

2010 Project Abstract

For the Period Ending June 30, 2012

PROJECT TITLE: Identifying Critical Habitats for Moose in Northeastern Minnesota

PROJECT MANAGER: Ronald A. Moen

AFFILIATION: Natural Resources Research Institute, University of Minnesota Duluth

MAILING ADDRESS: 5013 Miller Trunk Highway

CITY/STATE/ZIP: Duluth, MN 55811-1442

PHONE: (218) 720-7372

E-MAIL: rmoen@d.umn.edu

WEBSITE: <http://www.nrri.umn.edu/moose>

FUNDING SOURCE: Environment and Natural Resources Trust Fund

LEGAL CITATION: ML 2010, Chap. 362, Sec. 2, Subd. 3(k)

APPROPRIATION AMOUNT: \$507,000

Overall Project Outcome and Results

Moose are one of Minnesota's most prized wildlife species. In less than 20 years moose in northwestern Minnesota declined from over 4,000 to fewer than 100. The northeastern Minnesota moose population, which had over 7,000 moose until 2009, is in the middle of what appears to be a similar decline. Higher mortality in radiocollared moose is correlated with warmer temperatures. We used satellite collars to track moose in northeastern Minnesota and collected GPS locations day and night 365 days a year. Over 2 million moose locations and activity data were obtained. Specific habitats needed by moose were identified using the satellite collars. Spatial distribution and availability of habitat types has guided identification of specific sites for enhancement, protection, or acquisition. Habitat guidelines and recommendations help private and public land managers provide the best possible habitat for moose.

The project was part of a coordinated effort involving many resource management agencies to determine if it is possible to slow or prevent a decline in the northeastern MN moose population. Public outreach and education was accomplished with a website that provides information on moose in Minnesota and allowed the public to report almost 2,000 moose sightings. The Minnesota Zoo developed an on-site informational kiosk about Minnesota moose and zoo educators developed a curriculum for teacher workshops to be held both at the zoo and at the Boulder Lake Environmental Learning Center near Duluth. We gave over 70 moose presentations during the project, and continue to give presentations now.

The project combined research and education to increase public understanding of Minnesota moose now and in the future. Results and data from this project are still being used in current projects. We expect that there will be at least 2 more M.S. theses, 5 peer-reviewed publications, and additional NRRI Technical Reports developed from the data collected in this project that will be used to improve moose management. We also continue to work with the MN DNR adult and calf moose mortality projects using data and expertise obtained during this moose research project, and we have an ongoing collaboration with the Minnesota Zoo in Apple Valley with a deer-moose parasite project and a moose-wolf predation project.

Project Results Use and Dissemination

The project has had relatively wide dissemination, both in formal settings and in working with DNR and other resource management agencies to implement recommendations arising from the project. We gave over 70 presentations to the public about this project. We also developed a moose website that is used extensively by both biologists and the public. We will continue to update this website in the future.

In addition, because of the interest in moose, the project has received attention from the media, with newspaper and magazine articles, and radio and television interviews. Among the media outlets are the Duluth News Tribune, Minneapolis Star Tribune, and St. Paul Pioneer Press Dispatch, local TV stations, Minnesota Public Radio, Duluth News Tribune, Minneapolis Star Tribune, Los Angeles Times, BBC in Ontario and Newfoundland, Sweden Public Radio, Toronto Star, and others

Although not limited to this project, Moen was also asked by the DNR to present on the current status of moose in Minnesota at the 2014 Roundtable, and also gave testimony to the Environment and Natural Resources Policy Committee on February 25, 2014.

Finally, there are several peer-reviewed publications, theses, and technical reports that have arisen from work conducted on this project. Some of these publications are currently being peer-reviewed. We expect to produce several additional publications and theses from the data obtained in this project. To date we have:

- Chen, W.C. R. Moen, and S.K. Windels. Home range size and space use of moose in Voyageurs National Park. *Alces* in review.
- Cyr, T., S.K. Windels, R. Moen, and J. Warmbold. Diversity and abundance of terrestrial gastropods in Voyageurs National Park: Implications for risk of individual moose to *Parelaphostrongylus tenuis* infection. *Alces* in review.
- Joyce, M., R. Moen, and D. Bertolatus. 2014. Mapping forest harvest in northeastern Minnesota using aerial photographs and high resolution satellite imagery. NRRRI Technical Report No. NRRRI/TR-2014-17.
- McCann, N., R. Moen, and T. Harris. 2013. Warm-season heat stress in moose (*Alces alces*). *Canadian Journal of Zoology* 91(12):893-898.
- McCann, N. P., R.A. Moen, and S.K. Windels. Influence of temperature on summer bed site selection by moose (*Alces alces*). *Ecology* in review.
- McGraw, A.M. M.S. 2010. Characteristics of Post-Parturition Areas of Moose and Effective Temperature of Cover Types in Moose Home Ranges in Northeast Minnesota. Integrated BioSciences program, University of Minnesota, Twin Cities.
- McGraw, A.M., R.A. Moen, and M. Schrage. 2011. Characteristics of Post-Parturition Areas of Moose in Northeast Minnesota. *Alces* 47:113-124.
- McGraw, A.M., R.A. Moen, and L. Overland. 2012. Effective Temperature of Cover Types Found in Moose Home Ranges in Northeast Minnesota. *Alces* 48:45-52.

- McGraw, A.M., J. Terry, and R. Moen. Characteristics of post-parturition areas of moose in northeast Minnesota from high frequency GPS locations. *Alces* in review.
- Moen, R.A., M.E. Nelson, and A. Edwards. 2011. Using cover type composition of home ranges and VHF telemetry locations of moose to interpret aerial survey results in Minnesota. *Alces* 47:101-112.
- Ward, R.L. and R. Moen. Measuring actual and effective browse availability for moose using a new method in northeastern Minnesota. *Alces* in review.
- Ward, R.L. M.S. 2014. Browse availability and bite size for moose and effects of stand age on species composition and browse density in northeastern Minnesota. Integrated BioSciences program, University of Minnesota, Twin Cities.

Environment and Natural Resources Trust Fund (ENRTF) 2010 Work Program Final Report

Date of Report: April 4, 2014

Final Report

Date of Work Program Approval: June 9, 2010

Project Completion Date: June 30, 2013

I. PROJECT TITLE: Identifying Critical Habitats for Moose in Northeastern Minnesota

Project Manager: Ronald A. Moen

Affiliation: Natural Resources Research Institute, University of Minnesota Duluth

Mailing Address: 5013 Miller Trunk Highway

City / State / Zip: Duluth MN 55811-1442

Telephone Number: (218) 720-7372

E-mail Address: rmoen@d.umn.edu

FAX Number: (218) 720-4328

Web Site Address: <http://www.nrri.umn.edu/moose>

Location: *Cook, Lake, and St. Louis Counties*

Total ENRTF Project Budget:	ENRTF Budget:	\$ 507,000
	Minus Amount Spent:	\$ 507,000
	Equal Balance:	\$ 0

Legal Citation: ML 2010, Chap. 362, Sec. 2, Subd. 3(k).

Appropriation Language:

\$507,000 is from the trust fund to the Board of Regents of the University of Minnesota for the Natural Resources Research Institute to identify critical habitats for moose, develop best management habitat protection practices, and conduct educational outreach in cooperation with the Minnesota Zoo. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

II. FINAL PROJECT SUMMARY AND RESULTS:

Moose are one of Minnesota's most prized wildlife species. In less than 20 years moose in northwestern Minnesota declined from over 4,000 to fewer than 100. The northeastern Minnesota moose population, which had over 7,000 moose until 2009, is in the middle of what appears to be a similar decline. Higher mortality in radiocollared moose is correlated with warmer temperatures. We used satellite collars to track moose in northeastern Minnesota and collected GPS locations day and night 365 days a year. Over 2 million moose locations and activity data were obtained. Specific habitats needed by moose were identified using the satellite collars. Spatial distribution and

PROJECT TITLE: Identifying Critical Habitats for Moose in Northeastern Minnesota

availability of habitat types has guided identification of specific sites for enhancement, protection, or acquisition. Habitat guidelines and recommendations help private and public land managers provide the best possible habitat for moose.

The project was part of a coordinated effort involving many resource management agencies to determine if it is possible to slow or prevent a decline in the northeastern MN moose population. Public outreach and education was accomplished with a website that provides information on moose in Minnesota and allowed the public to report almost 2,000 moose sightings. The Minnesota Zoo developed an on-site informational kiosk about Minnesota moose and zoo educators developed a curriculum for teacher workshops to be held both at the zoo and at the Boulder Lake Environmental Learning Center near Duluth. We gave over 70 moose presentations during the project, and continue to give presentations now.

The project combined research and education to increase public understanding of Minnesota moose now and in the future. Results and data from this project are still being used in current projects. We expect that there will be at least 2 more M.S. theses, 5 peer-reviewed publications, and additional NRRI Technical Reports developed from the data collected in this project that will be used to improve moose management. We also continue to work with the MN DNR adult and calf moose mortality projects using data and expertise obtained during this moose research project, and we have an ongoing collaboration with the Minnesota Zoo in Apple Valley with a deer-moose parasite project and a moose-wolf predation project.

III. PROGRESS SUMMARY:

December 20, 2013: We continued monitoring the deployed GPS collars each day after downloading locations via the Iridium satellite network. We recovered 9 collars whose dropoff mechanism worked from January to March 2013. There are 2 Collars whose dropoff mechanism malfunctioned that are still transmitting. We will monitor these collars until the battery fails, and will try to recapture them in winter 2014. There have been no recorded mortalities on active collars since August 2012, although the number of moose with functioning collars is lower.

We continued cooperation with the DNR. The DNR is responsible for the ENRTF funded adult moose mortality project (PI Michelle Carstensen) and the ENRTF funded calf mortality project (PI Glenn DelGiudice). In addition to checking for mortalities daily on our collared moose, we assisted with both DNR ENRTF projects (adult moose capture in January/February 2013 and calf collar deployment in Ely, MN in May 2013).

We also organized the third NE MN moose research meeting on December 9-10, 2013. We had to host the meeting at the Cloquet Forestry Center instead of NRRI because attendance increased over 2012's meeting. Glenn DelGiudice (DNR) and Ron Moen were the organizers, and over 70 tribal, DNR, university, county, and Superior National Forest biologists and managers attended. 12 of 26 presentations were by graduate students or post-doctoral scientists working with me and were directly associated with this ENRTF project, or were using locations of moose from this project. 5 presentations were about the DNR ENRTF projects, 2 presentations were about the ENRTF project

PROJECT TITLE: Identifying Critical Habitats for Moose in Northeastern Minnesota

for which James Forester is PI, and 1 presentation was on the Outdoor Heritage Fund moose habitat project. The remaining talks from Michigan, Ontario, and Sweden, illustrate the broader nature of the moose “problem.”

We have finished compiling all moose location data into a common format for final analysis (except for the 2 collars that are still transmitting, and any remaining collars that are found). There are 5 papers that will be in review for peer-reviewed literature in January.

We finished digitizing all locations of forest harvest within the moose area since 2002. This shapefile will be published as an NRRI Technical Report in January 2014 and will be available to other scientists and managers.

We continued recording moose sightings reports and developing new pages for the website. An update of the moose website in June 2013 included new or updated topic pages (sightings reports, pictures, and moose literature).

December 31, 2012: We continued monitoring the deployed GPS collars each day after downloading locations via the Iridium satellite network. There was 1 additional mortality in 2012: Cow 31168 died on August 12, we reached the carcass on August 15th. There were collar movements post-mortality which we believe were due to wolves moving the collar. We continued cooperation with the DNR and the ENRTF moose mortality project (PI Erika Butler). In addition to checking for mortalities daily on our collared moose, we met twice to discuss project design and sampling schemes. As part of this cooperation we hosted the second NE MN moose research meeting in on December 7, 2012 at NRRI. Glenn DelGiudice (DNR) and Ron Moen were the organizers, and attendance was over 50 from tribal, DNR, university, county, and SNF biologists and managers. We also continued compiling all moose location data into a common format for final analysis. Initial data analysis on calf birth sites and post-parturition behavior indicated that cows stayed in one location for 7 to 10 days and then moved to a new location. Initial data analysis of thermal response indicated that we can detect a significant switch in cover types used when temperatures are warmer. Field work on bed sites in relation to temperature was conducted in Summer 2012, which will result in determining the basis for moose use of forest types for thermal cover. We are digitizing all locations of forest harvest within moose area since 2002. We continued recording moose sightings reports and developing new pages for the website. A significant update of the website includes new or updated topic pages (sightings reports, pictures, moose necropsy, Moose Advisory Committee update, and moose literature).

June 30, 2012: We redeployed 4 collars from mortalities in March, 2012. We continued monitoring the deployed GPS collars each day after downloading locations via the Iridium satellite network. There has been 1 mortality in 2012: Cow 31177 died on May 12, we reached the carcass on May 14th. This mortality occurred during calving so we initially thought that the localization was occurring because she had calved. The carcass was almost untouched by scavengers, there was no fetus present nor any indication of having recently given birth. Tissues were brought to the Vet Diagnostic Lab on UM-TC campus but we do not have a cause of death yet. We continued cooperation with the DNR and the ENRTF moose mortality project (PI Erika Butler). In addition to checking

PROJECT TITLE: Identifying Critical Habitats for Moose in Northeastern Minnesota

for mortalities daily on our collared moose, we met 3 times to discuss collar performance and testing for the collars to be used in that project. The DNR also funded helicopter flights to confirm calf births for most of the ENRTF collared cows. Moose locations are updated in the database as of 6/1/2012. We finished the data cleaning algorithms discussed in the 12/31/11 update. Project partners have been assisting with recovering moose mortalities and checking collar performance (1854 Treaty Authority and Fond du lac Resource Management) and maintaining the educational kiosk (Minnesota Zoo).

December 31, 2011: We monitored the deployed GPS collars each day after downloading locations via the Iridium satellite network. There were 3 more mortalities in 2011: (1) Cow 31181 was euthanized on 9/4/2011. She was laying down and unable to stand up. Tissues were collected and cause of death was determined to be some form of cancer by the Veterinary Diagnostic Lab. (2) Bull 31186 was shot on 9/24/2011. This was either a wounding loss during the Tribal hunting season, or poaching (illegal kill) if the moose was shot by an unlicensed individual. We arrived on site about 30 hours after death and conducted a necropsy. (3) Bull 31191 was shot during the state hunting season. The hunter returned the collar to the Ely check station, and it has subsequently been returned. We now have about 800,000 locations of moose from these GPS collars. With other funding and other Co-PIs we have about 1,500,000 locations of moose from Voyageurs National Park, the Grand Portage Indian Reservation, and Quetico Provincial Park. All of these locations are entered into an Access data base. We have begun developing algorithms to automate cleaning up the data (occasional bad GPS locations need to be deleted, points can be interpolated on a short time intervals) and are exporting locations from Access to do this. Until the first year was completed we have been qualitatively analyzing moose use of different habitats, and collecting quantitative data through overlay of moose locations on aerial photographs. We will delay quantitative analysis of locations for 2-3 weeks in case we receive more snow in northeastern Minnesota. Moose were captured and radiocollared when snow depths were about 24 – 30 inches, while current snow depths are less than 12 inches. Ideally the analysis would include a return to snow depths of 18 to 24 inches. The zoo kiosk was finished and is installed at the moose exhibit next to a new moose statue. The moose project website (www.nrri.umn.edu/moose) will be updated again in early 2012 after an update in August 2011.

June 30, 2011: We deployed 25 collars on moose in Minnesota in January, 2011. These collars collect GPS locations every 20 minutes and transmit these locations via the iridium satellite network every 4 to 8 hours. We recovered the carcass of 1 mortality, a male that fell through the ice on McDougal Lake in March. We now have about 250,000 moose locations which are being imported into an Access database every 3-4 months. In the 2011 winter moose seemed to use mature forests with a mix of conifer and deciduous tree species more than expected. All cows that were pregnant based on progesterone concentrations localized their position in May 2011 and gave birth. In GPS collars deployed in 2011 (projects at Grand Portage Indian Reservation, Voyageurs National Park, Quetico Provincial Park and the ENRTF project), 39 of 46 cows gave birth based on GPS locations. We did not confirm birth by visiting birth sites. Progress continues on the zoo kiosk with the moose model commissioned and text being completed. A high school teacher workshop was completed in June 2011 that was

PROJECT TITLE: Identifying Critical Habitats for Moose in Northeastern Minnesota

attended by teachers from the Twin Cities area. The Boulder Lake Environmental Learning Center was used as a base. The moose project website (www.nrri.umn.edu/moose) has been updated twice this year.

February 28, 2011: We have deployed 25 collars on moose in Minnesota. This Work Program Amendment Request is being submitted to change dollar appropriations within budget categories. The bid process at the University of Minnesota resulted in an unexpected collar manufacturer (Lotek Wireless, Inc. was the low bidder) and a change in data transmission protocol. This was a cost-effective change that resulted in us paying more for each collar that was balanced out by a reduction in data transmission costs. Another benefit of this change is that we were able to deploy more collars (25) than originally expected (20) when the proposal was submitted. With this Work Program Amendment Request we are submitting a revised Attachment A in which budget categories have been shifted to reflect the change as itemized below in the budget section.

December 30, 2010: The most significant project accomplishment is preparation for moose capture and collaring in January 2011. Collars have been purchased, the helicopter capture company is lined up, supplies and logistical planning are nearly complete. We have also completed initial planning for the moose kiosk at the zoo, and have a design team in place to begin creating the zoo kiosk in January 2011. Plans are for the moose exhibit to include a moose model and updates on the moose collared during this project. The moose project website (www.nrri.umn.edu/moose) has been updated 3 times this year. We have about 1000 sightings reports and over 200 pictures that have been submitted to the website. Keeping the public engaged and interested in moose and other natural resources will be one of the long-term benefits of this project.

IV. OUTLINE OF PROJECT RESULTS:

RESULT 1:

Description: Identify habitats critical to moose survival in Minnesota. We will use behavioral data and habitats used by moose through the year to develop habitat guidelines for moose in Minnesota. Of urgent importance is the influence of increasing temperatures with climate change on moose mortality. Specific habitat types needed by moose in northeastern Minnesota will be identified. Spatial distribution and availability of habitat types will guide identification of specific sites for enhancement, protection, or acquisition.

Summary Budget Information for Result 1:	ENRTF Budget:	\$	452,000
	Amount Spent:	\$	452,000
	Balance:	\$	0

Deliverable	Completion Date	Budget
1. Draft Moose Habitat Guidelines from daily GPS locations downloaded via Argos	12/31/2011	\$226,000
2. Include activity and temperature data analysis in	06/30/2012	\$67,800

PROJECT TITLE: Identifying Critical Habitats for Moose in Northeastern Minnesota

revised Guidelines (from year 1 data)		
3. Revise Guidelines with year 2 location data	12/31/2012	\$67,800
4. Final product with 2 years of location, activity and temperature data	06/30/2013	\$90,400

Result Completion Date: December 20, 2013

Result Status as of December 31, 2010:

We have been preparing for moose capture in 2010. Items completed/in progress through December 31, 2010 are:

1. Collars ordered (9 delivered 12/24/2010, remainder in January 2011). We purchased collars from Lotek Wireless, Inc. because they submitted the winning bid. Collar specifications actually exceed those described in the initial proposal. We paid more for the collars than initially budgeted, but this cost over-run was balanced by a reduction in data acquisition costs (see #2).
2. Cell phone accounts for data acquisition set up and tested. Using Iridium cell phone technology instead of the Argos system we will obtain all locations from each collar each day. This Iridium based collars are also cheaper for data acquisition.
3. Capture company selected (scheduled for January 2011). We will be working with QuickSilver Air, which is the same company used in the last capture operation for the VHF project.
4. Logistical planning associated with moose capture in progress. This project is benefiting from other moose projects in Minnesota and Ontario, all with the same experimental design and specifications. We will have 25-26 moose collared in the ENRTF project area, the other projects in and near Voyageurs National Park (19 moose), the Grand Portage Indian Reservation (14 moose), and in Quetico Provincial Park (7 moose) will greatly enhance what we can learn from this project.
5. Since the ENRTF project was funded we have also been awarded a EPA Great Lakes Restoration project to create moose foraging habitat and also monitor moose use of browse. Near real-time locations of moose collared in the ENRTF area will be used to measure browse use and availability. Browse use and availability is relevant to defining moose habitat guidelines in Minnesota.
6. Subcontracts with Minnesota Zoo, Fond du Lac Reservation Resource Management Division, and 1854 Treaty Authority have been set up.

Result Status as of June 30, 2011:

Collars are deployed and sending moose locations for download. Items completed / in progress though June 30, 2011 are:

1. Collars deployed and locations being downloaded and imported into Access database that we set up. Import into the database is done every 3-4 months.

PROJECT TITLE: Identifying Critical Habitats for Moose in Northeastern Minnesota

2. Locations imported into GIS for spatial analysis. We have not begun formal analysis yet because we needed to have a complete time period (winter months).
3. Animal locations monitored daily for mortality as part of the collaboration with the MN DNR.
4. Recovery of 1 mortality, a male that fell through the ice. Assistance from Fond du Lac and DNR collaborators on the recovery.
5. 15 of 17 females gave birth in 2011 in ENRTF project, while 39 of 46 cows in the projects in northeast Minnesota and Quetico Provincial Park gave birth. All cows with high progesterone levels gave birth. Progesterone levels were determined from blood sampled at capture.

Result Status as of December 31, 2011:

Collars are continuing to send moose locations for download. Items completed / in progress through December 31, 2011 are:

1. Locations are being downloaded and imported into Access database that we set up. Import into the database is done every 3-4 months.
2. Locations imported into GIS for spatial analysis. We have not begun formal analysis yet because we wanted a full-year time period so that we did not have to do the same analysis twice.
3. Deliverable on habitat use will be delayed about 2 months because of the 1-year time period that had not been envisioned when the project and budget schedule was planned in 2010.
4. Animal locations are monitored daily for mortality as part of the collaboration with the MN DNR.
5. Recovery of 3 mortalities. Assistance from Fond du Lac and DNR collaborators on the recovery of each animal or collar. Details on causes of mortality in Section III.
6. Calf survival in the ENRTF project was low. Only 2 of 10 cows that were visually seen in November and December had a calf with them. We had tried to locate cows with calves earlier in the year with USFS-SNF funding but were unable to see cows through the leaves. This calf survival is similar to what has been observed on the aerial survey conducted for moose in recent years.

Result Status as of June 30, 2012:

Collars are continuing to send moose locations for download. Items completed / in progress through June 30, 2012 are:

1. Locations are being downloaded and imported into Access database that we set up. Import into the database is done every 3-4 months.
2. Locations imported into GIS for spatial analysis. We have begun quantitative analysis and have overlaid GPS locations on cover type, stand age, forest soils, and water coverages.
3. We have calculated home ranges for all moose on the ENRTF project. Overlays have been done on the points (#2) and on the home ranges. We are currently doing overlays on seasonal home ranges.

PROJECT TITLE: Identifying Critical Habitats for Moose in Northeastern Minnesota

4. Deliverable on habitat use is in progress. We cleaned up the stand age shapefiles, and we have also been digitizing new forest harvest areas that were not in existing shapefiles around each moose home range.
5. Animal locations are monitored daily for mortality as part of the collaboration with the MN DNR.
6. Recovery of 1 mortality. Assistance from Fond du Lac and DNR collaborators on the recovery. Cause of death is still unknown.
7. Calf production in the ENRTF project was about 1 calf per cow in May 2012. Some cows produced twins and other cows did not have calves this year. The calf flights were paid for by the MN DNR.

Result Status as of December 31, 2012:

Collars are continuing to send moose locations for download. Items completed / in progress through December 31, 2012 are:

1. Locations are being downloaded and imported into Access database that we set up. Import into the database is done every 3-4 months.
2. New locations imported into GIS for spatial analysis (as of 11/1/12) and we overlaid GPS locations on cover type, stand age, forest soils, and water coverages. Some preliminary findings were reported at a meeting of NE MN moose biologists at NRRI on December 7, 2012. Among the highlights with respect to habitat use are:
 - a. Treed wet bog use increased with summer warm temperatures
 - b. If wet bog not available, mature forest (Deciduous, Conifer, or Mixed) use increased with warm temperatures.
 - c. Identification of cow movements and cover type use shortly before calf birth and then for about 2 weeks post-parturition while calf has limited mobility.
3. More analysis for deliverable on habitat use. Analysis of existing satellite imagery on home range areas and on individual locations of moose. We continued digitizing new forest harvest areas that were not in existing shapefiles around each moose home range.
4. Animal locations are monitored daily for mortality as part of the collaboration with the MN DNR.
5. Recovery of 1 mortality. Assistance from Fond du Lac and DNR collaborators on the recovery. Cause of death unknown because carcass was entirely consumed by wolves and bones scattered. Tooth recovered for aging. The cow (31168) was either sick and consumed by wolves, or it was a predation event on a healthy adult cow.
6. Training began for 4 new graduate students (M.S.: Julian Terry, Tim Cyr, Yvette Ibrahim; Ph.D.: Amanda McGraw) who will be working on moose in Minnesota. All 4 of these students will be incorporating moose GPS locations from this project into their research project.

Result Status as of December 20, 2013:

PROJECT TITLE: Identifying Critical Habitats for Moose in Northeastern Minnesota

2 Collars are continuing to send moose locations for download. 9 collars have dropped off and been recovered. Other collars are lost because of collar malfunction and will only be recovered opportunistically. Items completed / in progress through December 20, 2013 are:

1. Locations are now set up to be accessed from a SQL database. In addition to locations, we also have activity data, temperature, and GIS data in the SQL database. Associated spatial variables from land cover shapefiles (e.g., cover type from satellite imagery, weather data) are also linked to the database.
2. Presentations have been given and papers are being written by graduate students associated with the project. The moose location data has been used by:
 - a. Dr. Nick McCann (Post-doctoral scientist with Minnesota Zoo supervised by Dr. Tara Harris and I). Nick first measured respiration rates and moose response to temperature at the zoo (McCann, et al., 2013, Canadian Journal of Zoology). A paper is in review measured habitat characteristics at 155 bedsites from GPS collared moose in this project (McCann, et al., in review).
 - b. Amanda McGraw (Ph.D. student). Amanda used GPS collar data to identify characteristics of bed sites used by moose, and to analyze moose movements before and after calving. (McGraw, et al., 2010, 2011, in review).
 - c. William Chen (Ph.D. student). William is calculating home ranges and cover type use for moose at different temperatures, and will have a paper in review in Alces in January 2014 (Chen, et al., in review). In a second project William is developing a segmentation movement model to predict how moose move across the landscape as part of his M.S. research.
 - d. Rachel Ward (M.S. student) used GPS collar locations to find foraging paths that moose were using in both summer and winter. Browse availability and use was measured in each foraging path. This paper is in review for Alces (Ward and Moen, in review; Ward, 2014), and her M.S. thesis will be published in 2014.
 - e. Julian Terry (M.S. student) used GPS collar locations to find bed sites of moose. She then searched these bed sites for winter ticks, one of the parasites affecting moose health in Minnesota.
 - f. Tim Cyr (M.S. student) used GPS collar locations to find bed sites and foraging sites of moose. Tim then deployed snail traps to identify snail density and distribution in different cover types used by moose. Snails are important as vectors for *P. tenuis*. *P. tenuis* infects moose and causes mortality. Tim's work is in review for Alces (Cyr et al., in review).
 - g. Trevor Vannatta (M.S. student) analyzed GPS collar locations for distance to water sources and presented a poster at the MN Lake Superior Watershed Stream Science Symposium, January 7-8, 2014.
 - h. Dr. Kim VanderWaal (Post-doctoral scientist with Minnesota Zoo supervised by Dr. Tara Harris and I) began working on her project mapping disease transmission risk for moose. The project will use deer

PROJECT TITLE: Identifying Critical Habitats for Moose in Northeastern Minnesota

locations from a new telemetry project and moose locations from this ENRTF project.

- i. Yvette Ibrahim (M.S. student) continued analysis of wolf scats for prey species composition. Wolf scats were collected in part during field work on this ENRTF project.
3. More analysis for deliverable on habitat use. We finished digitizing new forest harvest areas that were not in existing shapefiles around each moose home range. This shapefile will be published as an NRR Technical Report available to other research projects (Joyce, et al., 2014).
4. Animal locations are monitored daily for mortality as part of the collaboration with the MN DNR.
5. There have been no mortalities on this project since August 2012, but we have recovered collars that dropped off of moose in 2013.
6. Training began for 1 new graduate student (M.S.: Trevor Vannatta) who will be working on aquatic snails. Aquatic snails are important as hosts for one of the life stages of *F. magna*, the liver fluke.

Final Report Summary:

Three factors will affect the ability of moose to persist in Minnesota for the foreseeable future: Adult survival, Calf survival, and Habitat suitability. This project addressed Habitat suitability, with a desired outcome being to identify habitats critical to moose survival in Minnesota. We have acquired over 2 million moose locations, and over 15 million activity periods that provide a strong biological basis for recommendations.

The specific habitat types that we have identified are thermal refuge habitats that are used when temperatures are too hot, characteristics of foraging areas that are used by moose in summer and winter, and parturition habitats where cows give birth to calves. Specific descriptions of these cover types are in manuscripts that are in peer-review and theses, but I will briefly summarize habitat characteristics here. We also finished a preliminary paper on habitat use and home ranges for VHF data (Moen, et al., 2011). Initial work on air temperatures in areas used by moose was done by Amanda McGraw (McGraw, et al., 2011; McGraw, 2011).

Thermal refuge habitats are used primarily in the summer when temperatures are above 70 degrees. These habitats vary by geographic location. In the southern part of moose range in Minnesota, there is little topographical relief. In the day moose used wet habitats that are mappable via satellite-derived cover types as a mechanism to maintain body temperature. At night, especially on clear nights, moose would usually bed in open areas where they were foraging. This is because they could radiate heat to the cooler night sky. In areas with more topographical relief (north and east of Isabella/Finland) moose would use mature forests to bed down in during hot days. A manuscript describing bed site selection based on physical and habitat characteristics of 155 bed sites used by GPS collared moose is in review (McCann, et al., in review).

Foraging habitats, as expected, were mainly in younger regenerating forests. This analysis required that we create a digitized GIS map of recent forest harvest from aerial

PROJECT TITLE: Identifying Critical Habitats for Moose in Northeastern Minnesota

photographs. Rachel Ward has submitted a manuscript from measurements of foraging paths used by GPS collared moose in summer and winter (Ward and Moen, in review). She developed a new method to measure browse that is more effective and will be used in future browse measurement projects in Minnesota. Moose were more likely to use areas that had been harvested in the winter because browse availability was higher. In the summer, when moose can move longer distances, they would also forage in canopy gaps in mature forest. Another factor that is important based on the examination of winter foraging areas is the presence of horizontal cover. Many of the areas that moose chose to forage in winter had patchy conifer trees that were 10 to 15 feet in height. We are developing a method to map these types of areas across a large area to estimate how much foraging area is actually available to moose.

The third aspect of habitat that we examined was calving habitat. We now have 1 paper in press and 1 paper in review on calving habitat characteristics. Based on overall habitat characteristics from aerial photographs and satellite-derived cover typing, there are many places within each cow moose home range that could serve as calving habitat, which suggests that calving habitat is not limiting. This was also the first project that provided a detailed analysis of how cow moose move before, during, and after calving. A significant finding is that cows stay with their calves in a very small area for the first week after birth. The average size of a birth area was about 140x140 yards, and cows stayed within this area for an average of 6 days. This raises some questions about how they acquire enough food and water to survive, because many of these areas were not close to free water in streams or lakes, and cows did not make movements out of the area. This paper is in review in Alces (McGraw, et al., in review).

There are several other projects that are using the moose GPS collar locations from a habitat perspective. One project (Julian Terry, M.S. expected Fall 2014) is identifying which habitat types moose are more likely to acquire winter ticks, others are identifying the presence of snails in different habitats and water bodies (Tim Cyr, M.S. expected Fall 2014; Trevor Vannatta, M.S. expected Fall 2015). Parasites in snails have been a mortality factor in moose historically and recently, and winter ticks have also occasionally caused die-offs of moose (Kim VanderWaal, Post-Doctoral scientist). Another project is using data on habitat use to identify areas which moose will likely forage in, and to estimate browse availability in these areas (Amanda McGraw, Ph.D. expected 2016).

These projects are already being used in management actions. Characteristics of moose foraging habitat derived from this ENRTF project were used as one of the criteria in site selection for the Outdoor Heritage Fund moose habitat restoration project. The calving habitat results were positive in that specific management actions are not needed at this time. Thermal refuge habitats have been identified based on this project, and interspersions of foraging and thermal refuge habitats can now be done based on movements between habitats that moose in Minnesota have made based on different conditions. Managers are already using this data based on input from project personnel directly, and also from presentations at the Moose Management and Research Meetings that we have organized for the past 3 years. The meetings and direct input are important because of the time lag between completion of data collection and publication.

The interest in moose has also led to additional projects that are in part derived from and will use the data collected in this project. The Outdoor Heritage Fund moose habitat restoration project is using our data, and we will continue doing this in our part of that project (site selection, evaluation). We will also be doing some research on OHF project areas with new LCCMR funding which started July 2013. As a result of collaboration with the Minnesota Zoo we now have two post-doctoral scientists in funded research projects, both of which will be using moose location and habitat use data. One project is developing a disease-risk map, and the other project is investigating wolf-moose interactions. We also continue to collaborate and cooperate with other moose projects in Minnesota being led by the DNR and by James Forester at the University of Minnesota.

We have provided results to management agencies, involved essentially all terrestrial resource management agencies in northeastern Minnesota in the project, and will continue to do so to insure that project data and outcomes are used to the greatest extent possible over the next few years. The results of this project, combined with other research project, will make it possible to keep moose in Minnesota for the foreseeable future if at all possible.

Publication list:

- Chen, W.C. R. Moen, and S.K. Windels. Home range size and space use of moose in Voyageurs National Park. Alces in review.
- Cyr, T., S.K. Windels, R. Moen, and J. Warmbold. Diversity and abundance of terrestrial gastropods in Voyageurs National Park: Implications for risk of individual moose to *Parelaphostrongylus tenuis* infection. Alces in review.
- Joyce, M., R. Moen, and D. Bertolatus. 2014. Mapping forest harvest in northeastern Minnesota using aerial photographs and high resolution satellite imagery. NRRRI Technical Report No. NRRRI/TR-2014-17.
- McCann, N., R. Moen, and T. Harris. 2013. Warm-season heat stress in moose (*Alces alces*). Canadian Journal of Zoology 91(12):893-898.
- McCann, N. P., R.A. Moen, and S.K. Windels. Influence of temperature on summer bed site selection by moose (*Alces alces*). Ecology in review.
- McGraw, A.M. M.S. 2010. Characteristics of Post-Parturition Areas of Moose and Effective Temperature of Cover Types in Moose Home Ranges in Northeast Minnesota. Integrated BioSciences program, University of Minnesota, Twin Cities.
- McGraw, A.M., R.A. Moen, and M. Schrage. 2011. Characteristics of Post-Parturition Areas of Moose in Northeast Minnesota. Alces 47:113-124.
- McGraw, A.M., R.A. Moen, and L. Overland. 2012. Effective Temperature of Cover Types Found in Moose Home Ranges in Northeast Minnesota. Alces 48:45-52.
- McGraw, A.M., J. Terry, and R. Moen. Characteristics of post-parturition areas of moose in northeast Minnesota from high frequency GPS locations. Alces in review.
- Moen, R.A., M.E. Nelson, and A. Edwards. 2011. Using cover type composition of home ranges and VHF telemetry locations of moose to interpret aerial survey results in Minnesota. Alces 47:101-112.

PROJECT TITLE: Identifying Critical Habitats for Moose in Northeastern Minnesota

Ward, R.L. and R. Moen. Measuring actual and effective browse availability for moose using a new method in northeastern Minnesota. Alces in review.

Ward, R.L. M.S. 2014. Browse availability and bite size for moose and effects of stand age on species composition and browse density in northeastern Minnesota. Integrated BioSciences program, University of Minnesota, Twin Cities.

RESULT 2:

Description: Education modules on how climate change affects moose. We will use GPS data, activity data from this project, aerial photos, and GIS to develop educational content on how moose (and potentially other species) will be affected by climate change. Content will be used in presentations, curricula, website, and at zoo kiosk. Deliverables will be updated with satellite downloads of locations and recent sightings as appropriate throughout the project.

Summary Budget Information for Result 2:

ENRTF Budget:	\$ 55,000
Amount Spent:	\$ 55,000
Balance:	\$ 0

Deliverable	Completion Date	Budget
1. Website development – Moose information and sightings reports	08/01/2010	\$8,250
2. Kiosk development for MN Zoo component	09/30/2010	\$19,250
3. Curricula development for schools at K-12 level	03/31/2011	\$16,500
4. At least 25 presentations/year to the public by team members	06/30/2012	\$11,000

Result Completion Date: June 30, 2013

Result Status as of December 31, 2010:

1. We have a Moose website developed (www.nrri.umn.edu/moose). This website is used by the general public to report moose sightings, and also to learn about moose in Minnesota. The website has been updated with about 1,000 sightings reports and about 200 pictures that have been submitted to the site.
2. Even though the project hasn't really started, we have done 4 moose related presentations. We have interest (e.g., International Wolf Center) for presentations, and will be emphasizing this deliverable after we have collars deployed on moose.
3. Subcontract with Minnesota Zoo set up.
4. Planning meeting for exhibit and curriculum with R. Moen and Zoo personnel led to development of a rough exhibit concept. Timely updates of the exhibit based on moose locations from the Iridium cell collars is one of the goals of the exhibit. A team was contracted to design and build the exhibit based on the goals developed at the initial meeting, with the design process beginning in January 2011.
5. Zoo personnel met with Boulder Lake ELC partner on teacher workshops and curriculum distribution, have done content research to support development of curriculum outline, and developed a preliminary teacher workshop schedule.

Result Status as of June 30, 2011:

1. Moose website is being updated at least quarterly. We updated sightings database in June 2011 and added pages on the McDougal Lake mortality and the capture events.
2. Contract for moose model at Zoo kiosk has been let and supporting materials developed by zoo and edited by Moen. Zoo kiosk is now complete.
3. Curricula development on moose being done, with zoo photographer coming out to photograph moose habitat/foods, and teacher workshop completed in late June. Part of the teacher workshop was a tour of northeastern Minnesota moose habitat led by Moen.
4. At least 14 presentations by project representative on moose in Minnesota were given.

Result Status as of December 31, 2011:

1. Moose website was updated once since June 30, 2011. We will update the website again in February 2012.
2. Zoo kiosk is now complete with additional funding used to add a moose statue to the exhibit.
3. Curricula development on moose is nearly complete.
4. At least 8 presentations by project representative on moose in Minnesota were given since June 30, 2011.

Result Status as of June 30, 2012:

1. Moose website was updated once since last status report. We will update the website again in August 2012.
2. Zoo kiosk and moose statue are now on exhibit at the zoo.
3. Curricula development on moose is complete.
4. At least 6 presentations by project representatives on moose in Minnesota have been given since December 31, 2011.

Result Status as of December 31, 2012:

1. Moose website preparations made for a major update in January 2012. There will be one more update for this project, but we will continue to maintain and add to the website in the future.
2. Zoo kiosk and moose statue remain on exhibit at the zoo.
3. Curricula development on moose is complete and presentations are being given by Galen Sjostrom at the Minnesota Zoo.
4. 6 presentations by project representatives on moose in Minnesota were given between July 1, 2012 and December 31, 2012, and 12 were given in 2012.

Result Status as of December 20, 2013:

1. The Moose website had a major update in June 2013. We will continue to update the website with results of moose research in the future with other funding. When graduate students and post-doctoral scientists finish all products derived from this project will be posted on the website.
2. Zoo kiosk and moose statue remain on exhibit at the zoo. A new sign was installed in summer 2013.
3. Curricula development on moose is complete and presentations are being given by Galen Sjostrom at the Minnesota Zoo.
4. The moose research projects at the University of Minnesota Duluth were featured on the UMD homepage in November 2013.
5. Over 28 presentations by project representatives on moose in Minnesota were given in 2013 (ENRTF funds were not used for travel outside of MN).
 - a. 6 presentations at Minnesota Chapter of The Wildlife Society meetings February 5-7 2013 in Walker, MN
 - b. 5 presentations at the 47th North American Moose Conference May 2013 in Whitefield, NH.
 - c. 2 presentations at the national The Wildlife Society meetings in October 2013
 - d. 1 presentation at a wildlife health meeting in International Falls, MN in October 2013
 - e. 1 presentation at a moose health workshop in Sweden in October 2013
 - f. 1 presentation at the University of Minnesota Duluth in December 2013
 - g. 12 presentations at the 2013 Moose Research and Management meeting in Cloquet, MN

Final Report Summary:

Description: Education modules on how climate change affects moose were developed at the Minnesota Zoo. We used GPS data, activity data from this project, aerial photos, and GIS to develop educational content on how moose (and potentially other species) will be affected by climate change. Content was used in presentations, curricula, website, and at zoo kiosk. Deliverables will be updated with satellite downloads of locations and recent sightings as appropriate throughout the project.

The primary outcome of this Result is to inform the public about the moose population in Minnesota. This outcome was made possible through several information transfer methods, including presentations, websites, media interviews, and curricula development at the Minnesota zoo.

The website that we developed is located at www.nrri.umn.edu/moose. It is one of the most visited websites at NRRI, and we will continue to update it after the project is over. The website has been used by schools, students in college, the general public, and management agencies. Some parts of the website such as the peer-review literature section are designed for professional biologists, while others such as the picture pages are of more interest to the general public.

PROJECT TITLE: Identifying Critical Habitats for Moose in Northeastern Minnesota

The Minnesota Zoo completed its signage and information area in 2011, and it has been viewed by thousands of zoo visitors since then. The signage is located at the moose exhibit at the Minnesota zoo, and acknowledges the role of ENRTF in funding the research projects. The Zoo also developed an elementary school curriculum on moose, and features educational activities in person and on-line based on the moose project.

Many of the personnel involved in this project gave presentations to public and professional audiences. In the status reports there are over 54 presentations recorded, and I know that I missed some of the presentations by collaborators and cooperators. I have given about half of these presentations. I will also be presenting a moose update at the 2014 DNR Roundtable in January. The level of attendance at presentations is an indication of how important moose are to Minnesota.

There have also been many media requests for interviews over the course of this research project. Interviews have appeared in newspapers, magazines, and on television. The interest by the media has been highest in the last year, driven in large part by the continuing decline in the moose population in Minnesota, and by the listing of moose as a Species of Special Concern by the MN DNR. Articles have appeared in local newspapers such as the Duluth News Tribune, Minneapolis Star Tribune, and St. Paul Pioneer Press, in addition to Outdoor News. Minnesota Public Radio and TV also did interviews that were broadcast, as did local TV news stations in Duluth. Especially in the last year, with the continued decline of moose in Minnesota, the decline of moose in other parts of the U.S., and the start of the DNR ENRTF-funded project there has also been national and international media interest, with articles in the New York Times, Washington Post, Los Angeles Times, Wall Street Journal, and others.

Minnesota is in the lead in terms of research efforts to understand and prevent the moose population from declining compared to other states and provinces, and that is one reason for the media interest. I will continue to maintain and update the website, develop outreach projects, and give presentations in the future based on this ENRTF project.

V. TOTAL ENRTF PROJECT BUDGET:

Personnel: \$244,687 Salary and Fringe calculated with University of Minnesota Electronic Grants Management System.

Within the UM personnel will be R. Moen as project manager (~41% FTE, Fringe 32%). Moen is on soft money funding and is required to write proposals to pay his salary. Other personnel are a Graduate Research Assistant (identity not known, ~50% FTE, Fringe 44%), a Lab Tech (identity not known, ~25% FTE, Fringe 37%), and several Undergraduate Research Assistants (identity not known, ~15% FTE, Fringe 7%). Personnel effort may be adjusted depending on availability and tasks.

Contracts: \$ 73,124

Minnesota Zoo. \$12,000. \$8,000 materials, design, installation of kiosk graphic, \$3,000 curriculum development (5% FTE, Fringe 32%), \$1,000 teacher workshop supplies.

PROJECT TITLE: Identifying Critical Habitats for Moose in Northeastern Minnesota

1854 Treaty Authority Resource Management Division. \$19,357. Moose capture, necropsies, outreach presentations (8% FTE, Fringe 16%), \$3996 travel, \$1180 field supplies. The 1854 Treaty Authority is an Inter-Tribal Natural Resource Management Agency that manages the off-reservation hunting, fishing, and gathering rights of the Grand Portage and Bois Forte bands of the Lake Superior Chippewa in the territory ceded under the Treaty of 1854. Personnel to be funded are on soft money funding and proposal funding is required to maintain positions.

Fond du Lac Reservation Resource Management Division. \$4,338. Moose capture, necropsies, outreach presentations. 2% FTE, fringe 16%, \$2664 travel, \$789 field supplies.

Moose capture. \$37,429. Capture 25 moose in first year and additional moose in second year to replace mortalities. Estimated about \$1,333 / moose.

Other direct operating costs:

Spotter plane. \$5,644. Needed during capture and for mortality searches (125 hrs * \$200/hr). We will use DNR or Superior National Forest (SNF) airplanes if available. Costs change from year to year so we have estimated flight time at \$200 / hour. If DNR and SNF planes are not available we will let flight contracts out for bid.

Argos. \$27,187. Cell phone contract with JouBeh Technologies Inc. for data transmission. Estimated costs just over \$800/year/collar. This is a single source item.

Capital equipment over \$3,500:

Lotek Wireless, Inc. \$110,780. GPS-Iridium collars with activity counter (26 collars at \$4,230).

Equipment/Tools/Supplies: \$ 26,542

Field supplies. \$2,807. Moose capture, necropsy supplies, temperature loggers.

Workshop supplies. \$1,000. Items needed for teacher workshops.

Capture drugs. \$13,779. Needed for areas where darting is required (vs. net-gunning).

GIS Lab hourly rate. \$1,500. Hourly rates to use NRRI GIS lab.

Refurbish collars for year 2. \$8,456. Estimated collar refurbishing costs for year 2.

Lotek GPS-Iridium collars that will be deployed on moose in the ENRTF study area. There are now 3 companies in the world who can make collars meeting bid specification. Residual value of some collars will be low if wolves chew on belting or antenna. Collars may be useable for another year or two if other projects exist (e.g., additional regulatory and project costs associated with use and value include permitting, moose capture, Iridium cell phone communication) but residual value is hard to quantify at this time.

PROJECT TITLE: Identifying Critical Habitats for Moose in Northeastern Minnesota

Travel: \$ 19,036. All travel is in state following guidelines.

We have estimated these amounts and they may vary depending on areas where moose are collared, investigating mortalities if they occur during the year, evaluation of habitats used by moose and capture operations. We estimated \$15,000 for field work (mileage, per diem food, and lodging). We have budgeted \$12,000 for Presentations and Teacher workshops. Presentations will be throughout much of the state, and thus will require mileage. We will also need per diem food and lodging when presentations are too far from study site. Teacher workshops will be for presenters, and also some funding for travel by teachers to and from the workshops. Finally, we estimated \$3,000 for travel during development of the kiosk and for developing the teacher training workshops. Because group members are based in the Twin Cities and in northern Minnesota, overnight travel will be required. We will attempt to minimize travel during development through the use of conference calls and electronic communications.

TOTAL ENRTF PROJECT BUDGET: \$ 507,000

Explanation of Capital Expenditures Greater Than \$3,500: Collars obtained by bid as explained above. Since the project began collar technology has improved tremendously. The vendor used by the MN DNR for it's ENRTF Adult Moose Mortality Project is different and currently provides a product that is less expensive than refurbishing the collars used in this project. The new technology is also superior to the satellite collars used in this project, which means these collars currently have little residual value.

VI. PROJECT STRATEGY:

A. Project Partners:

Project Partners with Contracts

Michael Schrage, Fond du Lac Resource Management Division (FDL). FDL committed to \$40,000 in-kind match over the 3-year project. FDL receive \$9,000 over the three year project for moose capture, necropsy assistance, and presentations. The FDL contract was reduced to \$4338 because FDL contributed effort in kind.

Andrew Edwards, 1854 Treaty Authority (1854). 1854 committed to \$10,000 in-kind match in the first year of the project. Budget planning horizon prevented further commitment. The 1854 contract will receive \$10,000 over the three year project for moose capture, necropsy assistance, and presentations. 1854 contributed significantly to the project with staff time and travel support.

Grant Spickelmier, Minnesota Zoo. The Zoo committed to \$8,000 in-kind match in the first year of the project. The Zoo will receive 12,000 over the three year project for Kiosk design and construction, website development, curriculum development, and teacher training workshops

Project Partners without contracts

Dr. Mark Lenarz, MN DNR
 Mark Johnson, MDHA

B. Project Impact and Long-term Strategy:

Moose have great economic and emotional value to Minnesota. The near disappearance of moose from NW MN heightened concern for the NE moose population, and led to the formation of a Moose Advisory Committee (MAC) by the MN DNR at the direction of the Minnesota Legislature. The MAC made several recommendations for moose management and research that are being incorporated into a Moose Management Plan being written by the DNR. Members of the MAC are on this proposal, and will work with the DNR to implement Best Management Practices guidelines.

We will also be reaching the people of Minnesota via multiple pathways. The moose website (www.nrri.umn.edu/moose) is active and has received over 350 sightings reports in less than 4 months. The zoo kiosk will be viewed by many zoo visitors, and presentations by the PI's to groups will also result in interactions with the public. Curricula development and teacher workshops for K-12 teachers will reach the school audience.

In short, because of the importance of moose to many people in Minnesota, we believe this will be a project that is popular and well-received, especially as we gain results over the next 3 years.

C. Other Funds Proposed to be Spent during the Project Period:

SOURCE OF FUNDS	AMOUNT	Source	Comment
NRRI, UMD	\$8,500	UM	NRRI funds to project manager (~10% FTE)
NRRI, UMD	\$17,000	UM	NRRI funds to project manager (~10% FTE). Pending.
MDHA (3 years)	\$5,000	NGO	Collar purchase or moose capture
In-kind Services:			
MN DNR DFW Forest Wildlife Research Group (3 yrs)	\$25,000	State	Salary and Fringe (~5% FTE) and mileage (est. \$1K / year).
MN DNR DFW Wildlife Health Group (3 yrs)	\$20,000	State	Salary and Fringe (~5% FTE) and mileage (est. \$1K / year).
Fond du Lac Reservation RMD (3 yrs)	\$40,000	Tribal	Salary and Fringe (~9% FTE) and mileage (est. \$2K / year).
Superior National Forest	-----	Federal	Pending. Flight time/Field Housing probable.
1854 Treaty Authority RMD (1 yr)	\$10,000	Tribal	Salary and Fringe (~9% FTE) and mileage (est. \$2K / year).
Minnesota Zoo (1 yr)	\$8,000	State	Salary and Fringe (~10% FTE).
Total	\$133,500		Sum of other funds is about 30% of project (see also Spending History)

PROJECT TITLE: Identifying Critical Habitats for Moose in Northeastern Minnesota

D. Spending History:

Prior to and concurrent with the ENRTF project are projects in Voyageurs National Park (~\$300K) and on the Grand Portage Indian Reservation (~\$200K) using same collars and same experimental design. These projects are stand-alone and independent of the ENRTF project but results from other two projects will strengthen ENRTF results.

\$5K has been spent by NRRI-UMD (Moen) on website development, temperature measurements, and collar testing.

VII. DISSEMINATION:

December 31, 2010:

1. We have made 4 presentations to different groups from 7/1/2010 to 12/31/2010
2. The moose website (www.nrri.umn.edu) is both active and passive dissemination
3. We have begun planning for media presence at the January 2011 moose capture

June 30, 2011:

1. We made at least 14 presentations to different groups from 1/1/2011 to 6/30/2011.
2. Moose website updated and new content added.
3. Coverage of moose capture and collar event in Duluth News Tribune and Minneapolis Star Tribune, as well as local newspapers.

December 31, 2011:

1. We made at least 8 presentations to different groups from 6/30/2011 to 12/31/2011.
2. Moose website updated and new content added in August.
3. Coverage of moose project / moose issues in Duluth News Tribune and in TV interview on Duluth TV station, November 2011.

June 30, 2012:

1. We made at least 6 presentations to different groups from 12/31/2011 to 6/30/2012.
2. Moose website updated and new content added in February.
3. Preparation interview with Josephine Marcotti for an article in the Minneapolis Star Tribune, probably out in September, 2012.

PROJECT TITLE: Identifying Critical Habitats for Moose in Northeastern Minnesota

December 31, 2012:

1. We made at least 6 presentations to different groups from 6/30/2012 to 12/31/2012.
2. Moose website updated and new content added in January.
3. Discussions with press resulting in articles on radio and newspaper during this reporting period. One NPR link is still [active](http://minnesota.publicradio.org/display/web/2012/12/12/daily-circuit-moose-concern-dnr/) (<http://minnesota.publicradio.org/display/web/2012/12/12/daily-circuit-moose-concern-dnr/>).

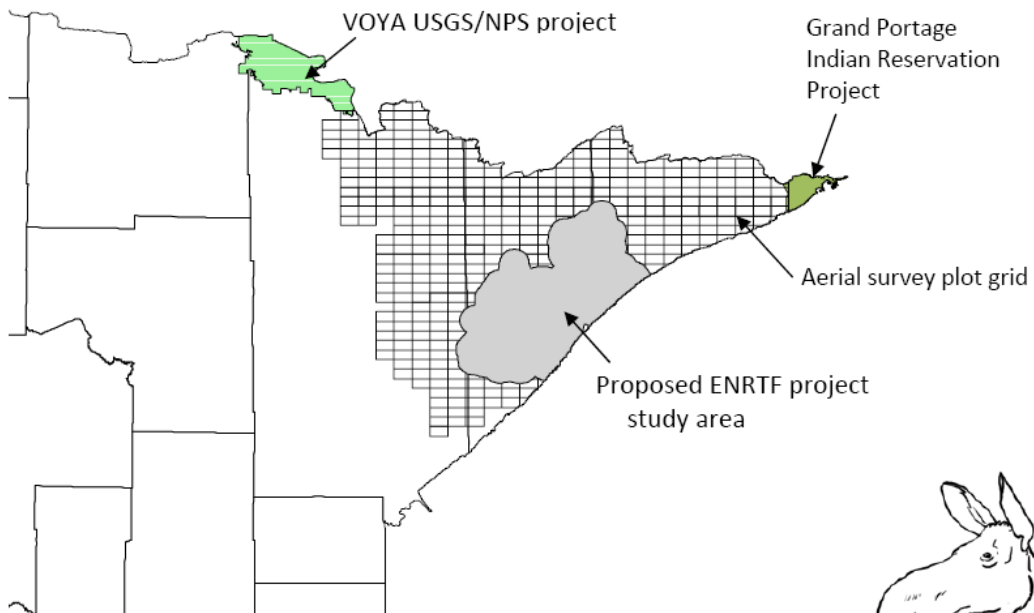
December 20, 2013:

1. Over 28 presentations by project members on moose in Minnesota were given in 2013. Presentations are listed in the Result Status section above.
2. Moose website updated and new content added in June 2013.
3. Many discussions with press resulting in articles on radio and newspaper during this reporting period. Media outlets included Minnesota Public Radio, Duluth News Tribune, Minneapolis Star Tribune, Los Angeles Times, BBC in Ontario and Newfoundland, Sweden Public Radio, Toronto Star, and others.

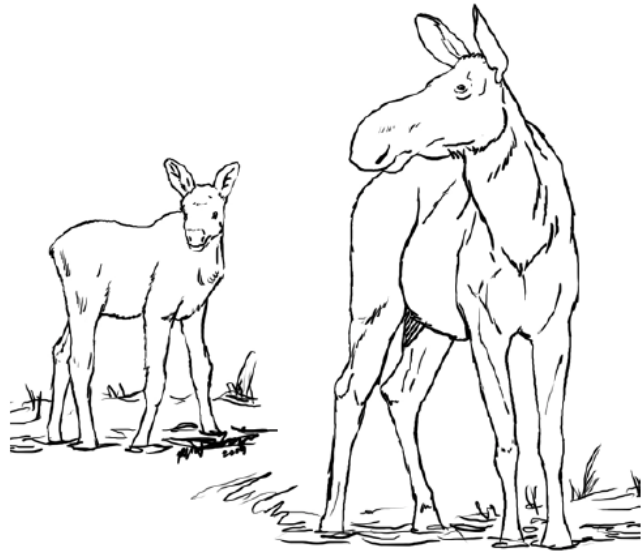
VIII. REPORTING REQUIREMENTS: Periodic work program progress reports will be submitted not later than the last day of December 2010, June 2011, December 2011, June 2012, and December 2012. A final work program report and associated products will be submitted between June 30 and August 1, 2013 as requested by the LCCMR.

IX. RESEARCH PROJECTS: A Research Addendum has been prepared.

X. Project Map



Proposed ENRTF GPS collar project study area is based on home ranges of moose in the ongoing VHF collar study. This VHF study in the southern portion of moose range provides baseline data on home range size and mortality from 150 moose with VHF collars. Critical habitat areas will be identified throughout the background grid of aerial survey plots used by the MN DNR for the annual moose survey.



Attachment A: Budget Detail for 2010 Projects - Summary and a Budget page for each partner (if applicable)							
Project Title: Identifying Critical Habitats for Moose in Northeastern Minnesota							
Project Manager Name: Ron Moen							
Trust Fund Appropriation: \$ 507,000							
2010 Trust Fund Budget	<u>Result 1 Budget:</u> <u>REVISED (3)</u>	Amount Spent (6/2013)	Balance (6/2013)	<u>Result 2 Budget:</u> <u>REVISED (3)</u>	Amount Spent (6/2013)	Balance (6/2013)	TOTAL BUDGET
	Identify habitats critical to moose survival in Minnesota			Education modules on how climate change affects moose			
BUDGET ITEM							
PERSONNEL: wages and benefits							
R. Moen (project manager). ~41% FTE, Fringe 32%	103,910	103,910	0	14,180	14,180	0	118,090
Grad RA (TBD). ~50% FTE, Fringe 44%	60,655	60,655	0				60,655
Lab Tech (TBD). ~25% FTE, Fringe 37%	37,924	37,924	0	4,517	4,517	0	42,441
Undergraduate RA (TBD). ~15% FTE, Fringe 7%	21,735	21,735	0	1,766	1,766	0	23,501
Other contracts							
Minnesota Zoo. \$8,000 materials, design, installation of kiosk graphic, \$3,000 curriculum development (5% FTE, Fringe 32%), \$1,000 teacher workshop supplies.				12,000	12,000	0	12,000
1854 Treaty Authority. Moose capture, necropsies, outreach presentations (8% FTE, Fringe 16%), \$3,996 travel, \$1,180 field supplies	16,357	16,357	0	3,000	3,000	0	19,357
Fond du Lac Reservation. Moose capture, necropsies, outreach presentations. 2% FTE, fringe 16%. \$2,664 travel, \$789 field supplies.	4,338	4,338	0	0	0	0	4,338
Moose capture. \$1,000/moose + ~ 2K helicopter time + Vet expenses + Travel	37,429	37,429	0				37,429
Other direct operating costs							
Spotter plane during capture/Mort searches (125 hrs * \$200/hr)	5,644	5,644	0				5,644
Iridium -- Satellite communications (est. \$800 / collar / year)	27,187	27,187	0				27,187
Capital equipment over \$3,500							
Lotek Iridium GPS satellite collars w/ activity counter (25 collars at \$4,230). Reduced data acquisition cost and no recapture -- shifting funds from Argos and Moose capture to cover deficit.	110,780	110,780	0				110,780
Supplies (list specific categories)							
Field supplies	2,807	2,807	0				2,807
Workshop supplies				0	0	0	0
Backup supplies (hard disk)							
Capture drugs	13,779	13,779	0				13,779
GIS Lab hourly rate	1,500	1,500	0				1,500
Refurbish collars for year 2	8,456	8,456	0				8,456
Travel expenses in Minnesota							
Study site work	15,036	15,036	0				15,036
Presentations/Teacher workshops				4,000	4,000	0	4,000
Kiosk and Workshop Development				0	0	0	0
COLUMN TOTAL	\$467,537	\$467,537	0	\$39,463	\$39,463	\$0	\$507,000