

# 2018 Moose Habitat Survey

Mike Schrage, Fond du Lac Resource Management Division

## Introduction

Fire and timber harvest are generally believed to be beneficial to moose (*Alces alces*) 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 has often included questions regarding benefits to moose. Along with other reasons, local timber harvest is frequently justified as creating better 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 fire (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 wild and prescribed fires, and similarly, whether moose will respond positively to proposed timber management projects. Although moose habitat quality is not necessarily seen as responsible for the continuing 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).

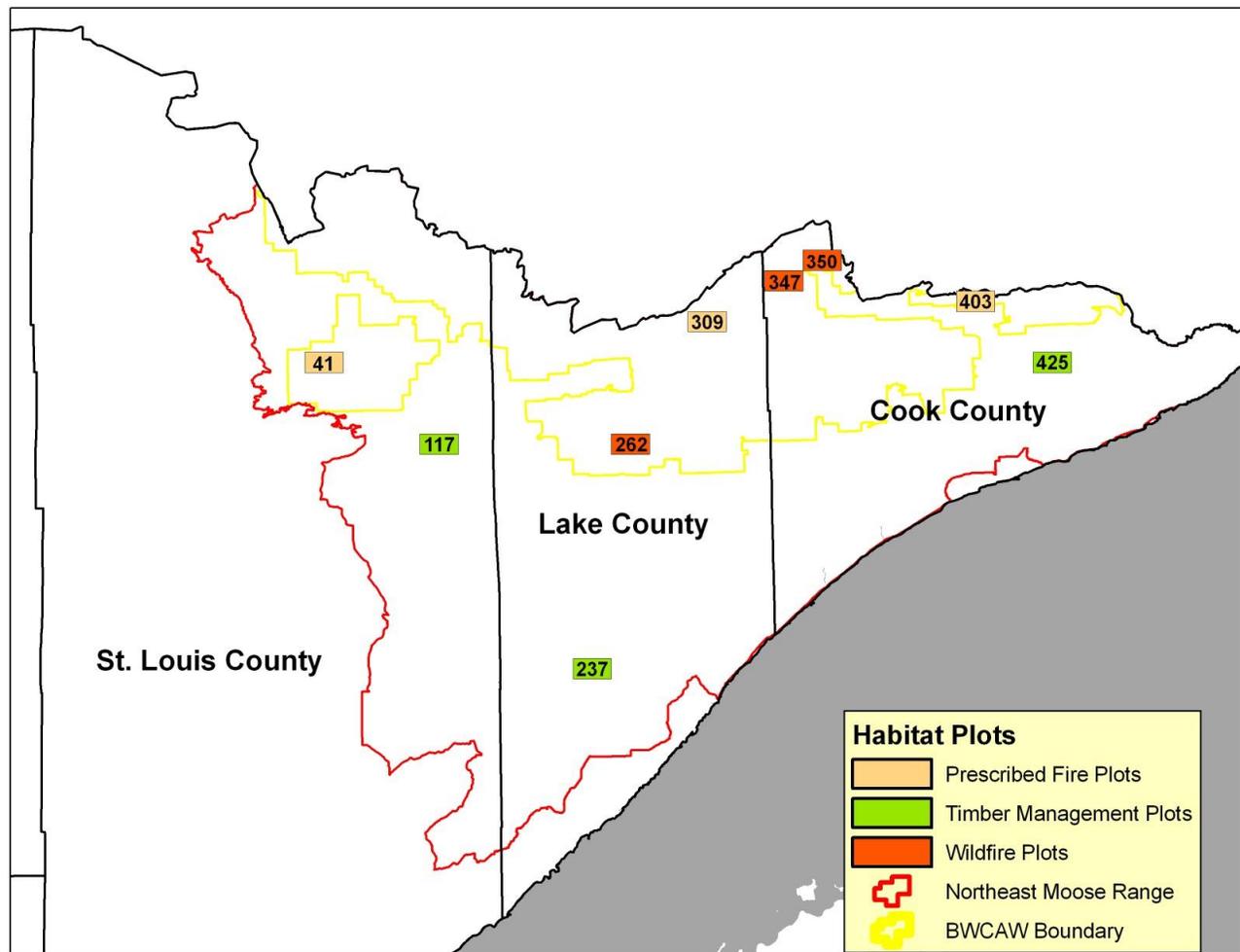
Prior to 2012 the stratified random sampling design for the annual moose population survey precluded regular observations of large habitat changes. Survey plots were randomly selected from high, medium or low moose density areas, and many years might elapse before the same survey plot was flown again. 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) fire, and timber management activities and determine how that response changes over time. This information is intended to assist decision-making regarding how to better manage habitat for moose, how to prioritize funding for 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, 2018). 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 2018 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 2014-18 plots in the highest density stratification are where an uncorrected count of  $\geq 8$  moose/plot is expected.



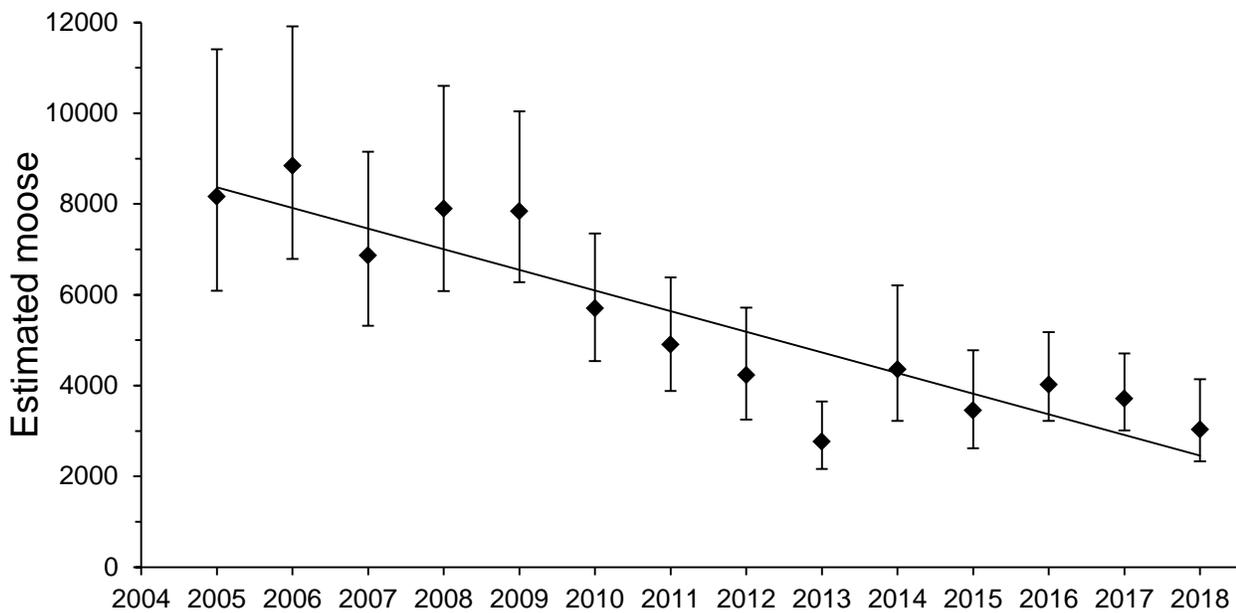
**Figure 1.** Locations and treatment types of the 9 moose habitat survey plots.

After consultation in 2011 with local tribal, DNR and SNF staff, 3 plots in each of 3 treatments types were selected to be flown as part of this survey. Treatment types were defined as wildfire, prescribed (Rx) fire, and broadly as timber management. 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 9 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 2018 were described by DelGiudice (2018). The survey was initiated on 3 January and completed on 13 January with 9 actual survey days. Including the 9 habitat plots, a total of 52 plots were surveyed in 2018. Snow depths were estimated at 8-16" on habitat plots 41, 117, 237, 262, 403 and 425 and >16" on plots 309, 347 and 350. Results for this habitat survey should be considered in the context of the entire northeastern Minnesota moose population. After declining from approximately 8800 moose in 2006, the population trend appears to have stabilized since 2012 at between 3000 - 4000 moose (Figure 2). In 2018 the average number of moose seen on the 16 high density moose plots was 14.



**Figure 2.** Point estimates, 90% confidence intervals, and trend line of estimated moose numbers in northeastern Minnesota, 2005-2017 (DelGiudice, 2018).

## **Timber Management Plots**

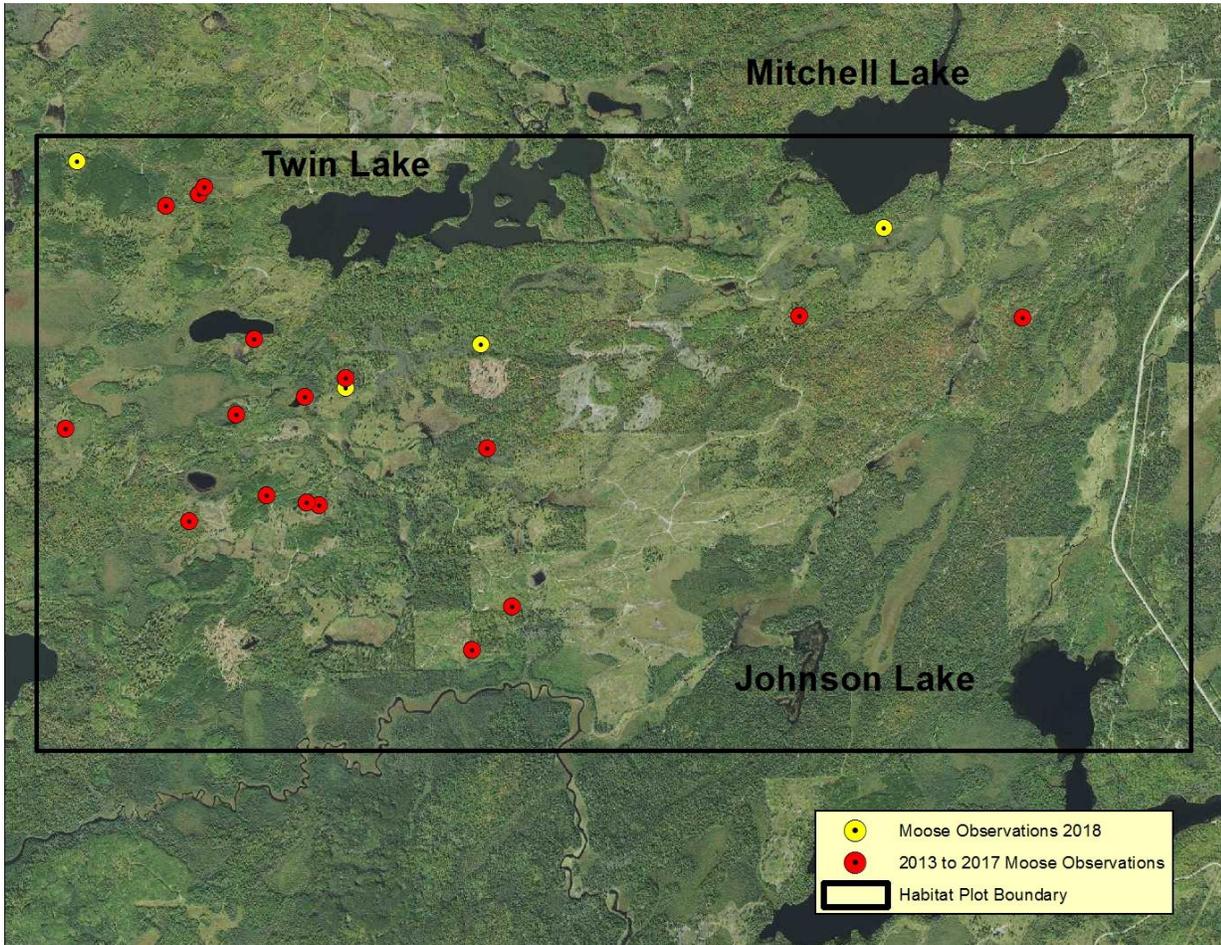
### **Plot 117: Twin-Mitchell Project Area**

Plot 117 is located 7 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 Fire plot 41 are the only two habitat plots where white-tailed deer are regularly observed during the survey.

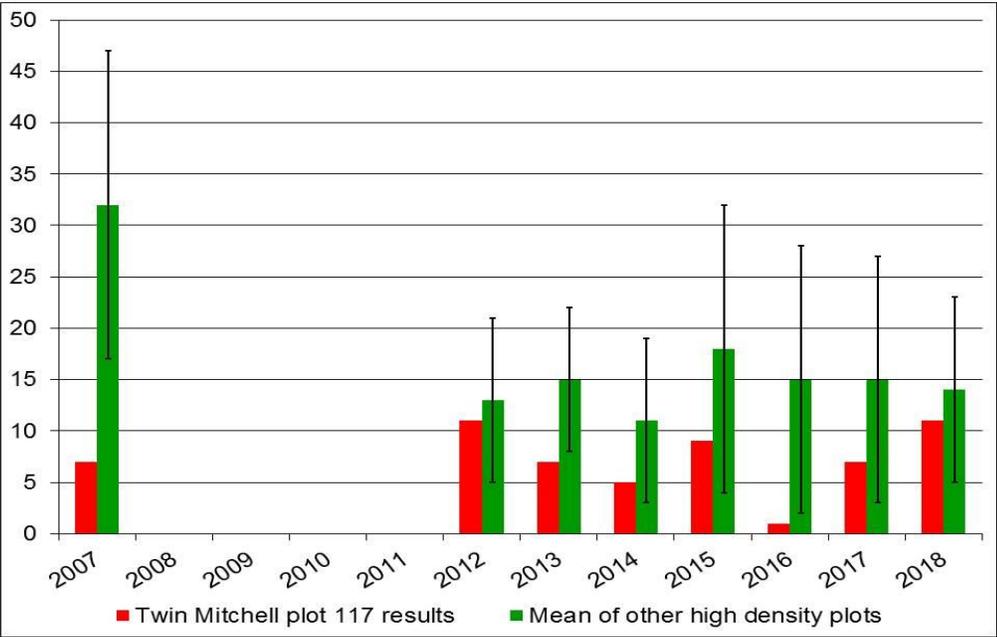
State land ownership accounts for 1,528 acres of the total plot and is comprised of 70% conifers, 24% hardwoods, and the remaining 6% a mix of lowland brush, muskeg, permanent and non-permanent water habitats. Approximately 55% of the State conifer stands are 0-20 years old, 7% are 20-40 years, and 13% 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.

On SNF lands approximately 41% is aspen and aspen/conifer mix, 33% lowland conifer, 16% spruce fir, and 11% pine. About 20% of the SNF land was harvested approximately 20-30 years ago. The remainder is in a mature and older condition. There has been 12 acres of lowland black spruce and 8 acres of upland aspen harvested both in 2014. 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 2018, 11 moose were observed on plot 117, part of the Twin-Mitchell Project Area (Figure 4). For the eight years observations have been made on plot 117, the results have underperformed the median for other high density moose plots in the same year.



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



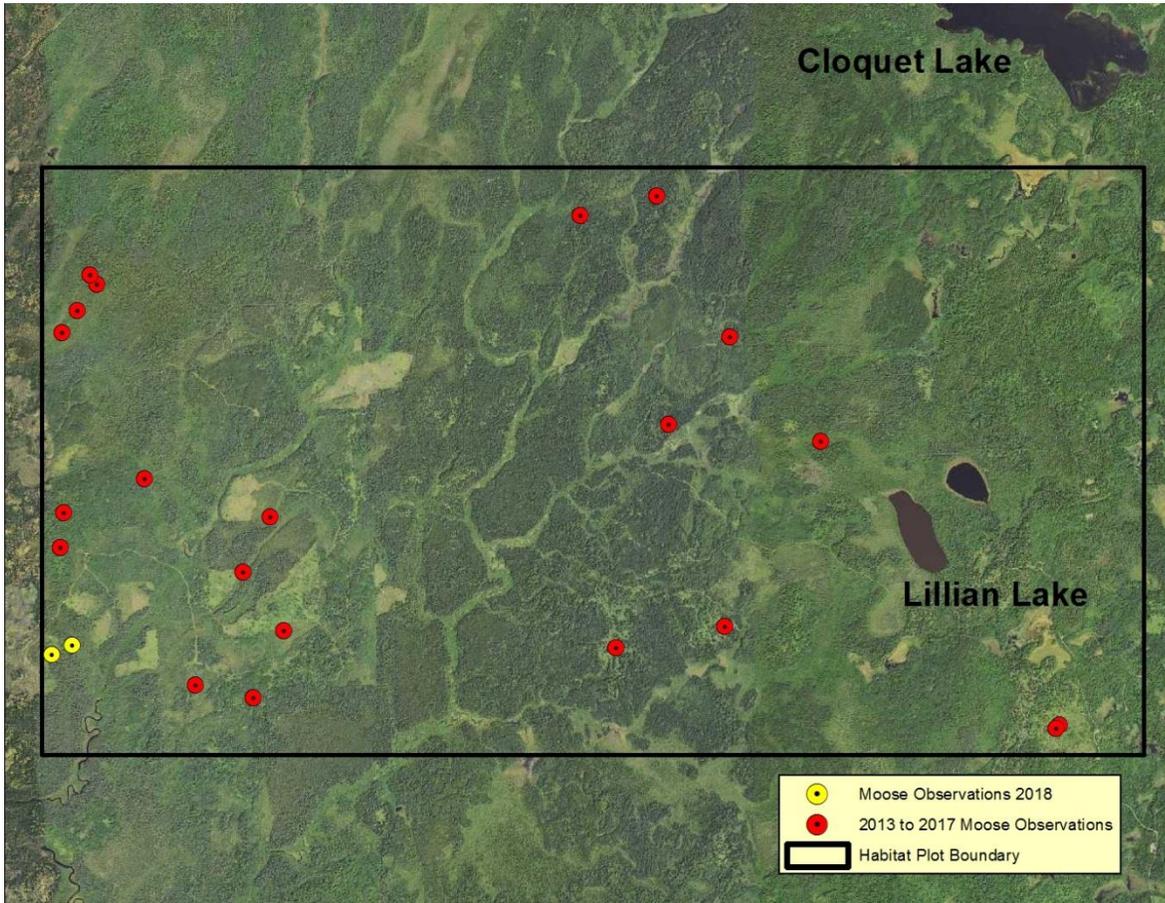
**Figure 4.** Twin Mitchell plot 117 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

### **Plot 237: Lillian Creek Project Area**

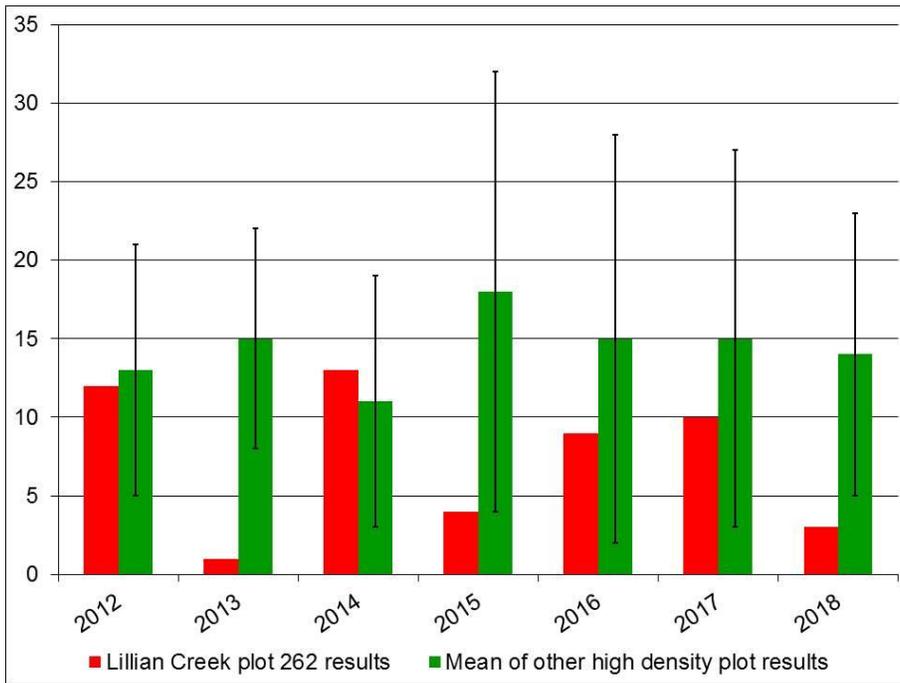
Plot 237 is located southwest of Cloquet Lake in Lake County (Figure 5). The plot has mixed ownership; 65% SNF, 15% State, 15% Lake County, and the remaining 5% in private ownership. The plot is about half wetland and half upland habitat. The upland vegetation is dominated by the aspen/spruce-fir cover type. In addition, there are a few acres in stands typed as upland black spruce, jack pine and red pine. Many stands across all ownerships are typed as upland brush. Lowlands are dominated by black spruce, mixed swamp conifer, and lowland brush. The majority of timber (46%) on SNF land and about half the timber on State land is in age classes >70 years of age. On Lake County land 35% of the timber is >70 years of age and 41% is between 20 and 30 years of age.

There has been little recent timber harvest on the plot. Less than 13% of SNF land has been harvested in the last 20 years and an additional 17% of the SNF timber was cut 20-40 years ago. On State land, 8% of the forest has been harvested in the last 20 years, with an additional 19% cut or planted during the 1980s. Lake County has harvested 9% of their land in the last 20 years. The SNF's Whyte Creek Sale was completed in 2013 and 2014 on the western side of the plot. Within plot 237 the sale was even-aged management of 114 acres of aspen/spruce-fir and 76 acres of lowland black spruce. In 2015 and 2016, 207 acres of upland brush (paper birch, choke and pin cherry, hazel, mountain maple, mountain ash and juneberry) was cut with brush saws and about 120 of the brushed acres were planted with white pine and white spruce at low densities. The State clearcut 3 stands totaling 63 acres of lowland black spruce in 2014.

In 2018, 3 moose were observed on plot 237, part of the Lillian Creek Project Area (Figure 6). From 2012 – 2018 plot 237 has underperformed the median of other high density plots in 6 of 7 years. It's possible the relatively large amount of mature timber, the small amount of recent timber harvest and a significant amount of wetland and lowland conifer on the plot makes it less than prime moose habitat, at least during the January period of this survey.



**Figure 5.** Plot 237, part of the Lillian Creek Project Area for timber management.



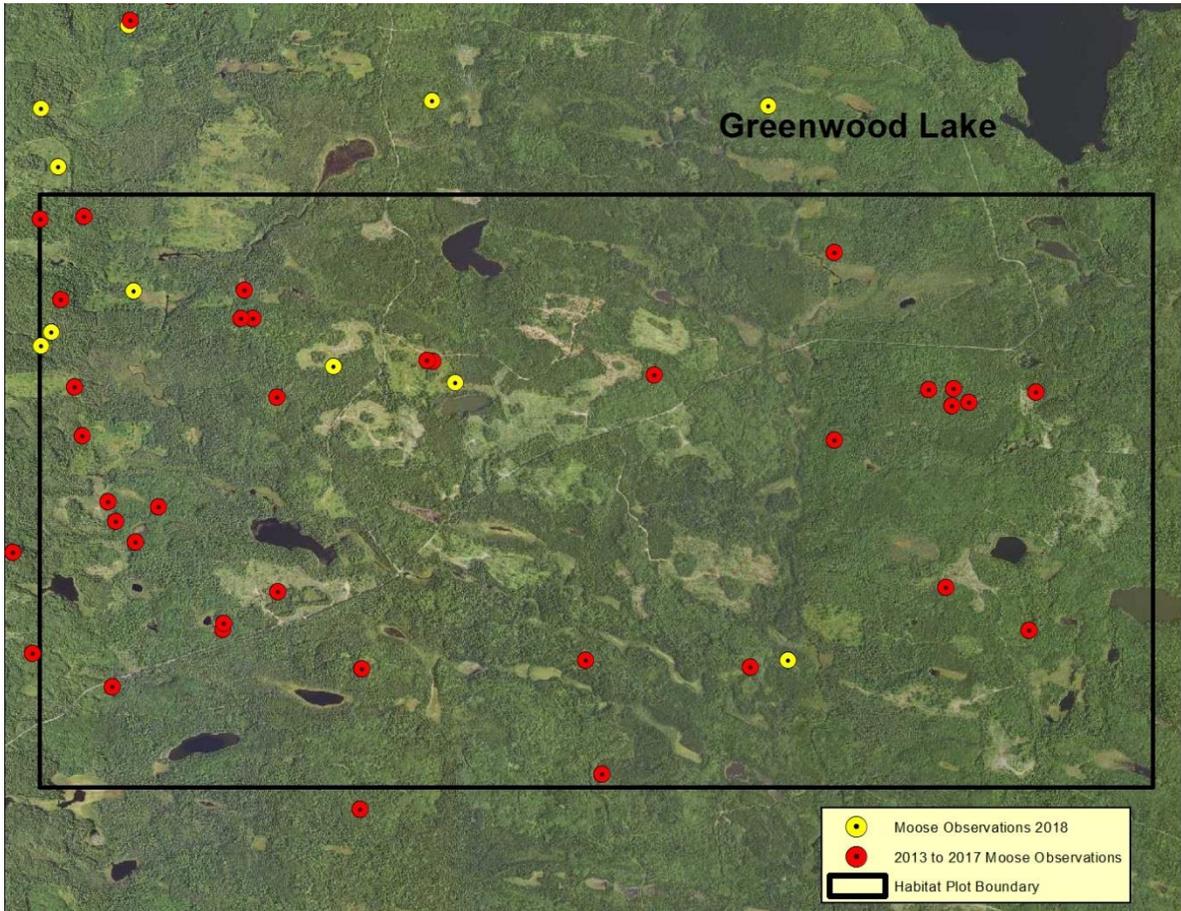
**Figure 6.** Lillian Creek plot 237 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

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

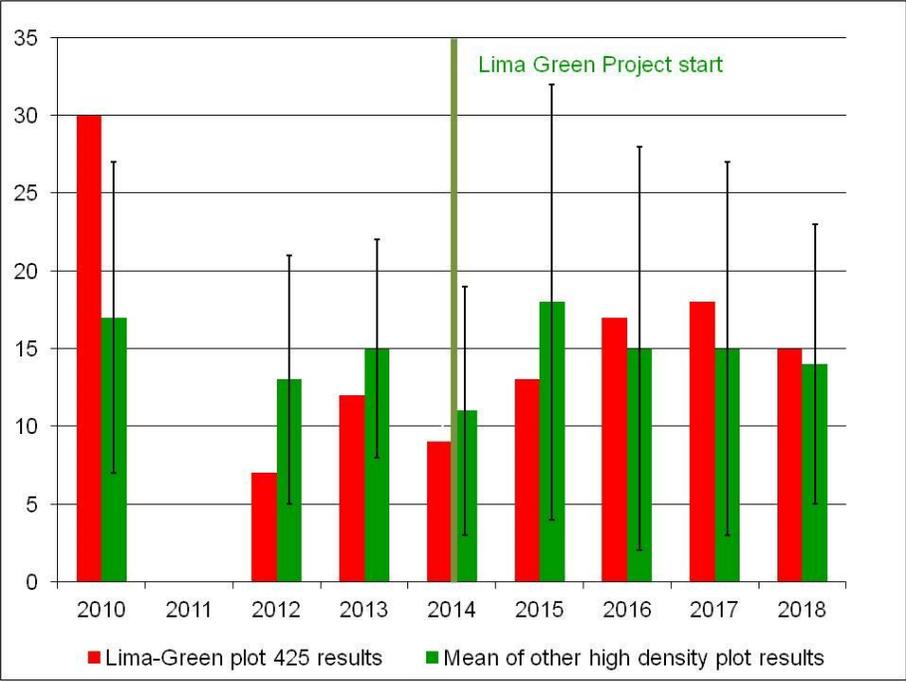
Plot 425 is located immediately southwest of Greenwood Lake in Cook County (Figure 7). Ownership is approximately 85% SNF and 15% State. Within the plot, mesic red and white pine forests comprise approximately 40% and mesic birch-aspen-spruce-fir approximately 37% of SNF lands. Lowland conifer comprises approximately 12% of local SNF land, with cedar, jack pine-black spruce, lowland non-forest and “other” making up the remainder. In 2015, < 1% of the forested cover on SNF land was < 10 years of age. Approximately 40% of the SNF acres are in the 10-49-year age class and 40% are in the 50-99 year age class. The remaining SNF acres are over 100 years old, mostly comprised of mesic red and white pine and lowland conifer forests. State land within plot 425 is 66% in upland forest with aspen-birch and jack pine stands dominating. Black spruce lowland forest is 22% of remaining State land with the rest in non-forest grass, brush or water. About 14% of upland forests on State land are < 10 years old, 22% 11-20 years, and 64% in the 21-160 years old. On State land 57 acres were regenerated to red pine in 2010, 25 acres to aspen in 2012 and 35 acres regenerated to jack pine and black spruce in 2013.

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. Approximately 136 acres had been harvested at the time of the January 2016 moose survey. There are no current plans for harvest on State land.

In 2018, 15 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 median of other high density plots in 3 of 4 years. From 2015-18 the results have flip-flopped and moose observations have outperformed the median of other high density plots in 3 of 4 years. This may be an encouraging result of the timber harvest as well as generally good moose numbers in the area.



**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 Fire Plots**

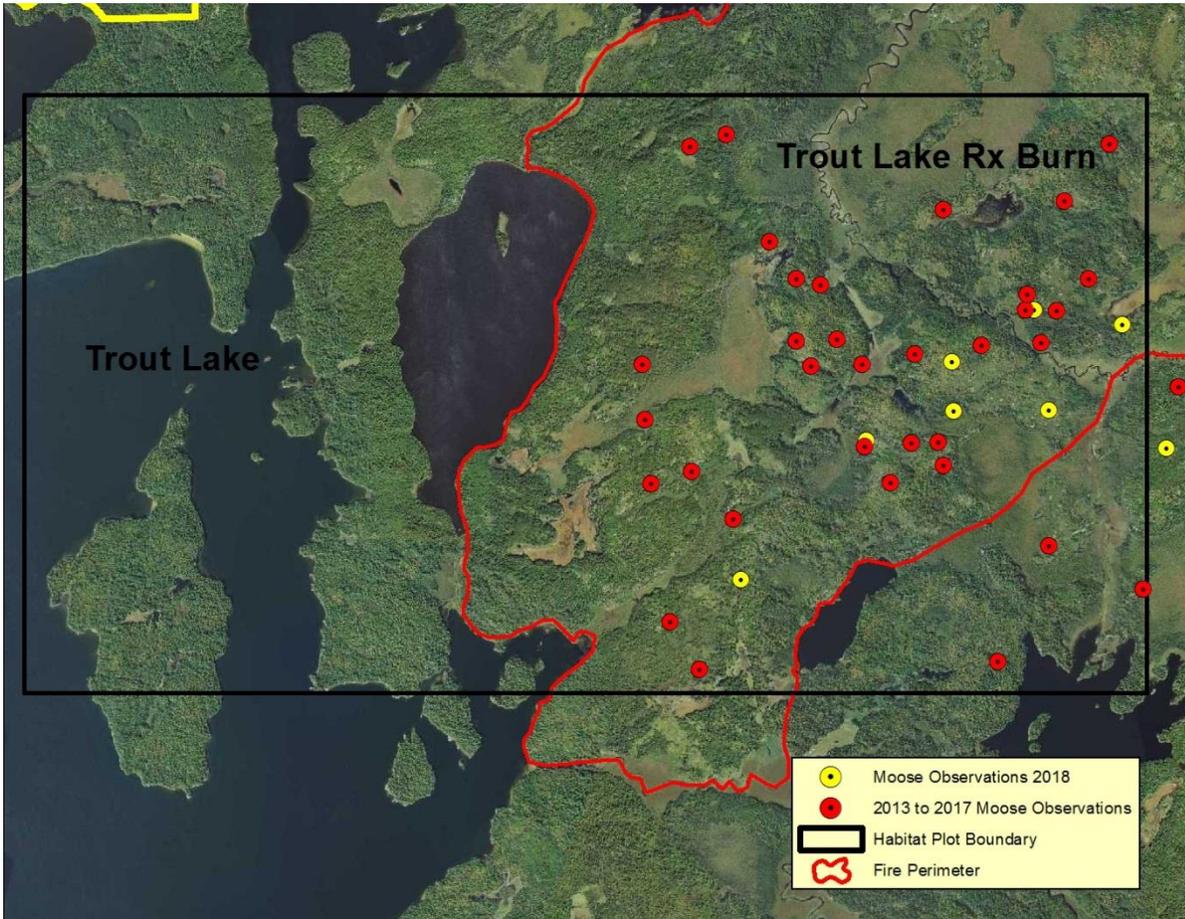
### **Plot 41: Trout Lake Rx Fire**

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 Fire 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.

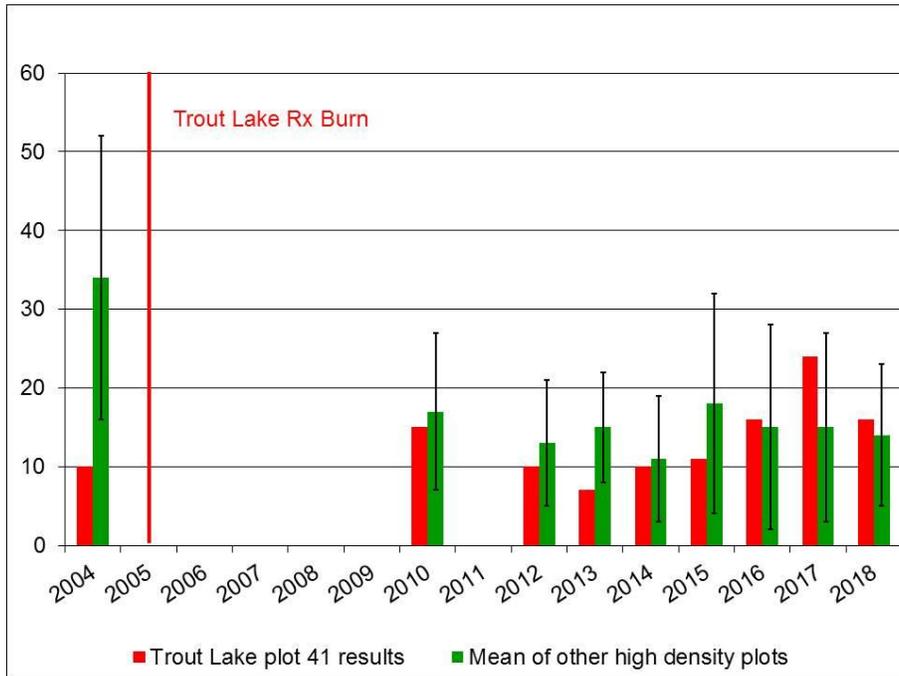
Almost all moose observations on this plot for the period of 2012-18 have been within the fire perimeter (Figure 9, Schrage, 2017). Aerial observation suggests fire intensity across the plot was relatively light. Regeneration is a mix of primarily aspen, jack pine, spruce and upland brush across most 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 fire

In 2018, 16 moose were seen on plot 41, part of the Trout Lake Rx Fire (Figure 10). Since the fire in 2005, this plot has generally produced results close to the mean of other high density plots each year and for the last 3 years plot 41 has outperformed the mean. Anecdotally, moose numbers in the western reaches of their range in NE Minnesota seem to have declined the most in recent years; however, the size of the Trout Lake Rx Fire and the mix of species regenerating post fire are likely positives for maintaining moose habitat.

In addition to plot 41, plot 60 adjacent to plot 41 to the east, was also flown in 2018. Approximately 20% of the northwest corner of plot 60 was part of the Trout Lake Rx Fire. In 2018, 16 moose were seen on plot 60 with 7 of them inside the fire perimeter.



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



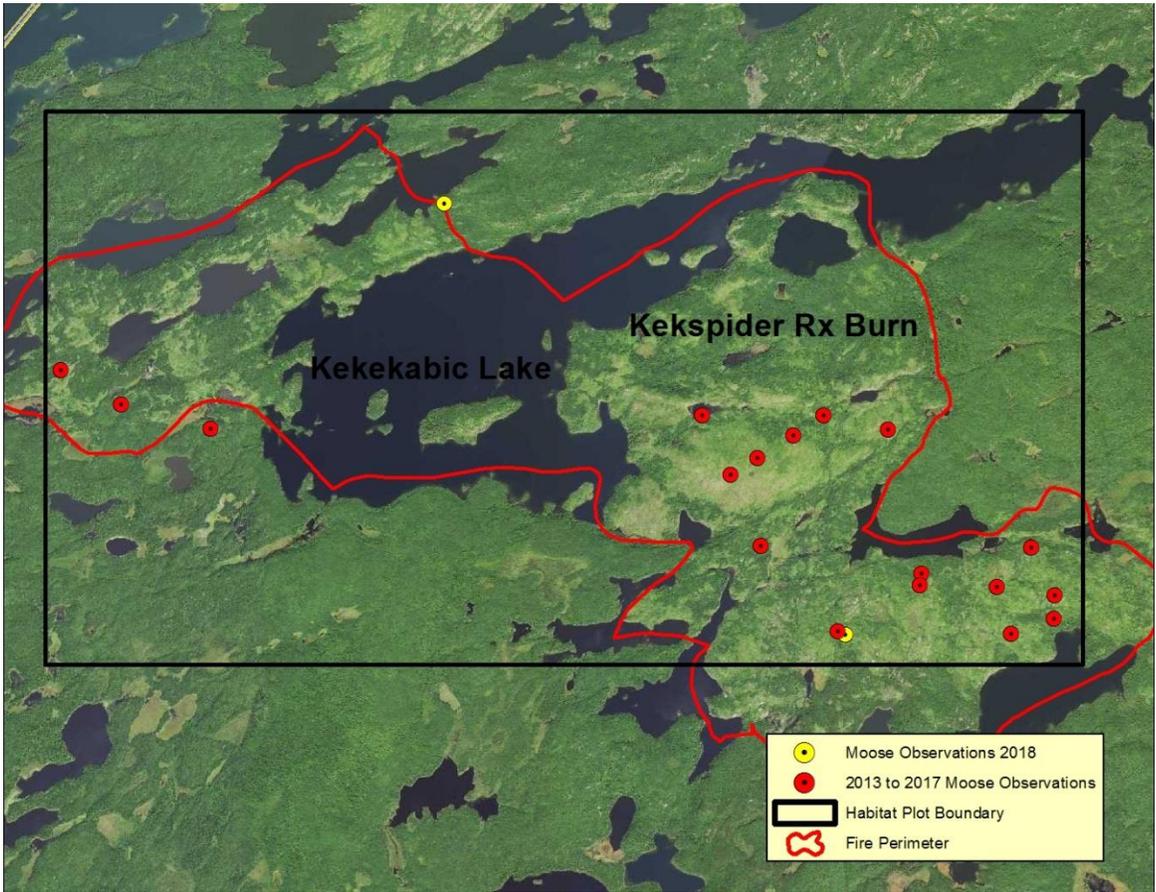
**Figure 10.** Trout Lake Rx Fire plot 41 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

### **Plot 309: Kekspider Rx Fire**

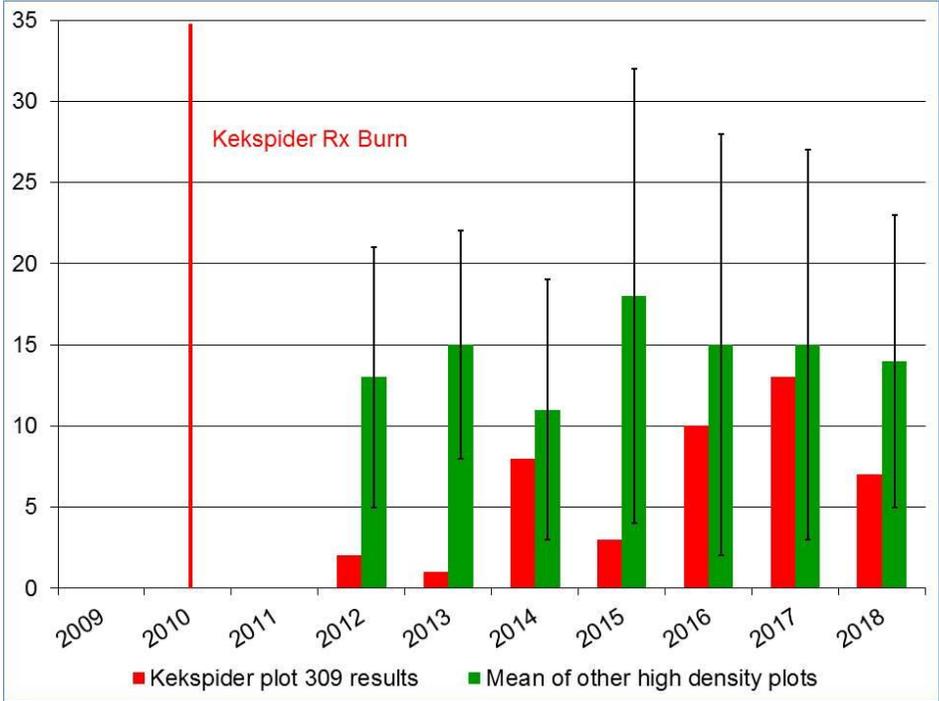
Plot 309 is located around Kekekabic Lake in the BWCAW in Lake County (Figure 11). The Kekspider Rx Fire was conducted in October, 2010 and totaled 4,961 acres of which approximately 4,270 acres are in the plot. The main purpose of the burn was to reduce fuel loads following the July, 1999 blowdown event. 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 2018, 7 moose were observed on plot 309, part of the Kekspider Rx Fire (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 7 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 5 times since 2009, including again in 2018, and an average of 31 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 may be working against providing attractive habitat for moose.



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



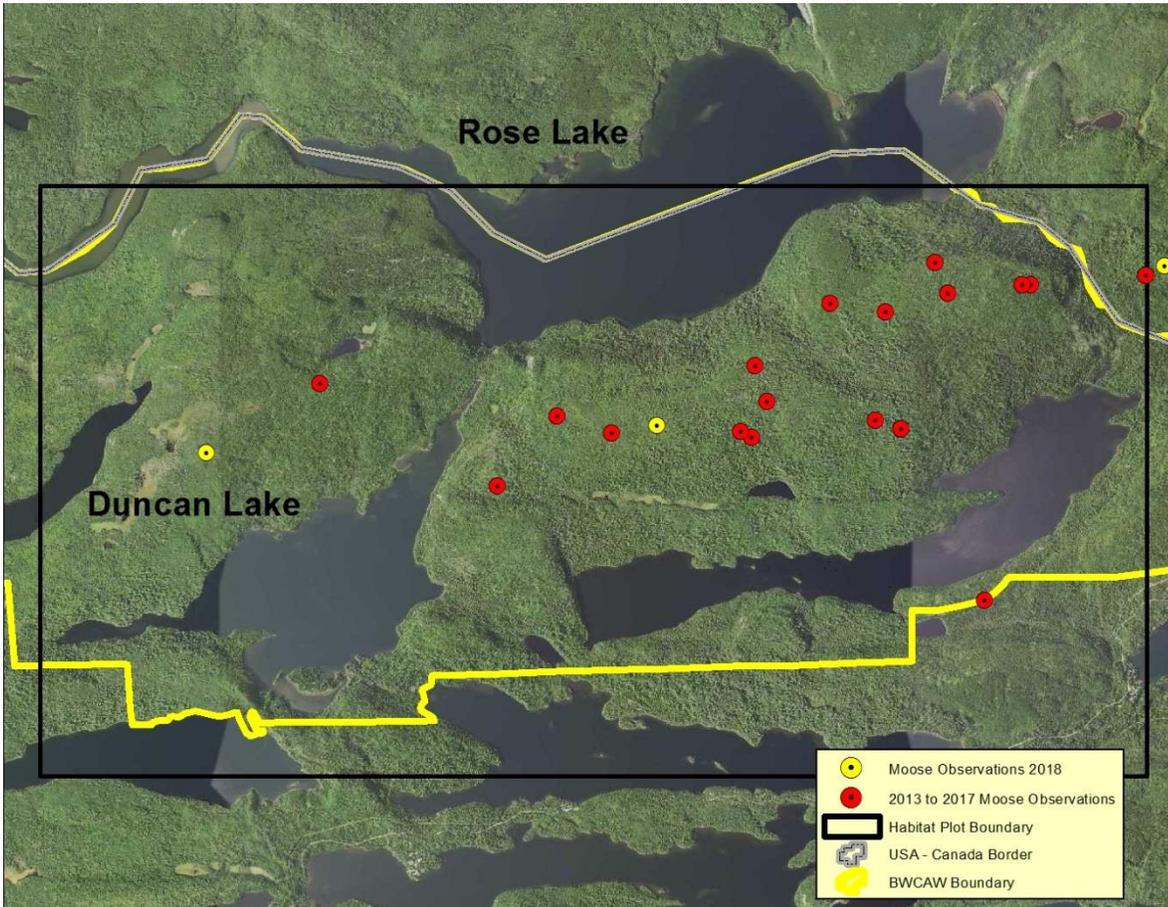
**Figure 12.** Kekspider Rx Fire plot 309 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

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

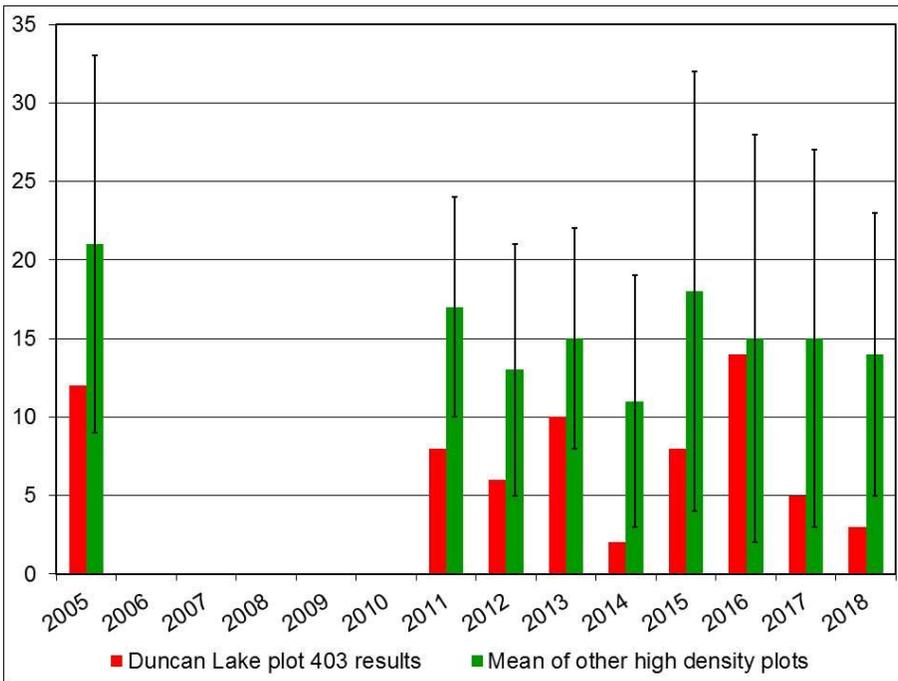
Plot 403 is located around Duncan Lake in the BWCAW in Cook County and contains a few acres on the Ontario side of the border (Figure 13). The Duncan Lake Rx Fire is proposed at 4,780 acres and is planned for a future ignition date. Approximately 4,100 acres of the burn would occur in the plot. The main 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 was balsam fir and birch and the understory was 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 2018, 3 moose were observed on plot 403, part of the planned Duncan Lake Rx Fire (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 Rx fire, 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 Fire.



**Figure 14.** Duncan Lake proposed Rx Fire 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**

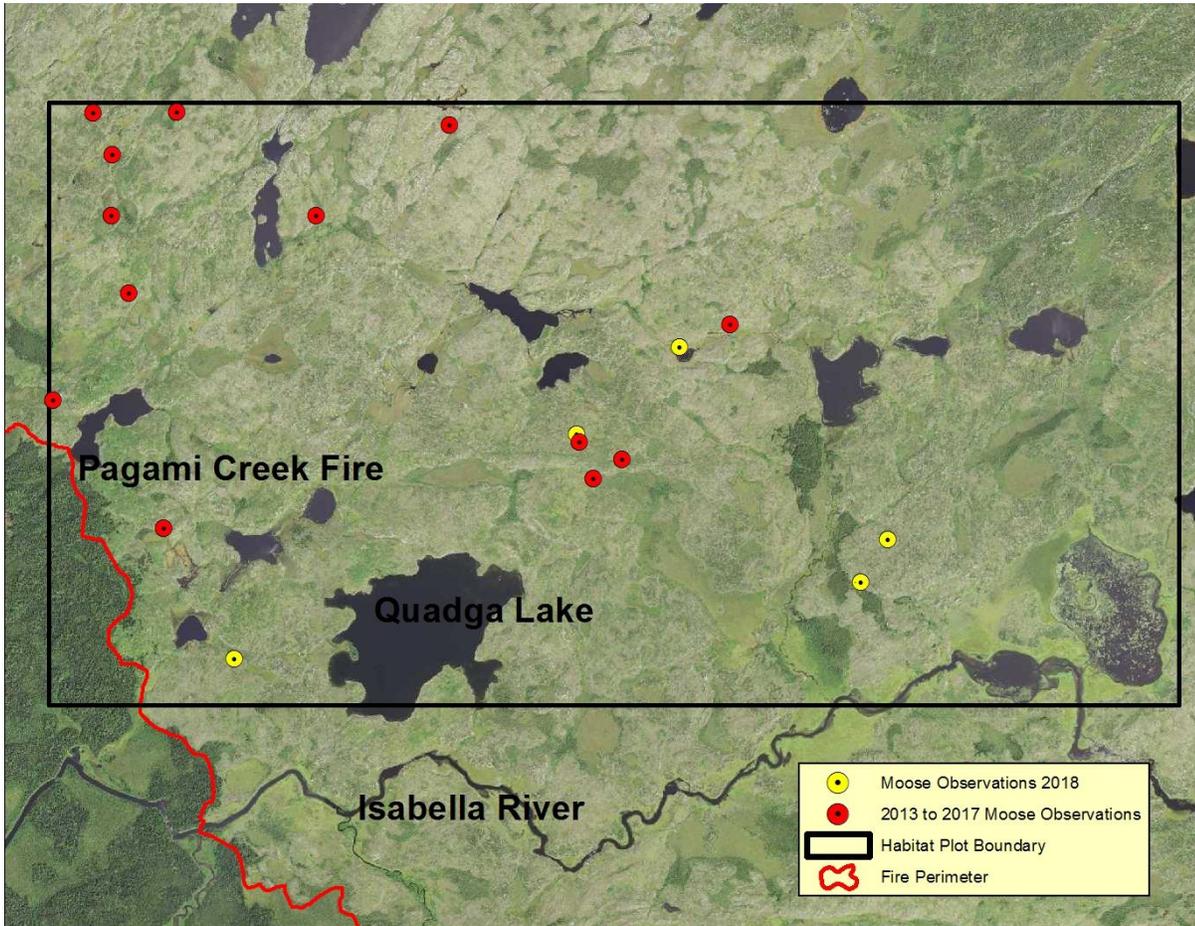
### **Plot 262: Pagami Creek Fire**

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.

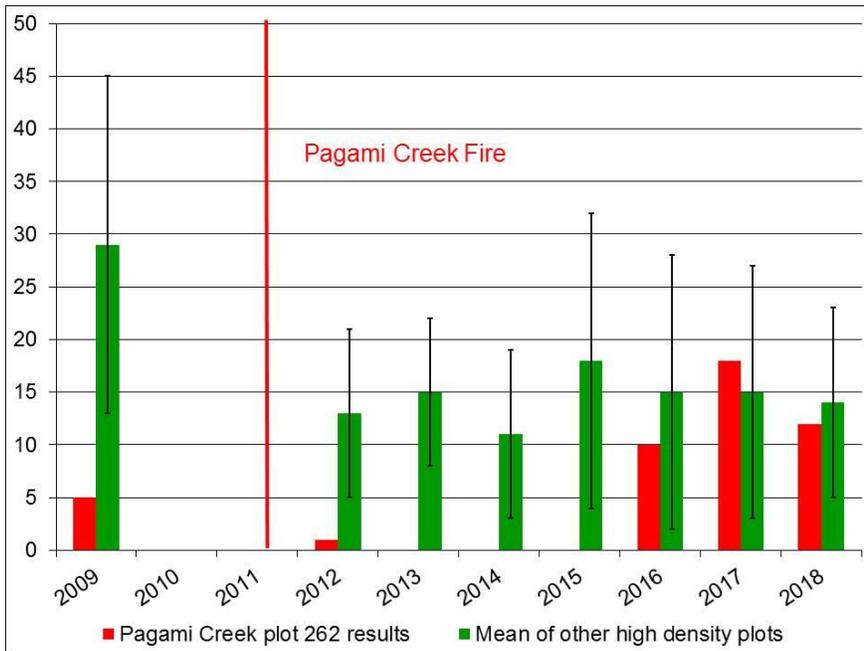
Aerial observation suggests the majority of plot 262 was severely burned. While much of it is still standing, almost the entire overstory including many lowland conifer stands, were killed in the fire. Aerial observation of the regeneration suggests large patches are dominated by jack pine intermingled 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 2018, 12 moose were seen on the Pagami Creek Fire plot 262. Following the fire from 2012-15 only 1 moose had been observed on plot 262 (Figure 16). This was 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 once and underperformed them twice although in all 3 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 fires such as Cavity Lake or Ham Lake or if the dominance of regenerating jackpine on much of the plot reduces its attractiveness for moose.

In 2018, 2 other plots overlapping the perimeter of the Pagami Creek Fire and about 5 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 2018 15 moose were observed on plot 303, 14 inside the fire perimeter. Plot 304 on the north side of plot 303 is almost entirely inside the Pagami Creek Fire perimeter and 17 moose were observed there. Interestingly, plot 304 was last flown in 2005, well before the Pagami Creek Fire. In 2005, 15 moose were observed on the plot.



**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.

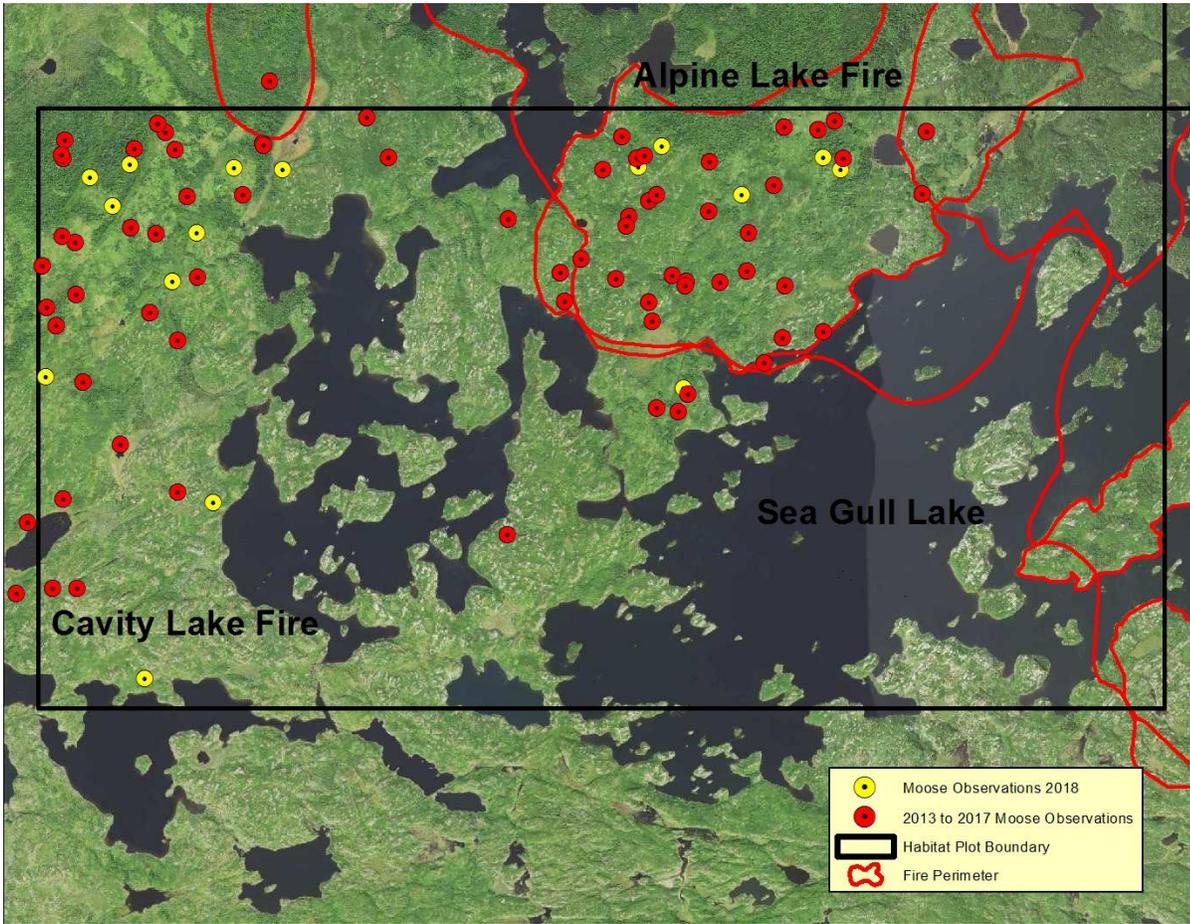
### **Plot 347: Cavity Lake Fire**

Plot 347 is located around Sea Gull Lake in the BWCAW in Cook County (Figure 17). Plot 347 was affected by 3 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 the plot. The August, 2005 Alpine Lake Fire burned 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 fire. 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).

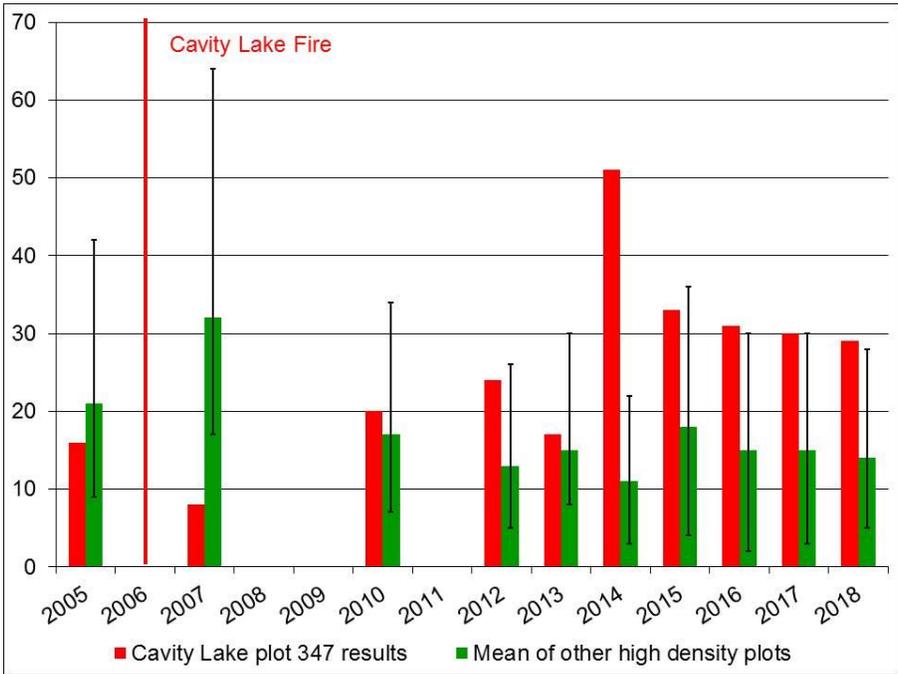
The southern part of plot 347 appears to have been burned more severely in the Cavity Lake Fire than the northern half of the plot. While regenerating brush is evident from the air, much of the upland overstory was removed on the southern half of the plot. In the northern half of the plot, the Alpine 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 2018, 29 moose were observed on plot 347 (Figure 18). In all 7 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 fire 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 appear to have retained their canopy 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 2018, 19 moose were observed on plot 350, part of the Ham Lake Fire (Figure 20). In 6 of the 7 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 neighboring 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 older Roy Lake Fire portion of the plot. Although equally disturbed by 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 352 to the south which includes Mine Lake and the Kekekabic Hiking Trail, was flown in 2018 as well. Almost all of plot 352 was impacted by either the Ham Lake or Cavity Lake Fires. In 2018, 11 moose were observed on plot 352.

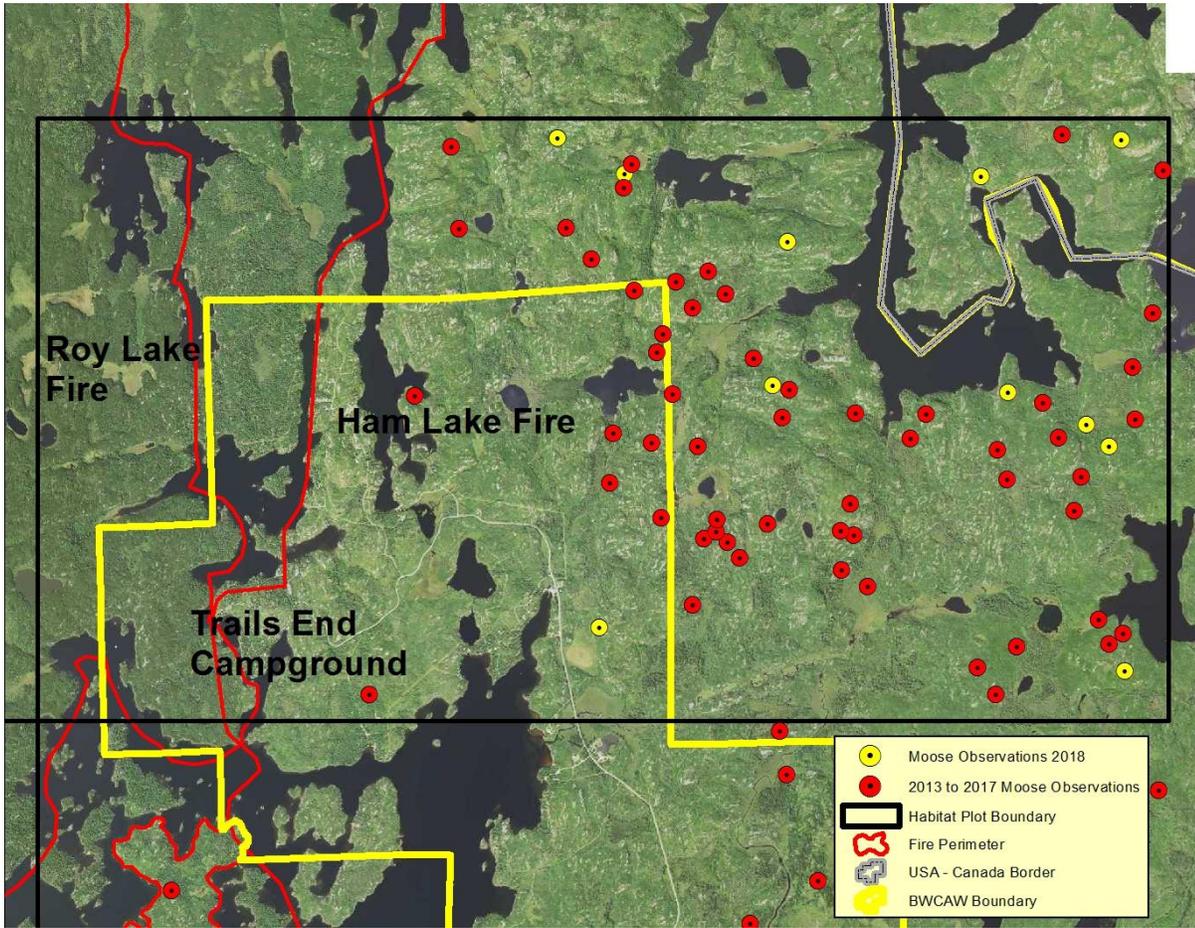


Figure 19. Plot 350, part of the Ham Lake Fire.

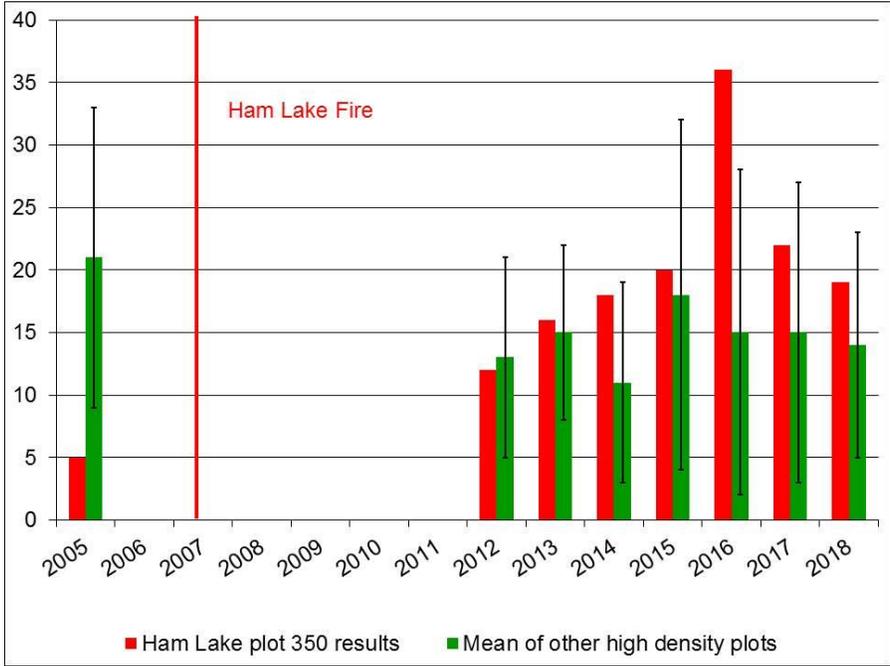


Figure 20. Ham Lake Fire plot 350 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

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**Figure 21.** A view across plot 350 and the 2007 Ham Lake Fire.

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