wildlife Management 48:807-813.

Sawyer, T. G., R. L. Marchinton, and W. M. Lentz. 1990. Defecation rates of female white-tailed deer in Georgia. Wildlife Society Bulletin 18:16-18.