

# 2019 Moose Habitat Survey

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## Introduction

Fire and timber harvest are generally believed to be beneficial to moose through the creation of early successional forest. A study of moose response to the 1971 Little Indian Sioux Wildfire in Minnesota by Peek (1974), and other authors (Lenarz et al. 2011 and Peek et al. 1976), support this view. Public and media interest following recent large fires in northeastern Minnesota often includes questions regarding benefits to moose. Along with other reasons, timber harvest in northeast Minnesota is frequently justified as a way to improve moose habitat (Superior National Forest [SNF] 2011).

Constitutionally dedicated funding for Minnesota wildlife habitat and a declining moose population has increased interest and support for moose habitat enhancement and led to discussions among managers about where and how to fund habitat projects using timber management and prescribed burning (M. Johnson, Minnesota Deer Hunters Association, personal communication). As a result, natural resource managers have expressed interest in better understanding whether or not moose have responded positively to recent large wildfires and prescribed burns, and similarly, whether moose will respond positively to proposed timber management projects. Although moose habitat quality is not necessarily seen as responsible for the recent decline in moose numbers, the Minnesota Moose Research and Management Plan recognizes that habitat management may have an important role to play in mitigating this decline (Minnesota Department of Natural Resources [DNR] 2011). More recent research, however, provides some evidence moose regularly face nutritional restriction during winter, which may be impacting population performance, and suggests habitat deficiencies are playing a role (DelGiudice, et. al. 2018).

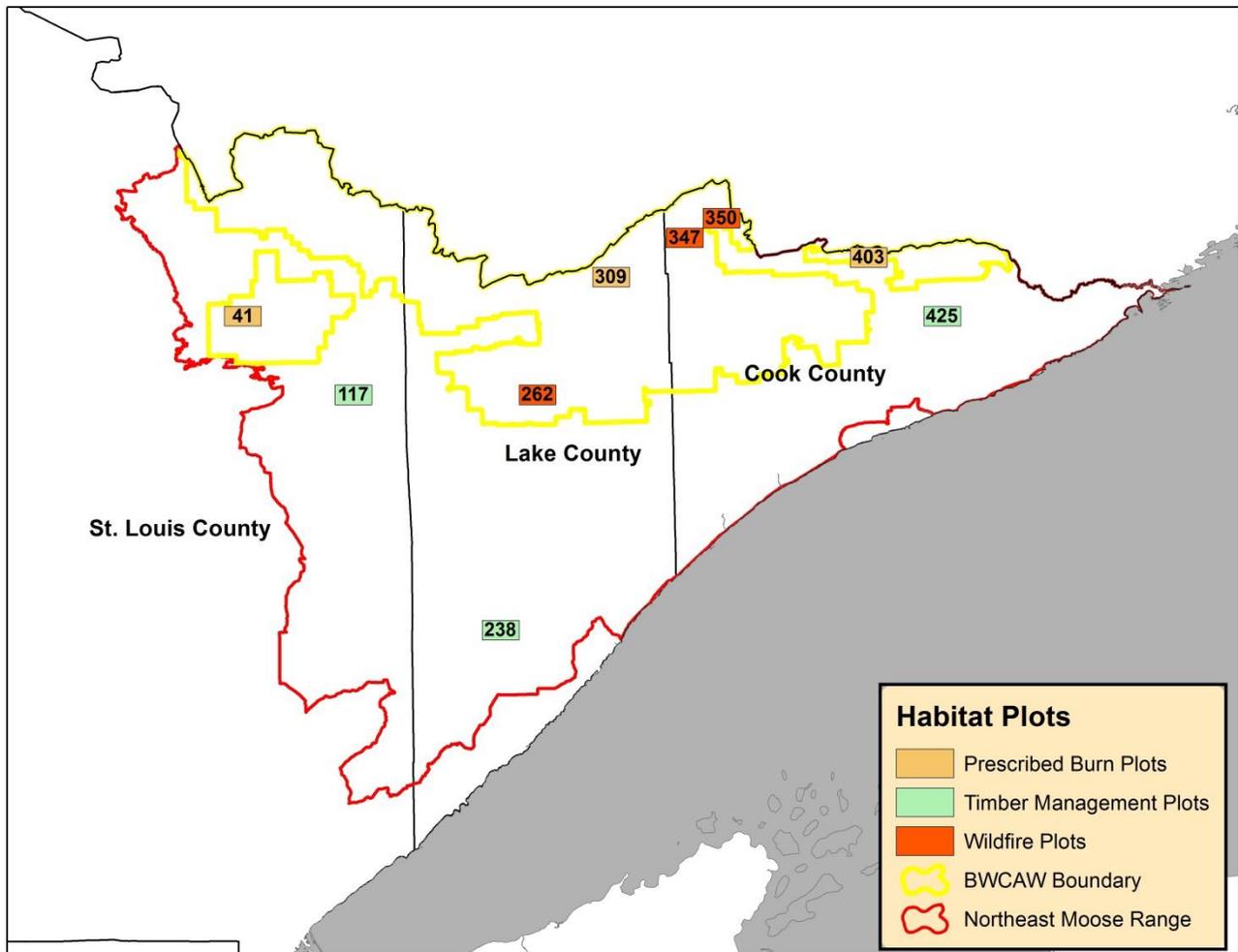
Prior to 2012 the stratified random sampling design for the annual moose population survey precluded regular observations of large habitat changes. Survey plots were randomly selected from high, medium or low moose density areas, and many years might elapse before the same survey plot was flown again. This made it difficult to obtain local knowledge on how moose responded to a large habitat change and how that response changed over time. To help fill this knowledge gap, this habitat survey was initiated in January, 2012. The primary objectives of this survey are to detect a numeric moose response due to wildfire, prescribed (Rx) burning, and timber management activities and determine how that response changes over time. This information is intended to assist decision-making for funding and moose habitat management, and to provide more accurate and local information to managers and stakeholders on how habitat changes have impacted moose.

## Methods

In order to minimize costs and time requirements and maximize comparison with other moose demographic data, the habitat survey is flown concurrent with and using the same methods as the annual moose population survey (DelGiudice, 2019). The population survey uses a stratified random sampling technique with 3 strata based on expected moose density. The demographic data from the habitat survey are incorporated into the population survey results through the use of a permanent 4<sup>th</sup> stratum.

Habitat survey plots were located across moose range in northeastern Minnesota (Figure 1.) All survey plots were rectangular (5 x 2.67 mi.) and 8,544 acres in size. The 2019 survey was flown using a DNR operated

Bell Jet Ranger (OH-58) and a MD500E helicopter. The program DNRSurvey, on Toughbook® tablet style computers, was used to record survey data. Although the population estimate incorporates visibility bias using a sightability model based on visual obstruction, for simplicity, this report compares direct observations of moose on each habitat plot to the mean observed number of moose on other plots in the high density stratification i.e. habitat plot results are compared against plots with the highest expected moose densities and presumably the best moose habitat. From 2004-13, plots in the highest density stratification were expected to have uncorrected moose numbers of  $\geq 21$  moose/plot. Due to the decline in moose numbers (Figure 2), stratification levels were changed prior to the 2014 survey. From 2014-19 plots stratified as high density plots are where an uncorrected count of  $\geq 8$  moose/plot is expected.



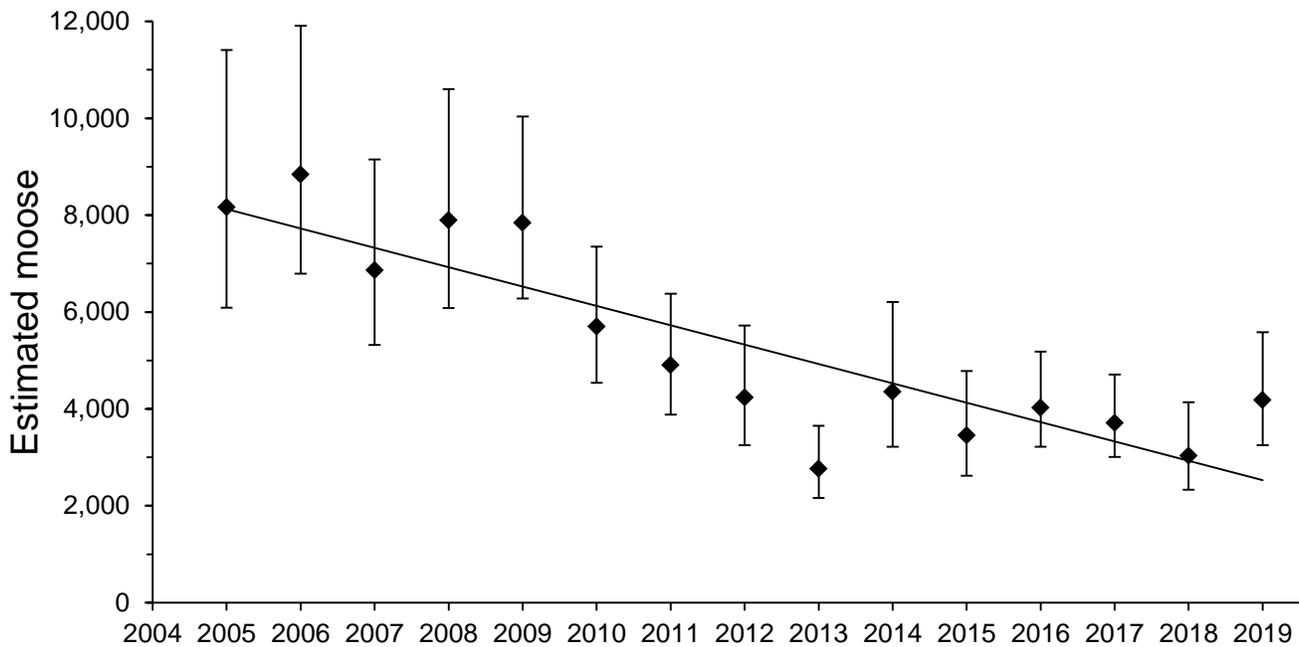
**Figure 1.** Locations and treatment types of the 9 moose habitat survey plots.

After consultation in 2011 with local tribal, DNR and SNF staff, three plots in each of three treatments types were selected to be flown as part of this survey. Treatment types were defined as wildfire, prescribed (Rx) burns, and timber management (primarily timber harvest). Plots were selected for a variety of reasons, including geographic distribution, availability of previous years' survey data, percentage of a plot impacted by a treatment, and time since treatment or until a planned treatment. Descriptions of vegetative type and ages, ownership patterns, and harvest history for timber management plots were obtained from local DNR and SNF wildlife staff. Information on fire history, acres burned, and 1999 blowdown patterns was obtained from SNF geographic information system (GIS) layers. Moose locations in this report are overlaid on summer 2017 Farm Service Agency photos provided by Minnesota Geospatial Image Service. The intention is to fly each of the

nine habitat plots on an annual basis for an estimated 20 years to help minimize the influence of annual variation of observed moose, and to determine how moose response to a disturbance or treatment changes over time. When available, plot data from previous surveys back to 2004 are included in this report. Results prior to 2004 are not directly comparable to results in this report due to changes in plot design and survey techniques. The number and location of moose observed are reported for each plot.

## Results and Discussion

Survey conditions in 2019 were described by DelGiudice (2019). The survey was initiated on 3 January and completed on 17 January with 10 actual survey days. Including the 9 habitat plots, a total of 52 plots were surveyed in 2019. Survey conditions were rated as “Good” and snow depths were estimated at  $>16$ ” on all 9 habitat plots. Results for this habitat survey should be considered in the context of the entire northeastern Minnesota moose population. While still a linear decline since 2006 when the population was approximately 8800 moose, the trend appears to have stabilized since 2012 at between 3000 - 4000 moose (Figure 2). In 2019 the average number of moose seen on the 12 high density moose plots was 16.



**Figure 2.** Point estimates, 90% confidence intervals, and trend line of estimated moose numbers in northeastern Minnesota, 2005-2019 (DelGiudice, 2019).

## **Timber Management Plots**

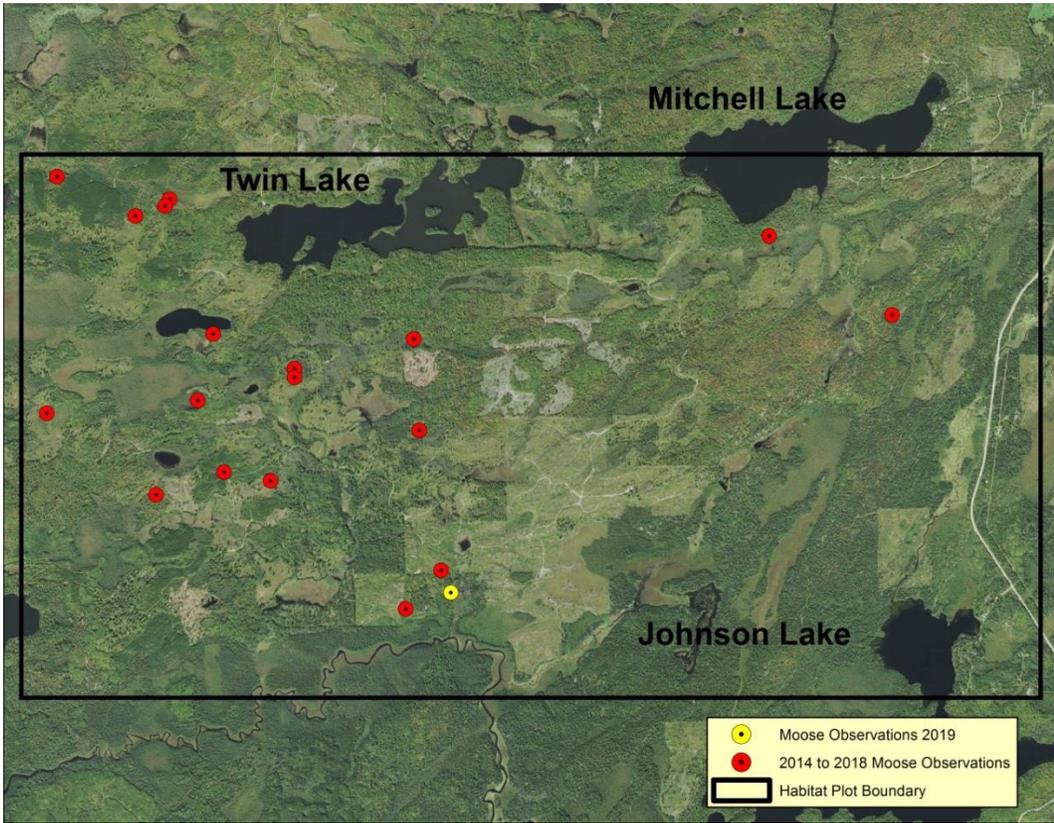
### **Plot 117: Twin-Mitchell Project Area**

Plot 117 is located seven miles southwest of Ely (Figure 3). Land ownership within the plot is a mixture of approximately 31% St. Louis County, 29% SNF, 19% State of Minnesota, 16% private, and 5% public waters of Minnesota. There is one DNR administered Scientific and Natural Area located partially within the plot boundary. It accounts for <1% of the State ownership and is mainly old growth red and white pine. The plot is a mix of upland forest with intermixed lowlands of black spruce, mixed swamp conifer, alder and lowland brush and grass. The upland vegetation is a mix of aspen/spruce-fir, red pine, white pine and jack pine cover types. Stand ages range from 0-9 age classes to some red and white pine stands that are 100+ years old. The majority of private lands are mature and older forest. This plot and the Trout Lake Rx Burn plot 41 are the only two habitat plots where white-tailed deer are regularly observed during the survey.

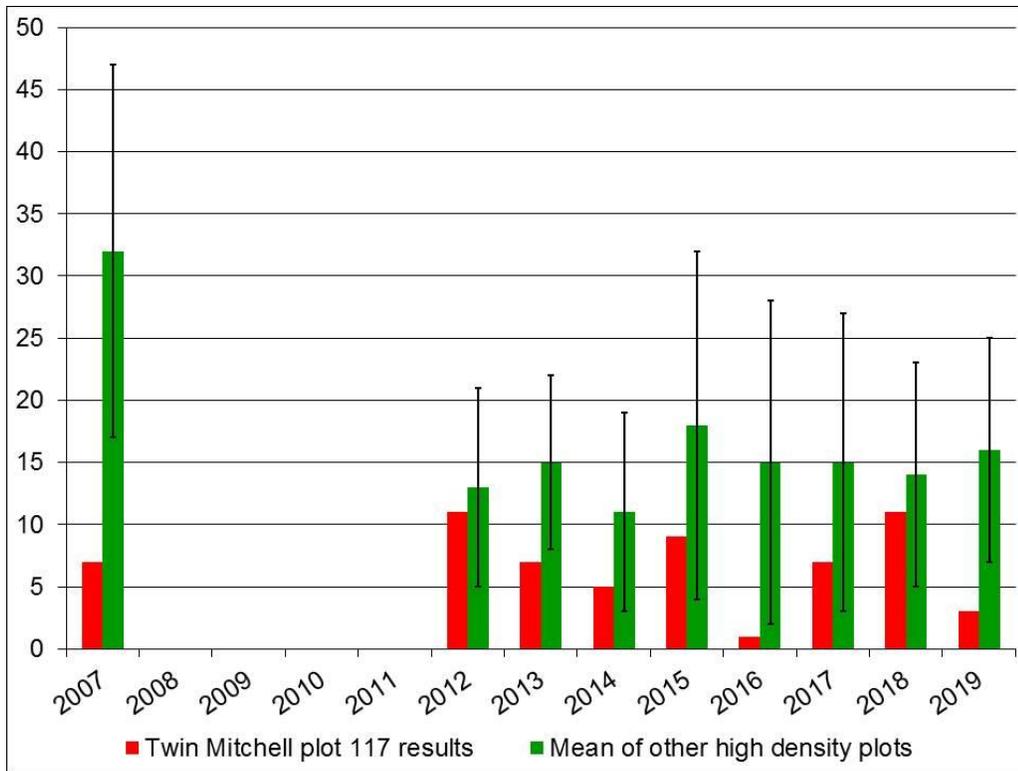
State land ownership accounts for 1,528 acres of the total plot and is comprised of 70% conifers, 24% hardwoods, and the remaining 6% a mix of lowland brush, muskeg, permanent and non-permanent water habitats. Approximately 55% of the State conifer stands are 0-20 years old, 7% are 20-40 years, and 13% are between the ages of 40-85. The remaining 25% includes stands of white pine, red pine, cedar and black spruce that are 100+ years old. Approximately 16% of the State hardwood stands are 0-10 years in age, 35% are 10-30 years, and 34% are between the ages of 30-85. The remaining 15% are mainly ash stands that are 100+ years old. Stands currently listed as “under development” include 94 acres or 76% of the hardwood stands in the 30-85 year old category. Since 2013 the state has harvested 40 acres of aspen, planted 54 acres of red pine and planted 20 acres of lowland black spruce. There has also been 21 acres of conifer enhancement completed within the plot. Past harvest of State lands within this plot has occurred primarily in white pine, red pine, black spruce, and aspen stands.

Superior National Forest land accounts for 2,423 acres of the total plot and is comprised of 47% upland deciduous or aspen/conifer mix, 19% lowland conifer, 20% upland conifer, and 14% lowland shrub or open wetland. Eleven percent of the SNF land was harvested sometime in the last 30 years. Approximately one third of those acres (97 acres) were harvested since 2014, and the rest about 20-30 years ago. The remainder of SNF land within this plot is in a mature and older condition. Between the years of 1995-2013 St. Louis County harvested approximately 1040 acres in aspen and conifer forest types. Since 2013 St Louis County has harvested approximately 220 acres of upland aspen and planted 55 acres of red pine.

In 2019, three moose were observed on plot 117, part of the Twin-Mitchell Project Area (Figure 4). For the nine years observations have been made on plot 117, the results have underperformed the mean for other high density moose plots in the same year.



**Figure 3.** Plot 117, part of the Twin-Mitchell Project Area for timber management.



**Figure 4.** Twin Mitchell plot 117 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

### **Plot 238: Beaver River Project Area**

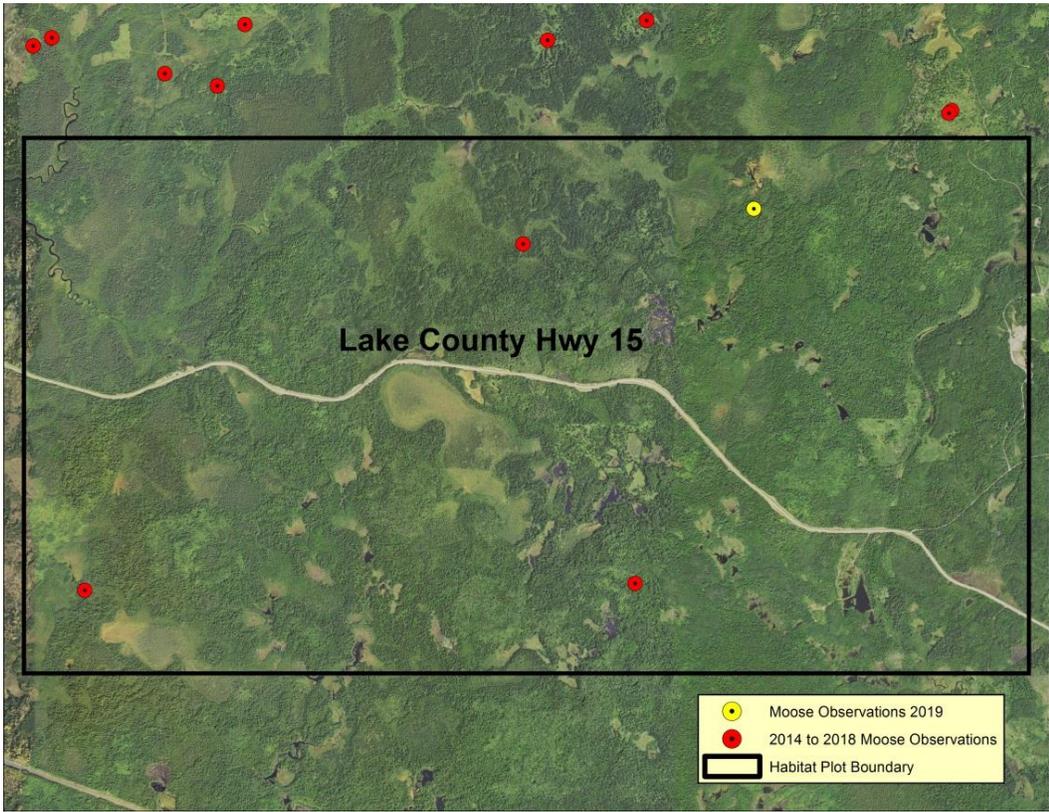
For 2019 the decision was made to drop the Lillian Creek plot 237 and replace it with plot 238 for this monitoring effort. The pending SNF Beaver River Project is proposed to impact substantially more acres on plot 238 than 237 (2,545 vs 410 acres). In addition, not much recent timber harvest or other forest management had been accomplished in recent years on 237, and 238 has more upland acres than 237 has. There were two previous moose surveys of plot 238 in 2010 and 2015, and harvest activities under the Beaver River Project are not likely occur for 1-3 years yet. This should allow for a string of pretreatment observations to help determine the impacts of the Project. Therefore it was felt 238 would be a better plot on which to assess the long term impacts of timber management on moose numbers.

Plot 238 is centered on Lake County Highway 15 from the Cloquet River crossing on the west to the Beaver River crossing on the east (Figure 5). The plot has mixed ownership; 77% SNF, 11% private ownership, 10% Lake County, and the remaining 2% in State ownership. Upland habitat comprises 56% of the plot and the upland vegetation is dominated by the aspen/spruce-fir cover type. In addition, there are a few acres in stands typed as upland black spruce, jack pine and sugar maple. Some stands across all ownerships are typed as upland brush. Freshwater Forested/Shrub Wetland is the dominant wetland type, and these are dominated by black spruce, mixed swamp conifer, and lowland brush. The majority of timber on SNF land (81%) is older than 70 years of age. On Lake County land 60% of the timber is >70 years of age and 19% is less than 12 years of age.

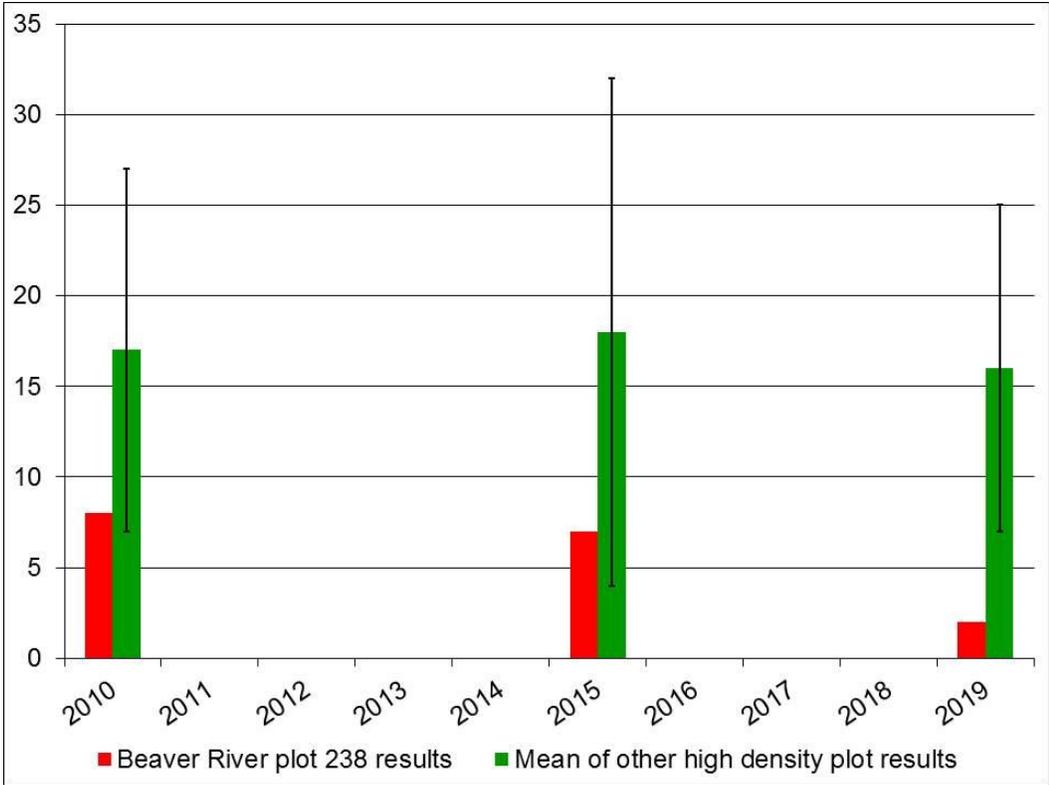
There has been little recent timber harvest on the plot. Less than 1% of SNF land has been harvested in the last 20 years (62 acres) and an additional 10% of the SNF timber was cut 20-40 years ago. Lake County has harvested 16% of their land in the last 25 years. Lake County plans to shear 96 acres for moose browse creation.

Harvest plans for SNF lands on Plot 238 are part of the Beaver River Project and include approximately 2,680 acres of various treatments, including 1,668 acres of clear-cut with reserves. The final environmental assessment for the Beaver River Project area was released 15 February, 2019. Timber harvest is expected to take 3-5 years to complete. There are no current plans for harvest on State land.

In 2019, two moose were observed on plot 238, part of the Beaver River Project Area (Figure 6). Plot 238 has underperformed the mean of other high density plots in all three years this plot has been surveyed since 2004. It will be interesting to see how or if moose numbers change as the Beaver River Project progresses.



**Figure 5.** Plot 238, part of the Beaver River Project Area for timber management.

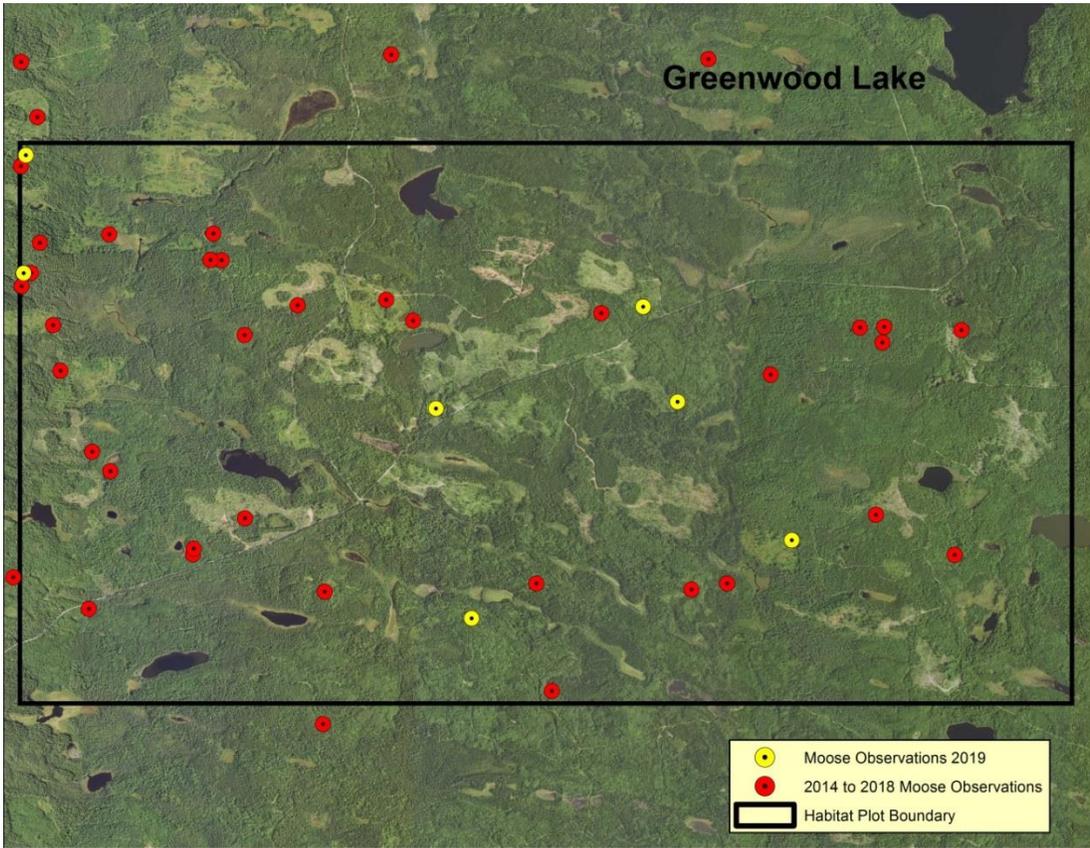


**Figure 6.** Beaver River plot 238 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

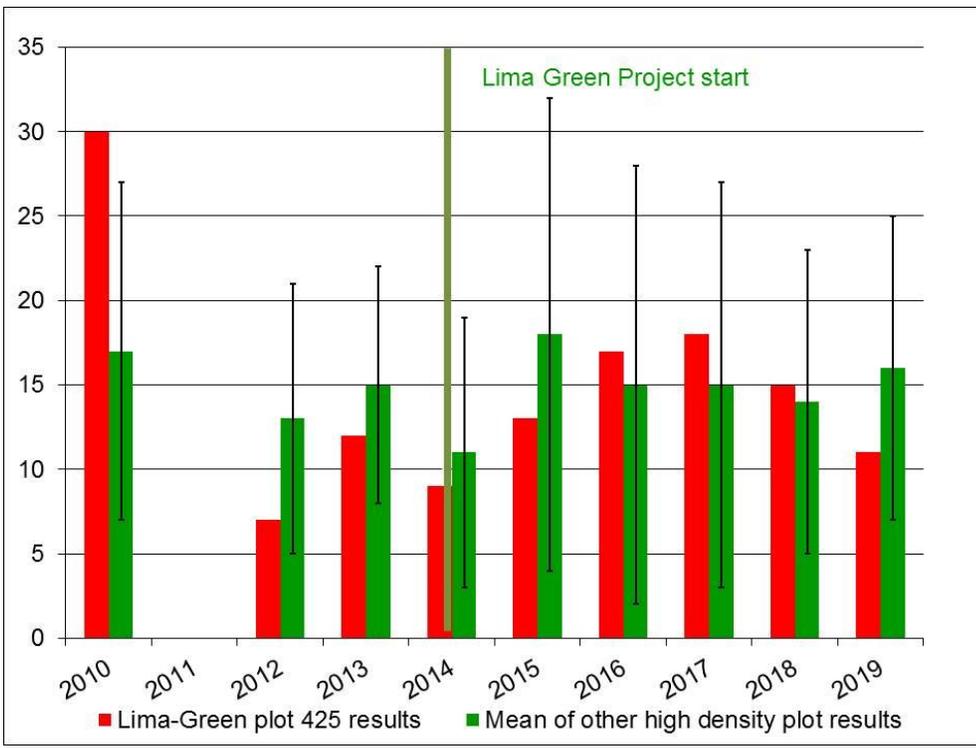
## **Plot 425: Lima Green Project Area**

Plot 425 is located immediately southwest of Greenwood Lake in Cook County (Figure 7). Ownership is approximately 85% SNF and 15% State. Harvest plans for SNF lands in plot 425 include approximately 2,375 acres of various treatments, including 1,917 acres of clear-cut with reserves. Timber harvest on the Lima Green Project began in April of 2014 and operations are anticipated to continue through 2020. Land cover definitions and forest ages were acquired from the most recent Forest Service and MN DNR stand inventory data. Previous descriptions of the plot erroneously reported landscape ecosystem cover definitions, which do not accurately reflect existing forest types. Across all ownerships, approximately 93% of the land cover is forested, while 7% is nonforest (open or semi-permanent water, herbaceous, or shrub cover). Of the forested cover, aspen-birch and aspen-mixed-conifer forest types are the most common (comprising approximately 46% of the plot), followed by black spruce (19%) and red and white pine (13%) forest types. Significant timber harvest has occurred in the plot within the last 10 years, especially on Forest Service land. Approximately 16% of the forest cover is less than 10 years old, with a majority of harvests occurring within the last 5 years. Nearly a quarter of the forested area of the plot (22%) is less than 20 years old. Approximately 38% of forests are between age 20 and 50, 16% are between 50 and 80 years old, and 24% are older than 80 years old. Regeneration across harvest units is primarily aspen with white pine and white spruce intermixed as a component of future stands through a combination of planting and natural regeneration from reserve trees.

In 2019, 11 moose were seen on plot 425, part of the Lima Green Project Area (Figure 8). In the 4 years observations were made on plot 425 up to the start of timber harvest associated with the Lima Green Project, results underperformed the mean of other high density plots in three of those years. Since 2015, the first year after the start of timber harvest, the plot has outperformed the mean of other high density plots in three of five years.



**Figure 7.** Plot 425 part of the Lima Green Project Area for timber management.



**Figure 8.** Lima Green plot 425 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

## **Prescribed Burn Plots**

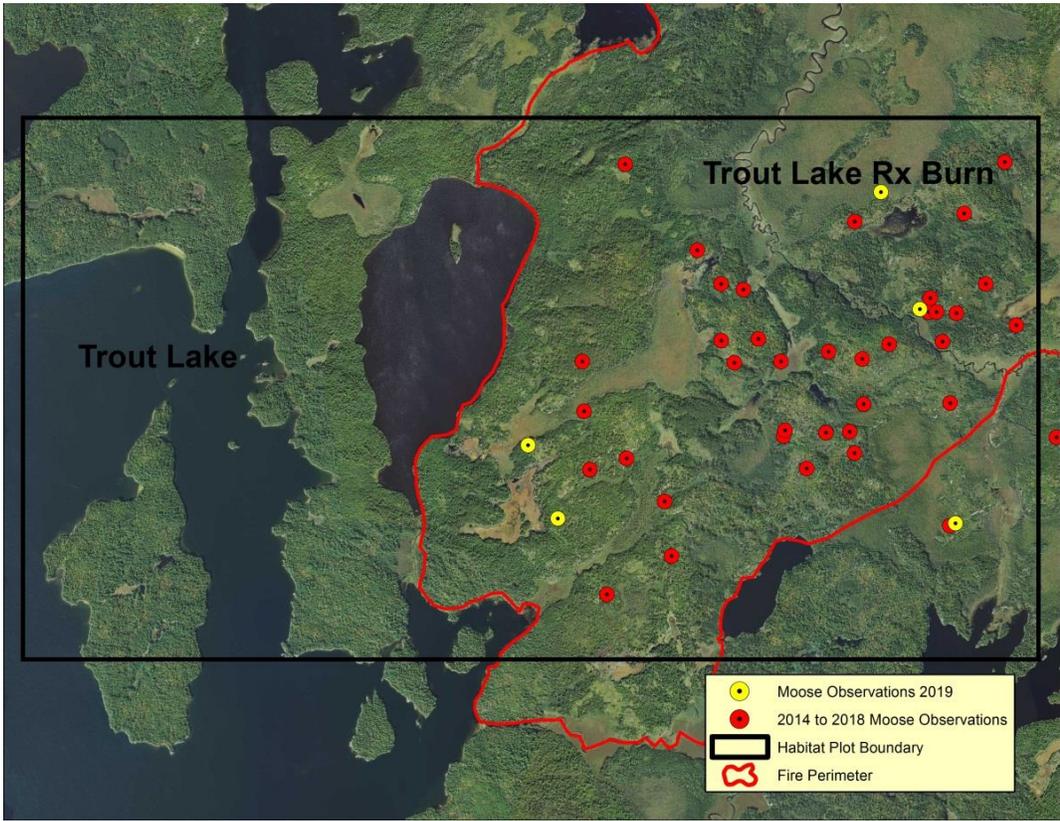
### **Plot 41: Trout Lake Rx Burn**

Plot 41 is located on the northeastern shore of Trout Lake in the Boundary Waters Canoe Area Wilderness (BWCAW) in St. Louis County (Figure 9). The Trout Lake Rx Burn was conducted in September, 2005 and totaled 9,867 acres of which approximately 3,860 acres are in the plot. The main purpose of the fire was to reduce fuel loads following the 4 July, 1999 blowdown event. Except for 1,250 acres in the northwest corner of the plot, plot 41 was entirely impacted by the blowdown with damage increasing in a generally west to east direction. On 1,540 acres, wind damage was estimated at 10-33% of the standing timber. On 4,400 acres across the central and southern portions of the plot wind damage was estimated at 34-66% of the timber. In the northeastern corner of the plot, 1,290 acres suffered damage to 67-100% of the timber. This plot and the Twin Mitchell plot 117 are the only two habitat plots where white-tailed deer are regularly observed during the survey.

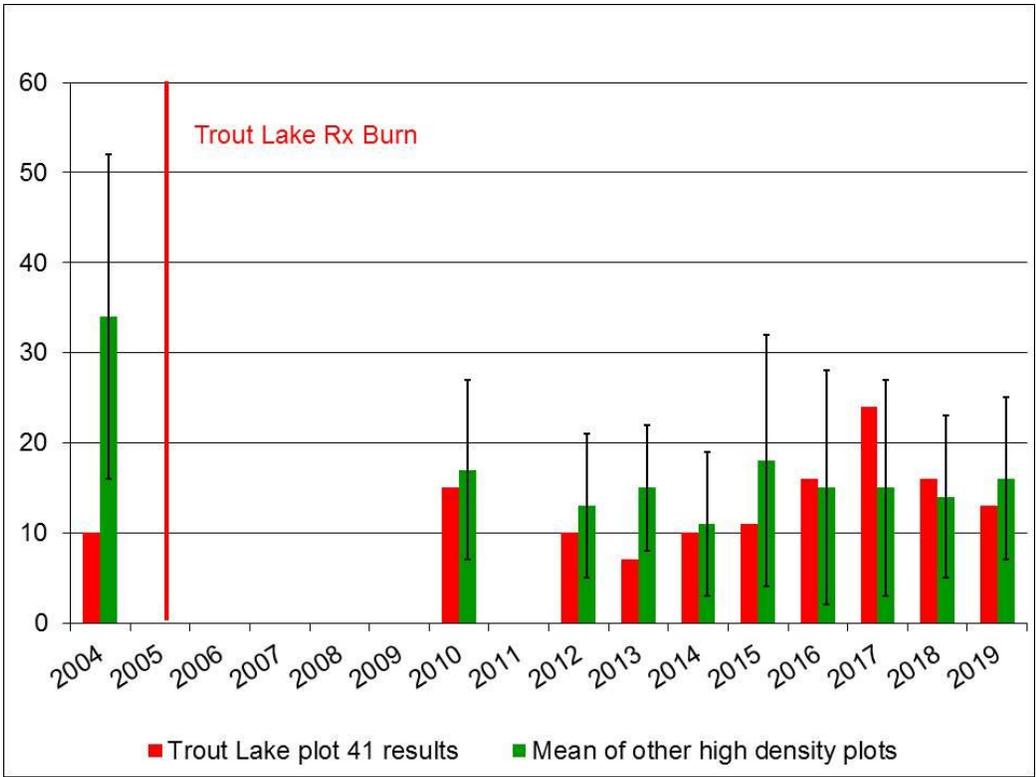
Almost all moose observations on this plot for the period of 2012-19 have been within the fire perimeter (Figure 9, Schrage, 2017). Aerial observation suggests fire intensity across the plot was relatively light. Regeneration is a mix of primarily aspen, jack pine, spruce and upland brush across most of the upland portion of the plot. Oak is a prominent component of the regeneration where there are rock outcrops. The plot contains a diverse mix of residual live trees and dead snags resulting in a patchy mix of live and dead post-fire vegetation. Lowland conifer and brush were generally not affected by the Rx burn. 1854 Treaty Authority staff visited the plot in May 2016 and September, 2017 and sampled plants within the burn area. Paper birch, trembling aspen, pin cherry, hazel, willow, mountain ash, juneberry, balsam fir, red maple, mountain maple, and red-osier dogwood were observed in the understory, with new and/or old moose browse on all species except mountain ash. It was noted that some oak regeneration was present on roughly half of the transects (M. Swingen, 1854 Treaty Authority, personal communication).

In 2019, 13 moose were seen on plot 41, part of the Trout Lake Rx Burn (Figure 10). Since the fire in 2005, this plot has generally produced results close to or above the mean of other high density plots each year. Anecdotally, in northeast Minnesota moose numbers in the western reaches of their range seem to have declined more rapidly than in the eastern reaches of their range; however, the size of the Trout Lake Rx Burn and the mix of vegetation species regenerating post fire are likely positives for maintaining moose habitat. For the last six years, almost all of moose observations on the plot have been inside the fire perimeter.

Plot 59 adjacent to plot 41 to the northeast, was also flown in 2019. Approximately 20% of the southwest corner of plot 59 is also part of the Trout Lake Rx Burn. In 2019, 15 moose were seen on plot 59 with seven of them inside the fire perimeter.



**Figure 9.** Plot 41 containing part of the 2005 Trout Lake Rx Burn.



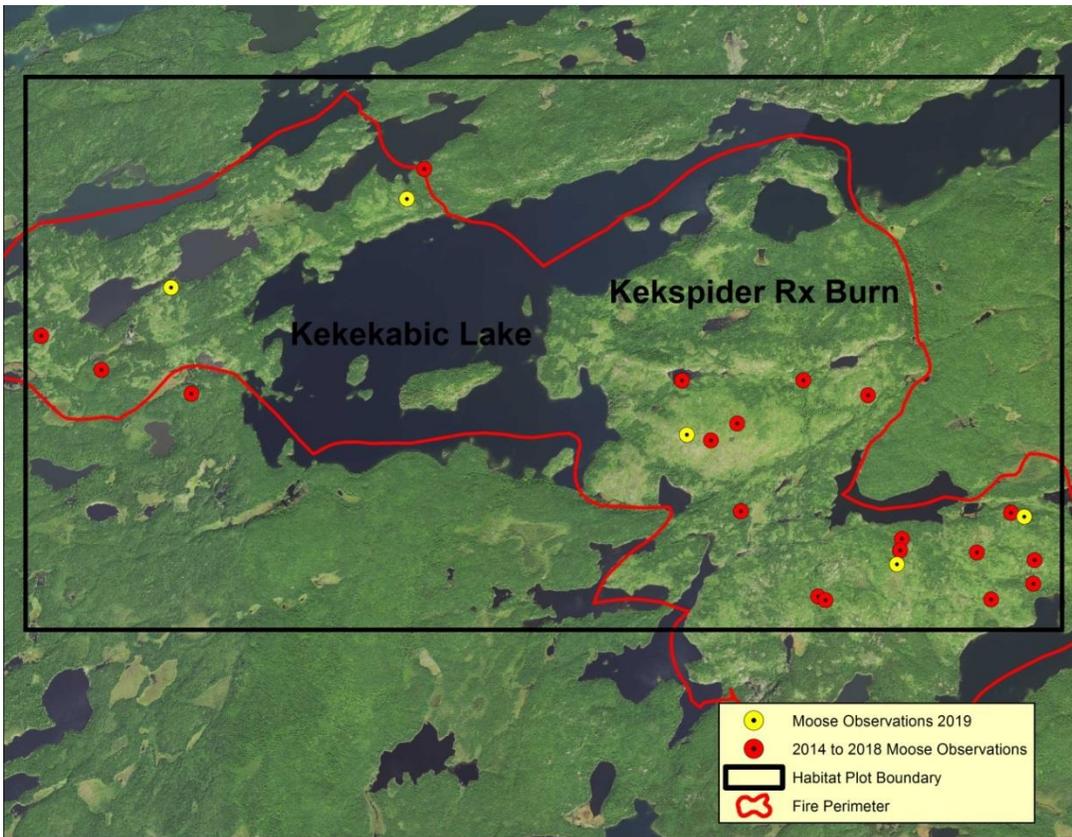
**Figure 10.** Trout Lake Rx Burn plot 41 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

### **Plot 309: Kekspider Rx Burn**

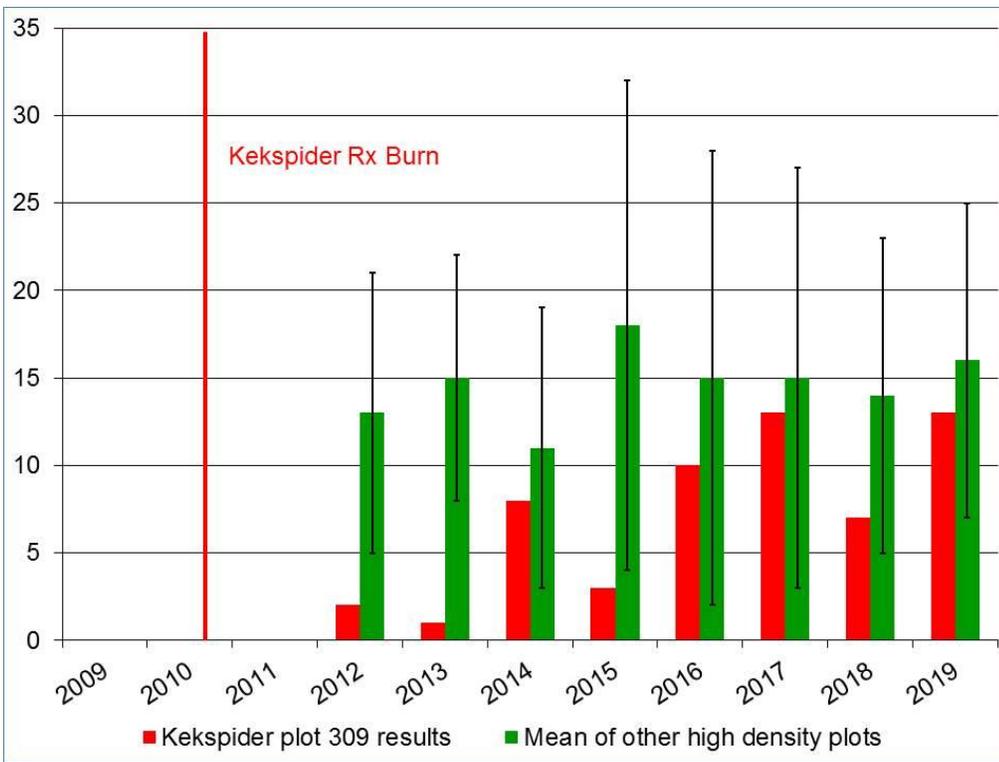
Plot 309 is located around Kekekabic Lake in the BWCAW in Lake County (Figure 11). The Kekspider Rx Burn was conducted in October, 2010 and totaled 4,961 acres of which approximately 4,270 acres are in the plot. The main purpose of the burn was to reduce fuel loads following the July, 1999 blowdown event. All of plot 309 was affected by the storm with damage to timber classified as 67-100% across the entire plot.

Since 2012, almost all moose observations on the plot have been within the perimeter of the burn (Figure 11). Aerial observation suggests the fire burned with various intensities across the plot. Regeneration following the blowdown and the fire, is generally well in evidence from the air and contains a strong conifer component. A field visit in 2012 indicated aspen sprouts in burned areas were  $\geq 2$  feet in some cases (E. Anoszko, University of Minnesota personal communication). The topography of the plot is relatively rugged.

In 2019, 13 moose were observed on plot 309, part of the Kekspider Rx Burn (Figure 12). All of the moose observations since 2012 on plot 309 have been either inside or very close to the perimeter of the fire (Figure 11, Schrage, 2017). This would indicate some attraction of the burn to moose; however, plot 309 has underperformed the mean of other high density plots in all eight years since this survey began in 2012. It's unclear why this is. Plot 315, encompassing Boulder and Makwa Lakes is adjacent to plot 309 to the southeast. Plot 315 has been flown six times since 2009, including again in 2019, and an average of 29 moose have been observed there each time. Clearly very good moose numbers are nearby. It's possible the rugged topography of plot 309 and the apparent strong conifer component in the regeneration are working against providing attractive habitat for moose.



**Figure 11.** Plot 309 containing most of the Kekspider Rx Burn.



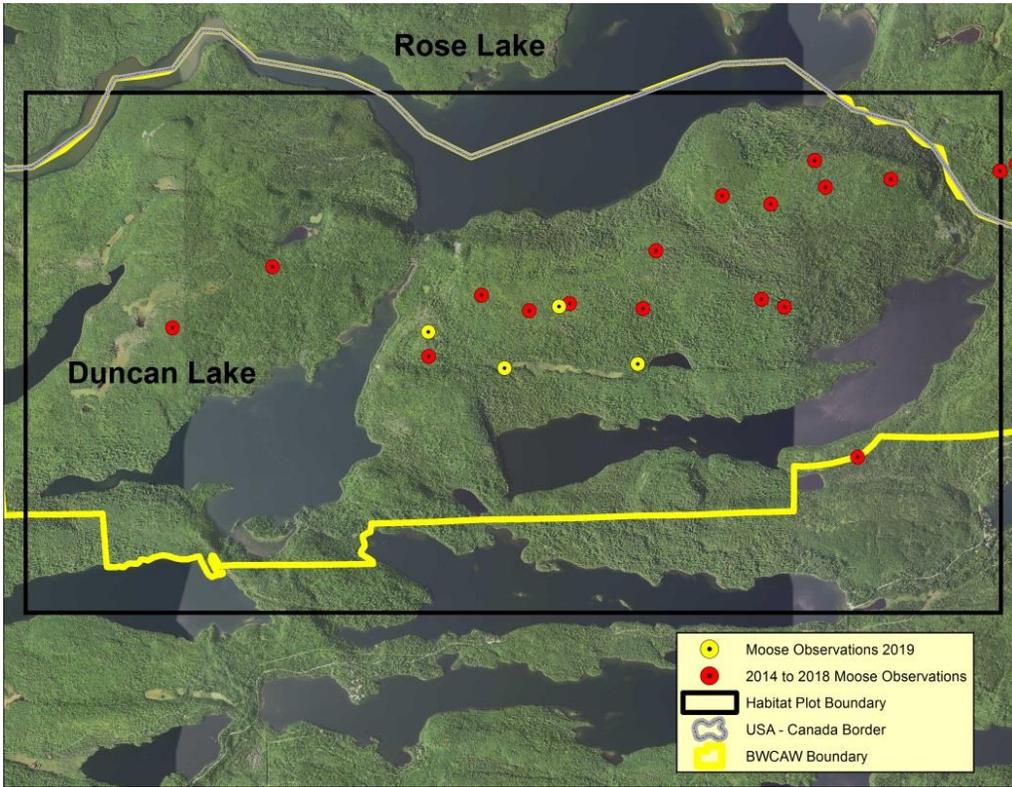
**Figure 12.** Kekspider Rx Burn plot 309 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

### **Plot 403: Proposed Duncan Lake Rx Burn**

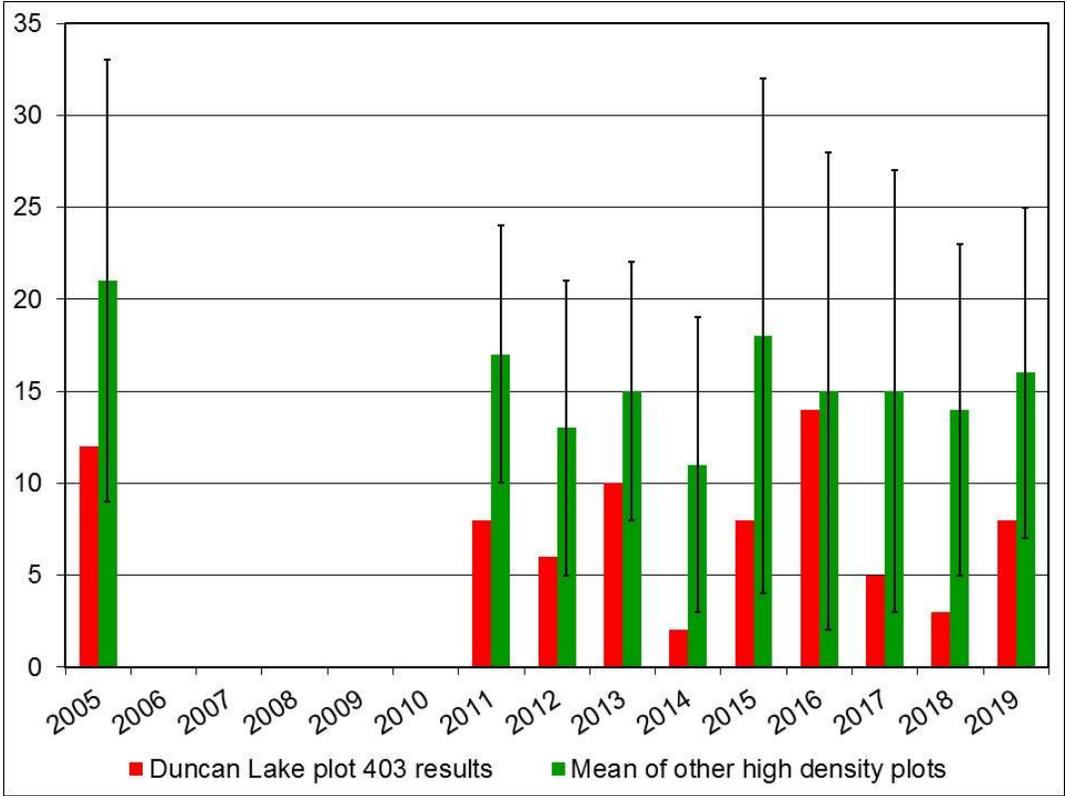
Plot 403 is located around Duncan Lake in the BWCAW in Cook County and contains a few acres on the Ontario side of the border (Figure 13). The Duncan Lake Rx Burn is proposed at 4,780 acres and is planned for a future ignition date. Approximately 4,100 acres of the burn would occur in the plot. The main purpose of the burn would be to reduce fuel loads following the July 1999 blowdown event. Wind damage on approximately 4,580 acres on the southern half of the plot is classified as affecting 10-33% of the timber. Wind damage is estimated at 34-66% of the timber on approximately 1,070 acres in the northwest corner of the plot. Approximately 2,840 acres of timber on the northern third of the plot were undamaged by the storm. In addition, approximately 440 acres in the southeastern corner of the plot were burned in the May 1988, Daniel-Bearskin Wildfire. The topography of the plot is relatively rugged.

As indicated above, this plot was moderately damaged by the 1999 blowdown event. Much of the overstory remains intact and includes a mix of hardwood and conifer. Vegetation measurements conducted in 2015 indicated the dominant overstory species are balsam fir and birch and the understory is dominated by dense stands of hazel and mountain maple (C. Maley, 1854 Treaty Authority, personal communication). Where the blowdown was more intense, the forest floor still contains significant large woody debris.

In 2019, eight moose were observed on plot 403, part of the planned Duncan Lake Rx Burn (Figure 14). Plot 403 has underperformed the mean of other high density moose plots in each year it's been flown. However; the size of the planned burn, mix of vegetation and the plot's proximity to other good moose habitat, suggest a fire here could improve the habitat for moose and a positive response in moose numbers could be expected.



**Figure 13.** Plot 403, part of the proposed Duncan Lake Rx Burn.



**Figure 14.** Duncan Lake proposed Rx Burn plot 309 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

## **Wildfire Plots**

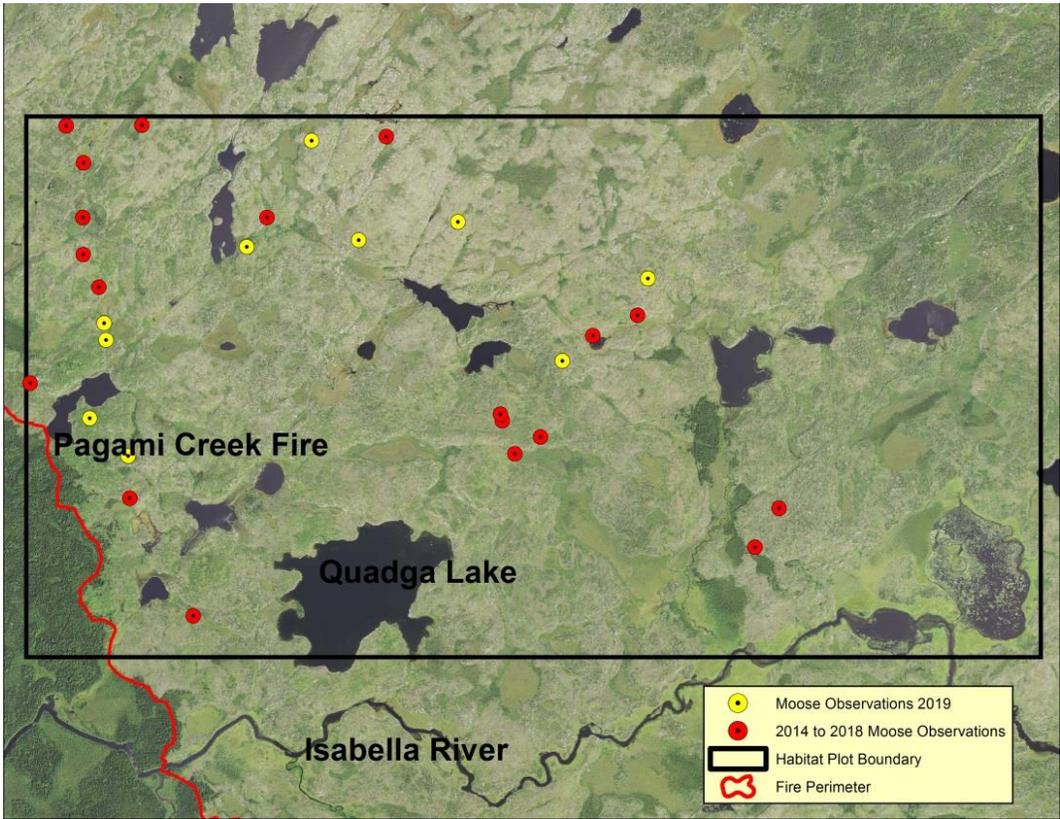
### **Plot 262: Pagami Creek Fire**

Plot 262 is located around Quadga Lake in the BWCAW in Lake County (Figure 15). The Pagami Creek Fire was first detected on 18 August, 2011; however, the majority of the fire burned on a single afternoon on 12 September when winds pushed it 16 miles to the east. Fire behavior on that day was particularly extreme. The fire eventually grew to 92,000 acres and “hotspots” remained until winter. Except for approximately 200 acres in the southwestern corner of the plot, the entire plot was affected by the fire. Most of the plot was unaffected by the July 1999 blowdown event. Damage from the blowdown to standing timber was estimated at 10-33% on approximately 250 acres in the northeastern corner of the plot.

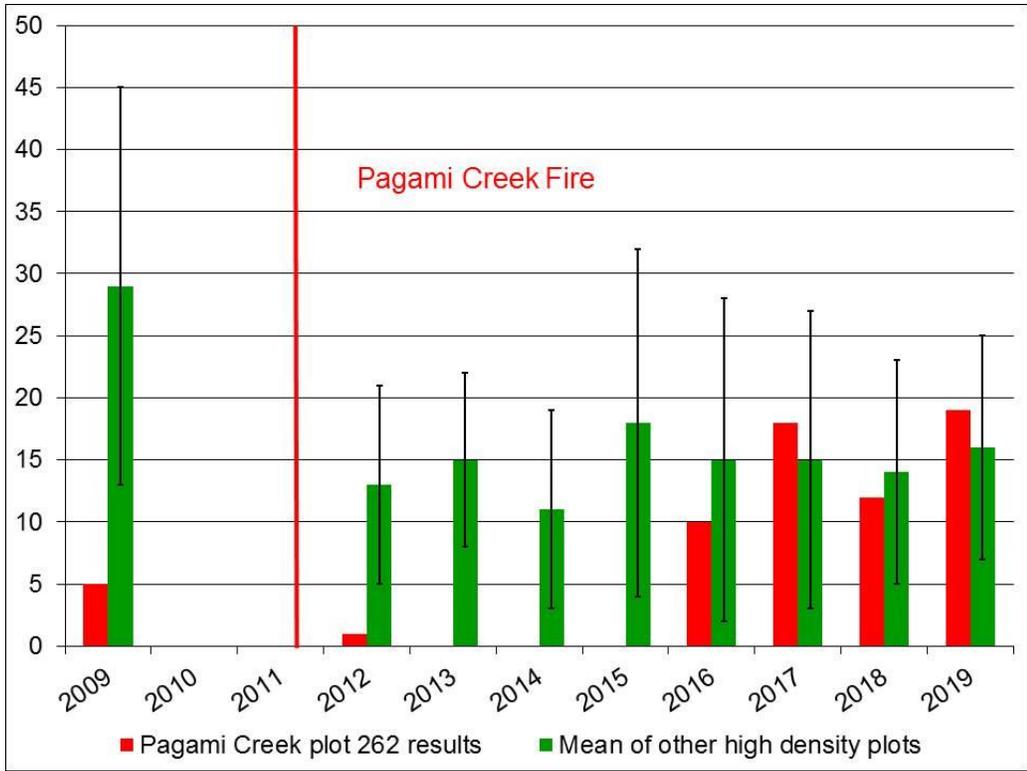
Aerial observation suggests the majority of plot 262 was severely burned. While much of it is still standing, almost the entire overstory including many lowland conifer stands, were killed in the fire. Aerial observation of the regeneration suggests large patches are dominated by jack pine intermingled with patches dominated by deciduous species. Vegetation sampling near the southern edge of the plot in 2015 indicated aspen averaging 9.8 feet in height was most abundant and willow and birch were relatively common. Jack pine averaging 4.5 feet in height also was observed frequently (C. Maley, 1854 Treaty Authority, personal communication).

In 2019, 19 moose were seen on the Pagami Creek Fire plot 262. From 2012-2015 after the fire only one moose had been observed on plot 262 (Figure 16). This is suspected to be a response to the time it took for the vegetation to recover to the point where moose found it attractive. In 2016, moose numbers jumped dramatically to 10 animals and this positive response has continued. Since 2016, plot 262 results have outperformed the mean of other high density plots twice and underperformed them twice although in all four years the results would have put it above the  $\geq 8$  moose observed threshold necessary to stratify it as a high density plot. It will be interesting to track the trend in moose numbers over time and see if the results compare more closely with wildfires such as Cavity Lake or Ham Lake or if the apparent dominance of regenerating jack pine on much of this plot reduces its attractiveness for moose.

In 2019, two other plots overlapping the perimeter of the Pagami Creek Fire and about 5-10 miles east of plot 262 were surveyed. Plot 303 is centered on Ferne Lake and was about 50% impacted by the Pagami Creek Fire. In 2019, 29 moose were observed on plot 303, 27 inside the fire perimeter. Plot 319 on the north side of Kawishiwi Lake was about 40% impacted by the Pagami Creek Fire. Twenty-four moose were observed there with 14 inside the fire perimeter. Interestingly, plot 319 was last flown in 2004, well before the Pagami Creek Fire, and 60 moose were observed at that time.



**Figure 15.** Plot 262, part of the Pagami Creek Fire.



**Figure 16.** Pagami Creek Fire plot 262 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

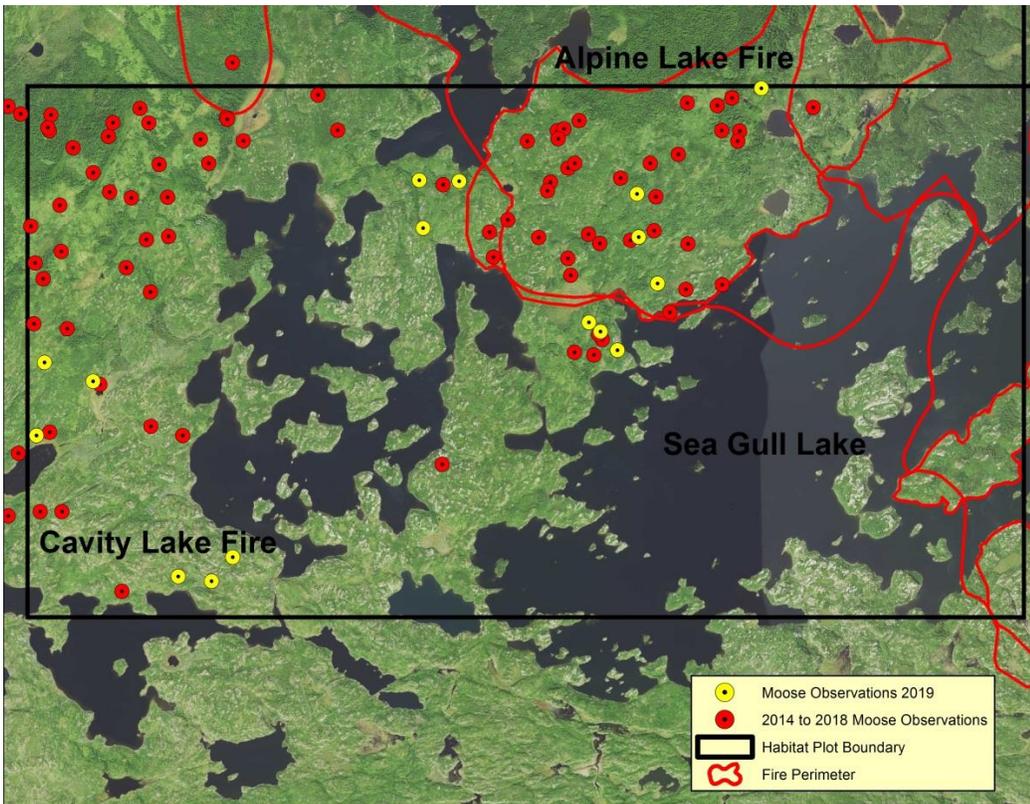
### **Plot 347: Cavity Lake Fire**

Plot 347 is located around Sea Gull Lake in the BWCAW in Cook County (Figure 17). Plot 347 was affected by three wildfires and a Rx burn between 2002 and 2007, as well as by the July 1999 blowdown event. The Cavity Lake Fire ignited on 13 July, 2006 and remained active until the middle of August, burning an estimated 31,830 acres total and 6,210 acres in plot 347. The August, 2005 Alpine Lake Fire burned another 1,070 acres in the north-central part of the plot and the Ham Lake Fire burned 110 acres in the very southeastern corner of the plot. On the southern end of Threemile Island, 140 acres within the plot were burned in a September, 2002 Rx burn. In addition to the fires, the entire plot was impacted by the July, 1999 blowdown. Damage to timber was estimated at 67-100% on approximately 3,500 acres in western and southern portions of the plot and at 34-66% on 4,500 acres in the central and northern portions. Remaining timber in the northeast suffered damage estimated at 10-33%. Surviving overstory was primarily balsam fir, red maple, birch, cedar, black spruce and jack pine (E. Anoszko, University of Minnesota, personal communication).

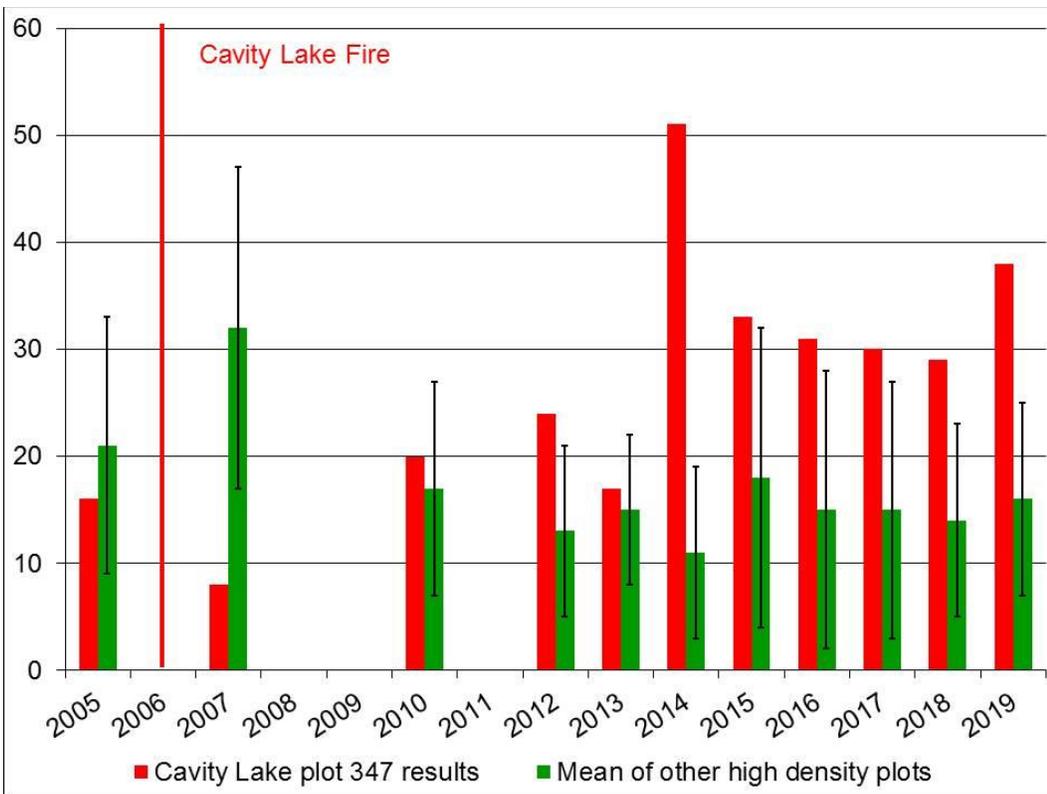
The southern part of plot 347 appears to have been burned more severely in the Cavity Lake Fire than the northern half of the plot. While regenerating brush is evident from the air, much of the upland overstory was removed on the southern half of the plot. In the northern half of the plot, the Alpine Lake Fire and the northwest corner of the plot in the Cavity Lake Fire appear to have burned less severely, and scattered individual and groups of overstory trees remain alive. Vegetation plots in moose plot 347 (n=318) established from 2011-2012 show regeneration dominated by birch (28% of stems) and aspen (26%) with lesser amounts of beaked hazel (11%) and other species (<5% each). At the time regeneration was sparse (<50% coverage) and generally <6 feet tall (E. Anoszko, University of Minnesota, personal communication). Vegetation sampling in 2013 and 2014 in plot 347 and elsewhere in the Cavity Lake Fire produced similar results (C. Maley, 1854 Treaty Authority, personal communication). Scattered young white spruce, jack pine, and white pine were also noted in 2016 (personal observation).

In 2019, 38 moose were observed on plot 347 (Figure 18). In all eight years since this survey began in 2012 plot 347 has outperformed the mean of other high density plots and substantially outperformed the mean in most years. This result is especially noteworthy considering much of plot 347 is water. The size of the disturbance, the extensive brushfields intermingled with patches of remaining overstory cover and the mix of species regenerating likely all contribute to the high moose numbers observed. The combination of blowdown followed by fire on most of this plot has shaped the forest succession towards species such as aspen and paper birch (Frelich 2002). These species are favored by moose for browsing and the succeeding forest may benefit moose for some years to come.

Since this survey started in 2012, and including the 2007 and 2010 population surveys, no moose have been observed on the portion of the 2002 Rx burn on Three Mile Island in plot 347 (Schrage, 2012).



**Figure 17.** Plot 347, part of the Cavity Lake and Alpine Lake Fires.



**Figure 18.** Cavity Lake Fire plot 262 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

## Plot 350 Ham Lake Fire

Plot 350 is located at the end of the Gunflint Trail in Cook County, partially in and out of the BWCAW with some acres in Ontario as well (Figure 19). The Ham Lake Fire started on 5 May, 2007, and eventually burned over 75,000 acres in Minnesota and Ontario. Approximately 6,480 acres on the eastern two-thirds of the plot were affected by this fire. In addition, approximately 1,160 acres along the western edge of the plot were burned in the August, 1976 Roy Lake Fire. The July, 1999 blowdown affected much of the plot as well. Timber damage estimated at 10-33% occurred on approximately 4,000 acres in the western and southern portions of the plot. Approximately 3,470 acres in the central and eastern portions of the plot suffered damage estimated at 34-66%, and an additional 640 acres in the east central area suffered damage estimated at 67-100% of the timber. The south central part of the plot is well developed with roads, cabins and campgrounds associated with the Gunflint Trail corridor.

Aerial observation suggests the eastern 2/3rds of the plot which was impacted by the blowdown and burned in the Ham Lake Fire, has abundant brush regeneration. Many of the conifer swamps in the fire's perimeter survived and provide an interspersed cover with the burned areas. Vegetation plots in the Ham Lake Fire portion of plot 350 (n=49) from 2011-12 show thick and well established brush regeneration (>50% coverage) and >6 feet tall. Aspen was 20% of the regenerating stems followed by hazel (14%), jack pine, (12%) alder (12%), mountain maple (11%), birch (9%), pin cherry (8%) and 5% willow species (E. Anoszko, University of Minnesota, personal communication). The western 1/3<sup>rd</sup> of the plot burned in the Roy Lake Fire is covered with dense, primarily jack pine, regeneration. Vegetation plots in the Roy Lake Fire portion of plot 350 (n=20) show few shrubs or other species present (E. Anoszko, University of Minnesota, personal communication). Additional vegetation sampling in the plot in 2013 and 2014 described 23% birch, 20% aspen and 20% willow with 9% beaked hazel and 9% pin cherry (C. Maley, 1854 Treaty Authority, personal communication).

In 2019, 19 moose were observed on plot 350, part of the Ham Lake Fire (Figure 20). In seven of the eight years since this survey began in 2012 the results have outperformed the mean of other high density plots and substantially outperformed the mean in a couple of those years. Similar to the neighboring plot 347 and the Cavity Lake Fire, plot 350 has extensive fields of brush and other potential moose forage intermingled with pockets of surviving overstory cover. The combination of blowdown followed by fire across most of this plot has likely shaped the forest succession towards species such as aspen and paper birch (Frelich 2002). These species are favored by moose for browsing and the succeeding forest may benefit moose for some years to come. As in past years, the moose observed on plot 350 were primarily inside the perimeter of the Ham Lake Fire. No moose have been observed since 2012 on the 1976 Roy Lake Fire portion of the plot which appears heavily dominated by maturing jack pine. Although disturbed by both blowdown and fire, relatively few observations of moose have been made in those parts of the plot adjacent to the Gunflint Trail and its associated development.

In addition to plot 350, plot 351 adjacent to 350 to the south, was flown in 2019 as well. Almost all of plot 351 was impacted by the Ham Lake Fire, and 14 moose were observed there.

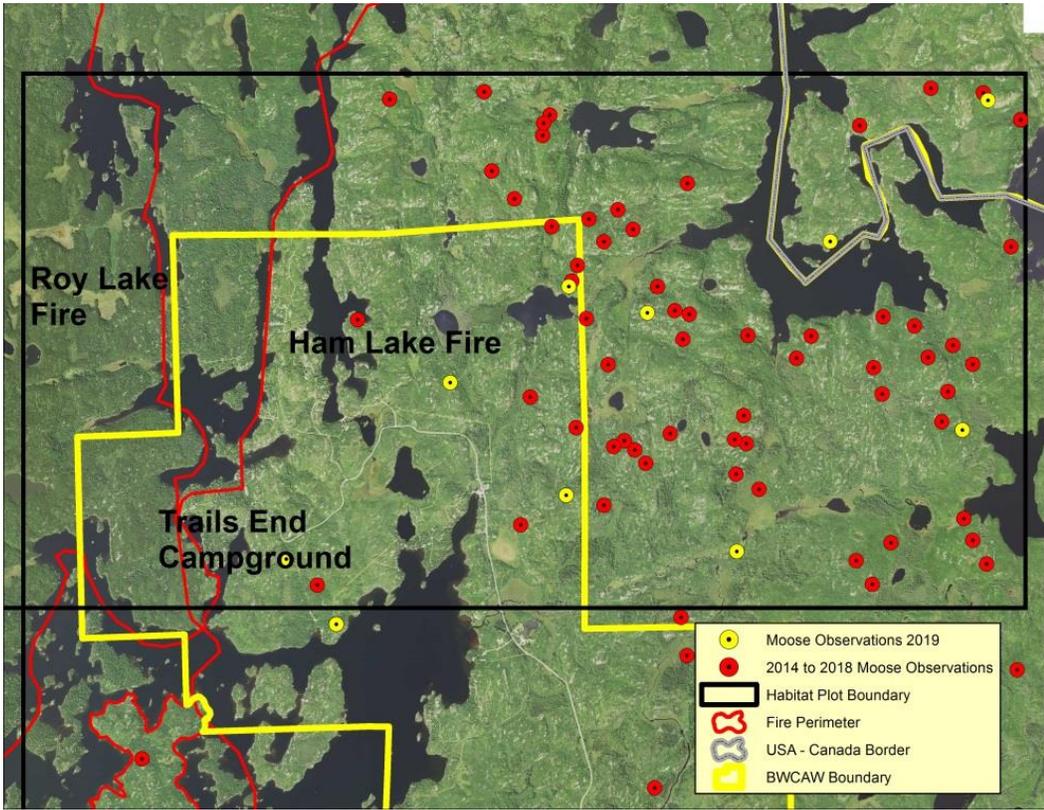


Figure 19. Plot 350, part of the Ham Lake Fire.

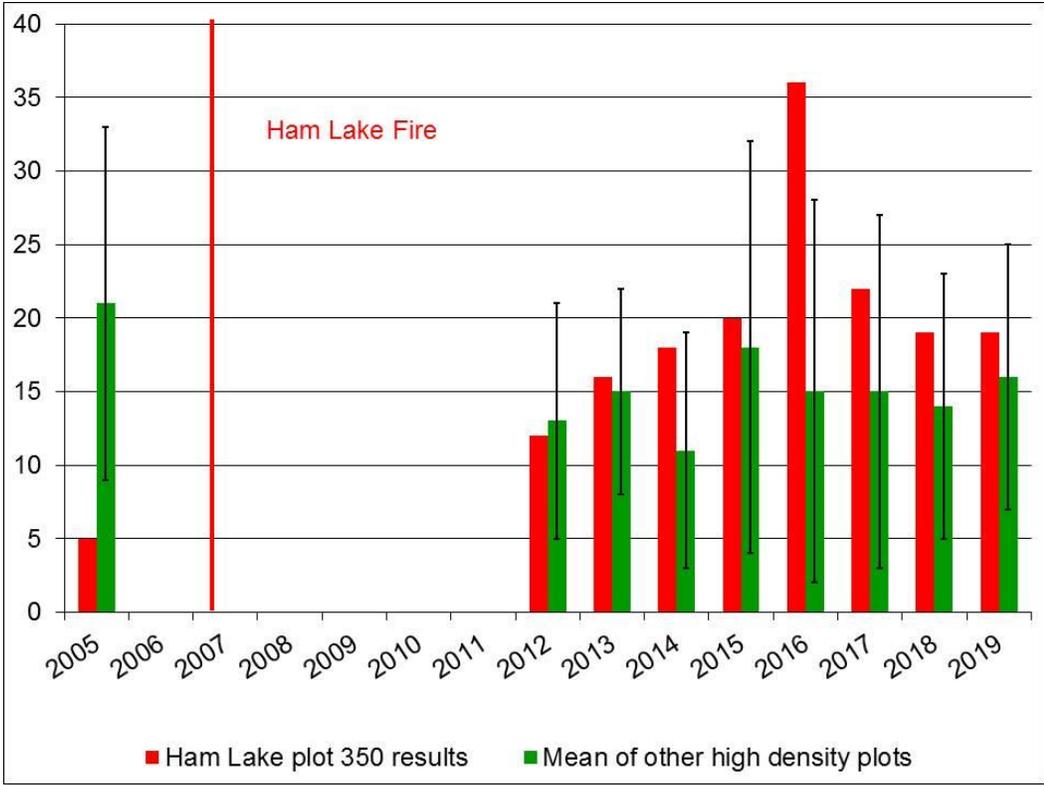


Figure 20. Ham Lake Fire plot 350 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

## Acknowledgments

Funding for this survey was provided by the Fond du Lac Band of Lake Superior Chippewa, 1854 Treaty Authority, United States Forest Service, Superior National Forest; and the Minnesota Department of Natural Resources. In 2019 field data was collected with the assistance of DNR Area Wildlife staff Tom Rusch, Chris Balzer and Nancy Hansen, 1854 Treaty Authority Wildlife Biologist Morgan Swingen and DNR pilots John Heineman, Luke Ettl and Brad Maas. Vegetation data was by collected by Eli Anoszko as part of his graduate research at the University of Minnesota and by Wildlife Research Assistant Christina Maley of the 1854 Treaty Authority as part of a larger study on moose browse.



**Figure 21.** A January, 2019 view across the Pagami Creek Fire .

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