Martha's Vineyard Deer Survey

Executive Summary

March 25, 2013

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Martha's Vineyard Deer Survey Summary Statistics

Total FLIR images recorded:	30452 – (111GB)
Total color images recorded	5316 – (56GB)
Total area of GIS based survey blocks:	21.36 sq. miles

Total canopy corrected deer density for all survey blocks (maximum):

54.31 per sq. mile

Total canopy corrected deer density for all survey blocks (minimum):

39.67 per sq. mile

* Total omission/commission error estimate +/- 16.7%

Survey Methodology

The main Island of Martha's Vineyard was flown on January 25, 2013 with the AIMS-Thermal aerial imaging system (Millette et al, 2011) for the purposes of estimating local deer *(Odocoileus virginianus)* population.

Survey Flights

The study area was sampled using a total of 25 survey units (SU) distributed relatively evenly across the census area (Fig. 1). Each SU was laid out systematically in ArcMap to cover approximately 20% of the Island and include all land cover types. Total linear distance of the SUs was 85.2 km.

Survey units were flown from a nominal altitude of 305 m agl, with a nominal horizontal image swath of 129 m and a nominal vertical image swath of 96 m, or 1.3 ha per image. Nominal instantaneous field of view (IFOV) of thermal images at 305 m agl is 20 cm, while nominal IFOV for natural color images is 1.8 cm. Airspeed of the aircraft was nominally 90 km/hr and frame rates of the thermal and color cameras were set to 500% and 30% overlap along the flight line respectively. The 500% overlap on the thermal imagery was done to preserve the opportunity to conduct double counts on moose and deer observations should they be deemed necessary, and to provide a detailed imagery database from which to analyze false-positive heat signatures in future research.

The AIMS-T system was deployed in January 25, 2013 and the entire study area was covered in a single flight flown between 0700 and 1500 h. This flight resulted in a total of 30,452 thermal images and 5316 high-resolution color images

recorded with discontinuous snow cover, and a variety of sky illumination conditions ranging from moderate overcast to broken sunshine.

Imagery Analysis
Image analysis was done with visual interpretation by the lead author. The analysis process involved scrolling through thermal images along each flight line looking for heat signatures. When candidate signatures were detected, the color photo center shapefile in the GIS was used to open the corresponding high resolution color photo which was then used to identify the actual source of heat. The distribution of deer observations across the Island illustrated in Fig. 2 indicate that they are spatially well-dispersed and show little evidence of spatial clustering. Examples of a portion of a thermal and corresponding color photo for a typical heat signature are in Fig. 3. Note that the radiometric resolution of the thermal image clearly indicates 6 hot targets, but that the spatial resolution is not adequate to identify the particular feature emitting the heat. Looking at the corresponding color image, it becomes obvious that the heat sources are deer.

Images verified to contain deer had the thermal imagery attribute table in the GIS database updated to reflect the number of individuals at each observation location. In locations where heat signatures were conspicuous, but the color image was obscured due to vegetation, the observation was attributed as "unidentified" in the GIS attribute table. Although attributed as unidentified, in most cases it is reasonable to assume that these obscured signatures are in fact deer given the strength of their emittance and the lack of any plausible explanation for the thermal return. Having the census animal locations included in the GIS database offers the potential for ecological assessments of deer population and habitat characteristics such as forest cover, vegetation community and land use.

Density Calculations
Density calculations for the Martha's Vineyard deer population were done by a three step process that included identifying deer in the aerial imagery, estimating the potential number of deer that were hidden by conifer canopy, and by estimating errors of omission and commission in the imagery analysis.

Imagery analysis for the 24% sample of the Island covered by the flight identified a total of 315 deer with an additional 63 heat signatures being attributed as unidentified due to vegetation obstruction or image quality in the color photos. Since there is a significant amount of closed conifer canopy on the main Island and because deer were not identified in these stands in adequate numbers by the thermal camera, we were unable to use the locally developed conifer correction factor (Kilpatrick et al. 2001) that was applied to the Nantucket Survey. This correction factor doubles the number of deer seen in conifers from an aerial survey based on experiments done with radio collared deer in an enclosed conifer stand in Connecticut.

To estimate the number of deer that was likely hidden in conifers and thick shrub we used a combination of Mass GIS data layers of vegetation communities, Mass GIS Orthophography, and AIMS-imagery from the survey flights to estimate the total amount of canopy (15.4% of the Island) that could potentially obscure deer from the thermal imager. Subsequently we calculated Island wide density using three hypothetical conifer density rates and adding them to the density in the non-conifer areas of the study area. The three rates were conifer density at 2.0 times the background rate, 2.5 times the background rate, and at 3.0 times the background rate. The rationale for these rates are they provide a useful range of estimates which are based on a combination of the spatial pattern of deer observations seen in the imagery, a general understanding of winter behavior of New England deer, and local knowledge developed from an identical survey conducted on Nantucket three days (January 28, 2013) after the survey described here.

The background deer density calculated from imagery for non-conifer areas was 21.0 per sq. mile. Although this is not an insignificant population, it is slightly less than half the density calculated for Nantucket where there is almost no closed canopy conifer for deer to seek shelter. Additionally, the survey for Martha's Vineyard was conducted on an unusually cold day (8^0-12^0 F) after a snow accumulation when deer are known to bed-down and seek shelter in conifers. Estimating that deer occupied conifer stands at double the background rate results in overall density climbing to 44.61 deer per sq. mile which is almost identical to the pre-omission/commission corrected minimum density estimates for Nantucket. Raising the conifer rate to 2.5 times the background rate results in an overall density of 51.36 deer per sq. mile which is also almost identical to the pre-omission/commission corrected maximum density estimates for Nantucket. Tripling the conifer occupancy rate results in an overall density of 58.01 deer per sq. mile which seemed a bit high given other known densities for Southern New England.

It was not possible to do a traditional estimate of errors of omission (deer missed by the imagery analyst) and commission (heat signatures identified as deer, but in fact were something other than deer) since there is no independent data source to verify our analysis. In an attempt to put some error range on our estimates we did the following: To estimate the error of omission we opened 609 (2% of all images and approximately 10% of the area imaged) random thermal images throughout the study area to see if any heat signatures had been missed and we found none. To create a substitute for a proper error of commission we used the observations attributed as unidentified to estimate the worst-case scenario that all unidentified observations were in fact not deer. In this case the 63 unidentified observations of the total pool of 378 leads to a commission error estimate of 16.7%.

The maximum density calculation for Martha's Vineyard was calculated as follows:

Density = (D+U+C)/A where D = deer observations, U = unidentified observations thought to be deer, C= canopy correction value and A=area sampled or (378+63+719)/21.36 = 54.31 deer per square mile.

The minimum density calculation for Martha's Vineyard was calculated as follows:

Density = (D+U+C)/(A)-(E) where D = deer observations, U = unidentified observations thought to be deer, C= canopy correction value, A=area sampled and E= the omission-commission correction value or (378+63+575)/(21.36)-(7.9) = 39.67 deer per square mile.

Qualifications
The estimate of deer density provided by this survey in our experience is high. However, the aerial imaging methodology used in this survey has worked in the past both for deer and moose and has been peer reviewed. We caution that the density estimates should be seen as a useful range rather than absolute numbers. These estimates may be vulnerable to errors in estimating the number of deer contained in conifer stands and the ad hoc methodology for estimating errors of commission.

Note on Chappaquiddick
The Island of Chappaquiddick was surveyed twice at 50% ground coverage on March 23, 2012 and February 13, 2013. In both circumstances the data quality was unsuitable to provide accurate estimates of deer. The March 2012 data was unsuitable because the ground was unfrozen and created a poor signal-to-noise ratio in the thermal imagery making it impossible to reliably detect deer. The February 13, 2013 data showed deer signatures in very low numbers, however these low numbers combined with the ratio of conifer cover to open areas would not support accurate conifer corrections. Should the BOH wish to resurvey Chappaquiddick we recommend a helicopter-based mark-recapture approach.

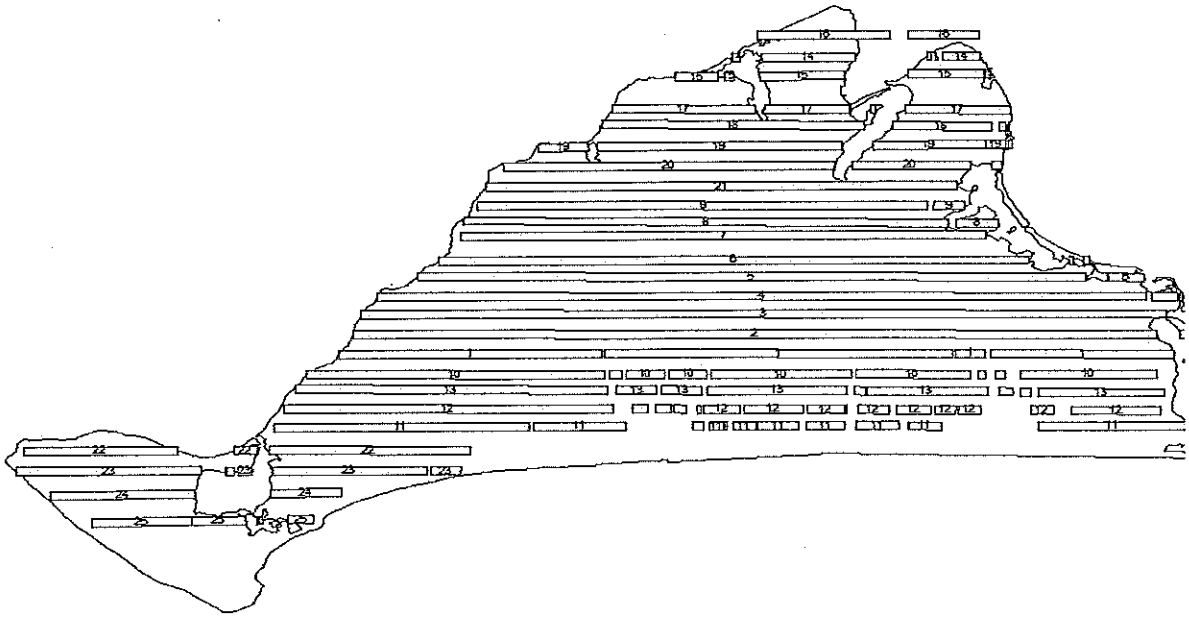

Fig. 1 Survey Block Numbering Scheme

Survey Block	Total Deer	Total Unidentified
01	30	8
02	29	5
03	45	2
04	14	4
05	26	2
06	3	2
07	0	0
08	0	0
09	1	1
10	0	0
11	29	4
12	31	8
13	0	0
14	22	1
15	0	1
16	4	0
17	0	1
18	6	1
19	2	1
20	4	0
21	15	6
22	27	7
23	13	6
24	14	2
25	0	1
Total	**315**	**63**

Table 1 - Deer Counts by Survey Block

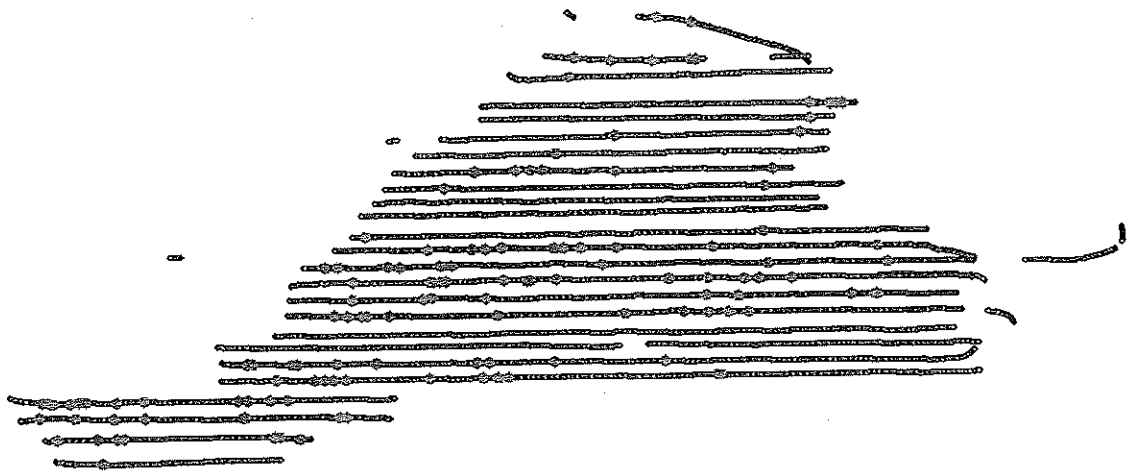

Fig. 2 Spatial Distribution of Deer by Flight Line

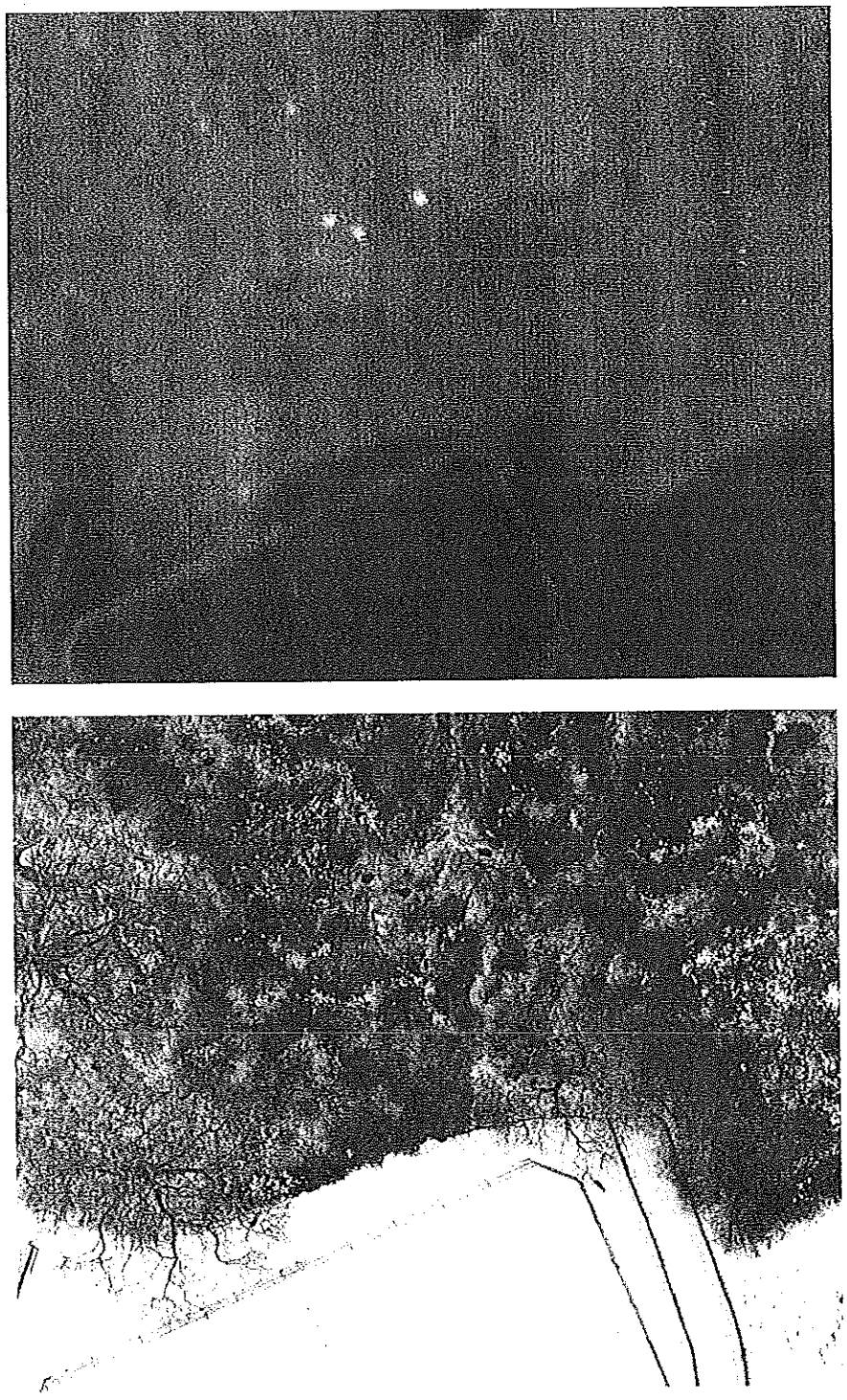

Fig. 3 Typical Example of FLIR and Matching Color Image from Survey

Martha's Vineyard Survey Imagery Metadata

Contents of data drive:

1. Root folder of the survey data (MVY) contains 2 folders with raw imagery (**color** for color images and **flir** for thermal images)

2. Two shapefiles that contain the photo and deer locations for all images (**color** for color and **thermal** for thermal images).

3. One shapefile (**vineyard_poly**) for the main Island.

4. One ArcMap MXD document (**Vineyard_survey**) with hyperlinks that will allow you to explore the imagery and deer locations.

5. One image viewing utility (**i_view32**) that will display images from the hyperlink tool in ArcGIS.

Bibliography

Millette, T.L., D. Slaymaker, E. Marcano, C. Alexander and L. Richardson. 2011. Aims-Thermal a thermal and high-resolution color camera system integrated with GIS for aerial moose and deer census in northeastern Vermont. *Alces.* 47:27-37.

Kilpatrick, H., S. Spohr, and K. Lima. 2001.Effects of population reduction on home ranges of female white-tailed deer at high densities. *Can. J. Zool.* 79:949-954.