2022 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 large fires in northeastern Minnesota often includes questions regarding benefits to moose. Along with other reasons, timber harvest in northeastern 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 increased interest and support for moose habitat enhancement and led to discussions among managers regarding 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). In addition, more recent research 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 consistent local knowledge on how moose responded to a large habitat change and how that response changed over time. To help fill this knowledge gap, a 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) burns, 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, 2022). The population survey uses a stratified random sampling technique surveying plots in high, medium and low strata based on expected moose density. All survey plots are rectangular (5 x 2.67 mi.) and 8,544 acres in size. The 2022 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 to plots with the highest expected moose densities and presumably the best moose habitat. From 2004-2013, plots in the highest density stratification were expected to have uncorrected moose numbers of ≥21 moose/plot. Due to the decline in moose numbers from 2005 – 2013 (Figure 2), stratification levels were changed prior to the 2014 survey. From 2014 onwards we expect uncorrected counts of ≥8 moose/plot for those stratified as high density plots.

In 2011, after consultation with local tribal, DNR and SNF staff, three plots in each of three treatments types were initially 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. Following the large Greenwood Fire in 2021, an additional plot in the wildfire treatment was added with the first post-fire moose survey conducted this year. Habitat survey plots are located across moose range in northeastern Minnesota (Figure 1). The demographic data from the habitat plots are incorporated into the larger population survey results through the use of a permanent 4th stratum.

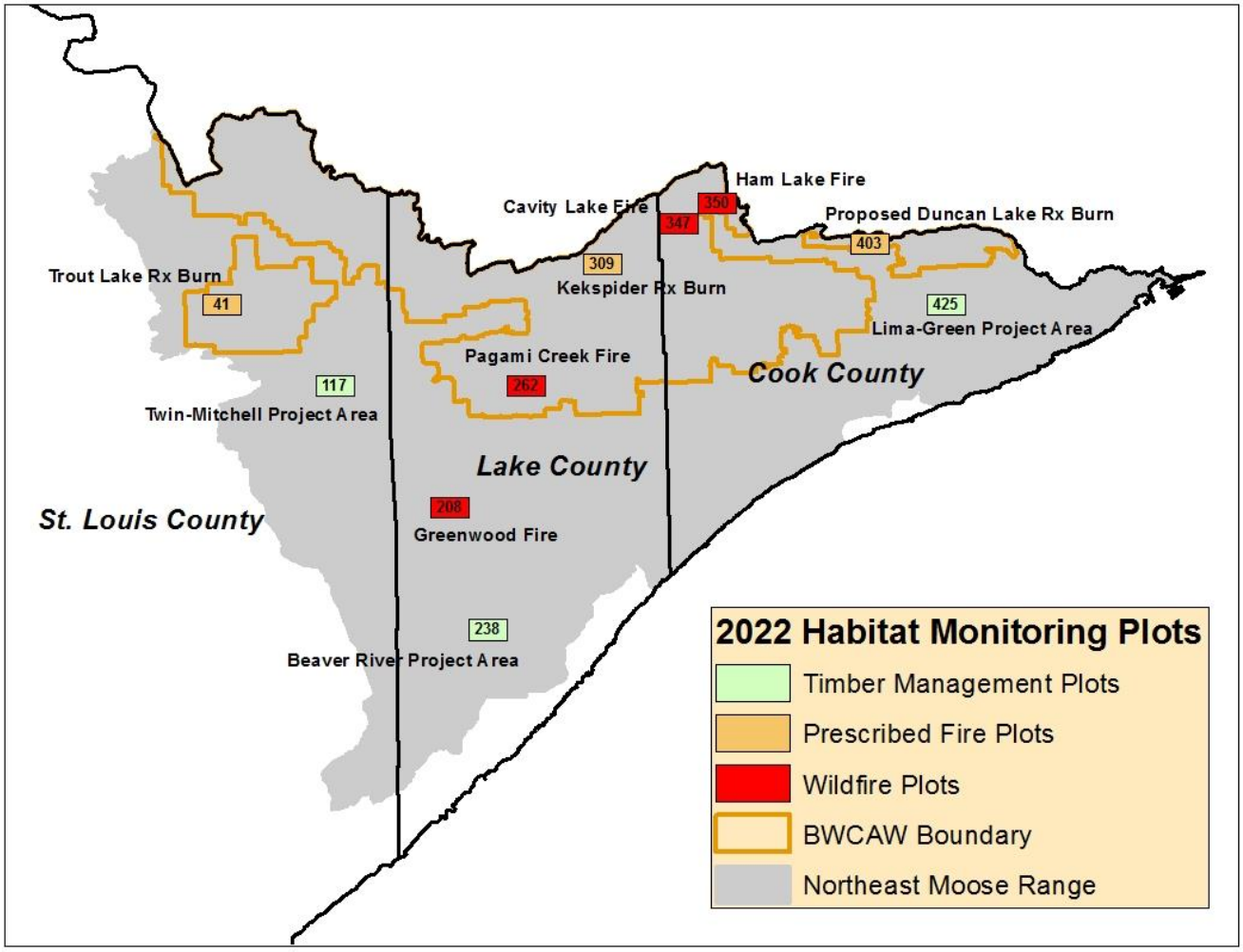

Figure 1. Locations and treatment types of the 10 moose habitat survey plots.

Habitat and vegetation age data was compiled by SNF Wildlife Biologist, Chris Beal using land cover definitions and forest ages acquired from the most recent Forest Service and MN DNR stand inventory data, or was noted anecdotally by survey crews while flying the plot or from past ground visits to each plot to measure

and describe the vegetation. 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 and 2019 Lake County aerial imagery. The intention is to fly each of the habitat plots on an annual basis on a semi-permanent basis 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. The number and location of moose observed are reported for each plot. When available, survey data for each plot 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.

Results and Discussion

Survey conditions in 2022 were described by DelGiudice (2022). The survey was initiated on 6 January and completed on 14 January with eight actual survey days. Including the 10 habitat plots, a total of 53 plots were surveyed in 2022. Survey conditions were rated as "Good" and snow depths were estimated at $\geq$8" on all 10 habitat plots. Results of this habitat survey should be considered within the context of the entire northeastern Minnesota moose population. While the population still exhibits a linear decline since 2005, the most recent trend appears to have stabilized at between 3000 - 4000 moose and may even be slightly increasing (Figure 2). In 2022 an average of 10 moose were seen on the 10 high density moose plots.

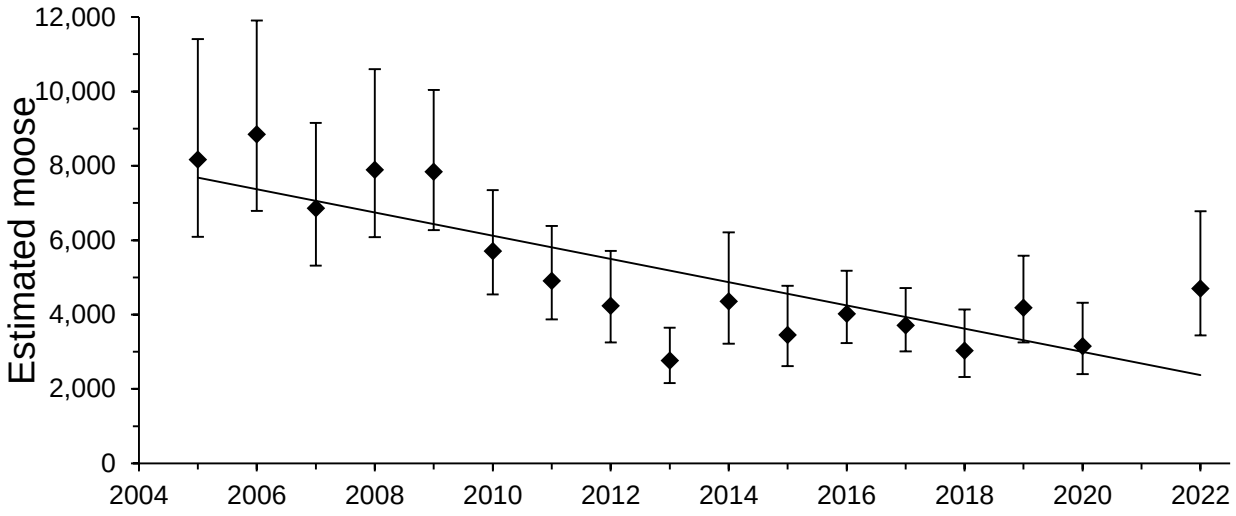

Figure 2. Point estimates, 90% confidence intervals, and trend line of estimated moose numbers in northeastern Minnesota, 2005-2022. The survey was not conducted in 2021 due to the Covid-19 pandemic (DelGiudice, 2022).

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 30% St. Louis County, 28% SNF, 22% private or other and 20% State. Habitat types are shown below in Table 1. Age data is available for 91% of the upland and lowland forest habitat types and is described in Table 2. County, Federal and State lands within this survey plot are actively managed primarily for timber production.

Habitat types	Total Acres
Upland conifer	3,070
Upland deciduous	1,682
Lowland forest	1,462
Lowland non-forest	1,114
Open water	507
Upland shrub	14
Other/Non-habitat	681
Total acres	**8,529**

Table 1. Habitat types in plot 117.

Forest types, known ages only	Overall	0-5 years	6-20 years	21-50 years	50-80 years	80+ years
Upland conifer	45%	0%	21%	4%	2%	17%
Upland deciduous	30%	2%	1%	13%	5%	8%
Lowland forest	26%	0%	4%	2%	2%	19%
Total acres	**5,643**					

Table 2. Known age classes of forest types in plot 117

In 2022, we observed five moose on Plot 117, part of the Twin-Mitchell Project Area. For the 11 years observations have been made on plot 117, the results have been lower than the means of other high density moose plots in the same year (Figure 4). In addition, 22 deer were observed. Since 2012 an average of 22 deer have been counted on plot 117 during each survey. This plot and the Trout Lake Rx Burn (plot 41) are the only two habitat plots where white-tailed deer have been observed during the survey.

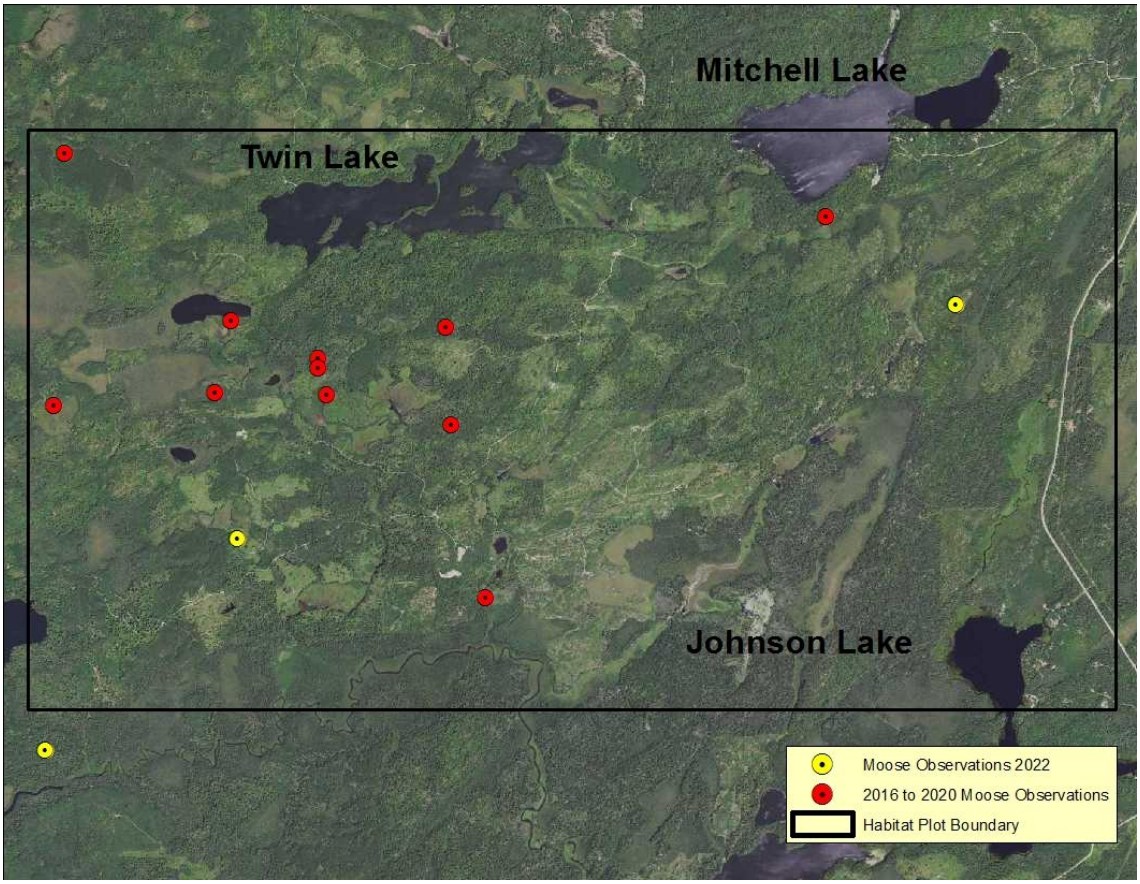

Figure 3. Plot 117, part of the Twin-Mitchell Project Area for timber management.

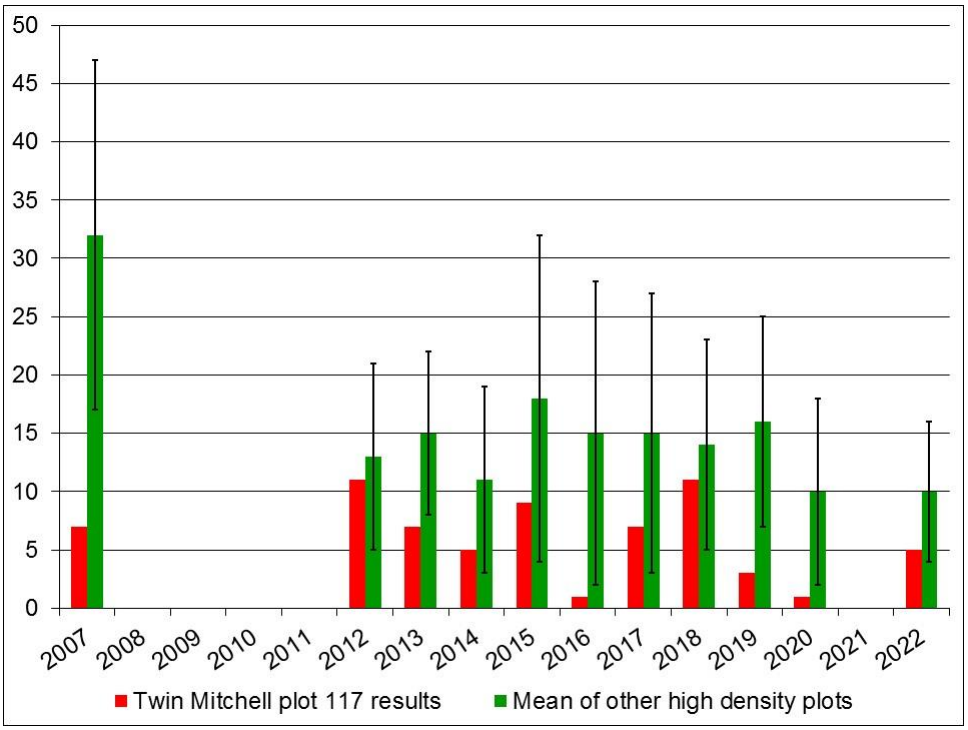

Figure 4. Twin Mitchell plot 117 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

Plot 238: Beaver River Project Area

Plot 238 replaced plot 237 in this survey in 2019 in order to better capture timber management associated with the upcoming Beaver River Project. The plot is centered on Lake County Highway 15 between the Cloquet River on the west and the Beaver River on the east (Figure 5). Land ownership is 77% SNF, 11% private or other, 8% State and 4% Lake County. Habitat types are described in Table 3. Age data is known for 89% of the upland and lowland forest habitat types and these are described in Table 4.

Habitat types	Total Acres
Upland conifer	2,306
Upland deciduous	2,533
Lowland forest	1,440
Lowland non-forest	1,893
Open water	60
Upland shrub	170
Other/Non-habitat	127
Total acres	**8,529**

Table 3. Habitat types on plot 238.

Forest types, known ages only	Overall	0-5 years	6-20 years	21-50 years	50-80 years	80+ years
Upland conifer	35%	0%	3%	8%	2%	23%
Upland deciduous	39%	0%	1%	11%	2%	26%
Lowland forest	26%	0%	0%	1%	0%	25%
Total acres	**5,597**					

Table 4. Known age classes of forest types on plot 208

There has been little recent timber harvest on the plot. Less than 2% of SNF land has been harvested or thinned in the last 20 years (155 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 and sheared and planted 44 acres for moose habitat improvement in the spring of 2019. 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. Work to lay out timber sales has commenced with the first sales expected in the summer of 2022. In addition, 120 acres of brush shearing was done between 2018-2020. There are no current plans for harvest on State land.

In 2022, 10 moose were observed on plot 238, part of the Beaver River Project Area (Figure 6). With the exception of 2022, moose numbers on plot 238 were lower than the mean of other high density plots the four previous times this plot has been surveyed since 2004.

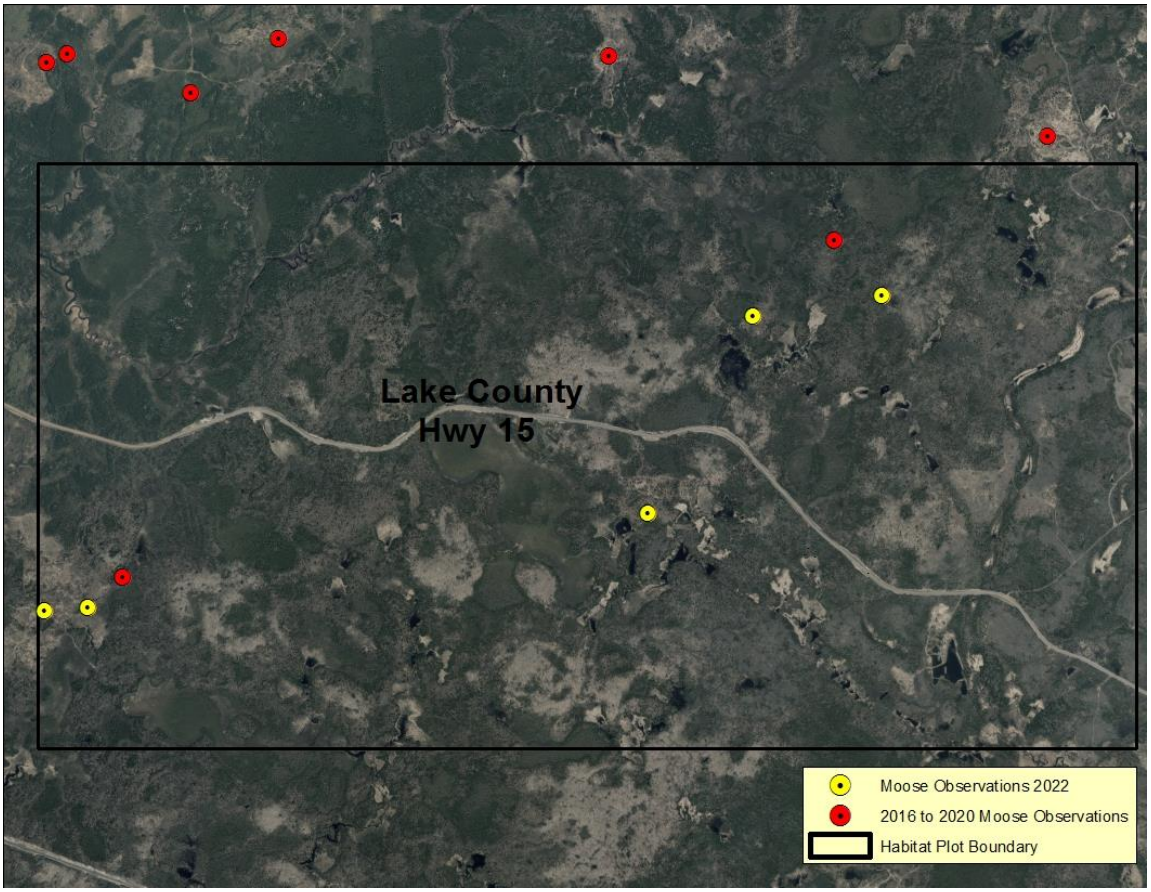

Figure 5. Plot 238, part of the Beaver River Project Area for timber management.

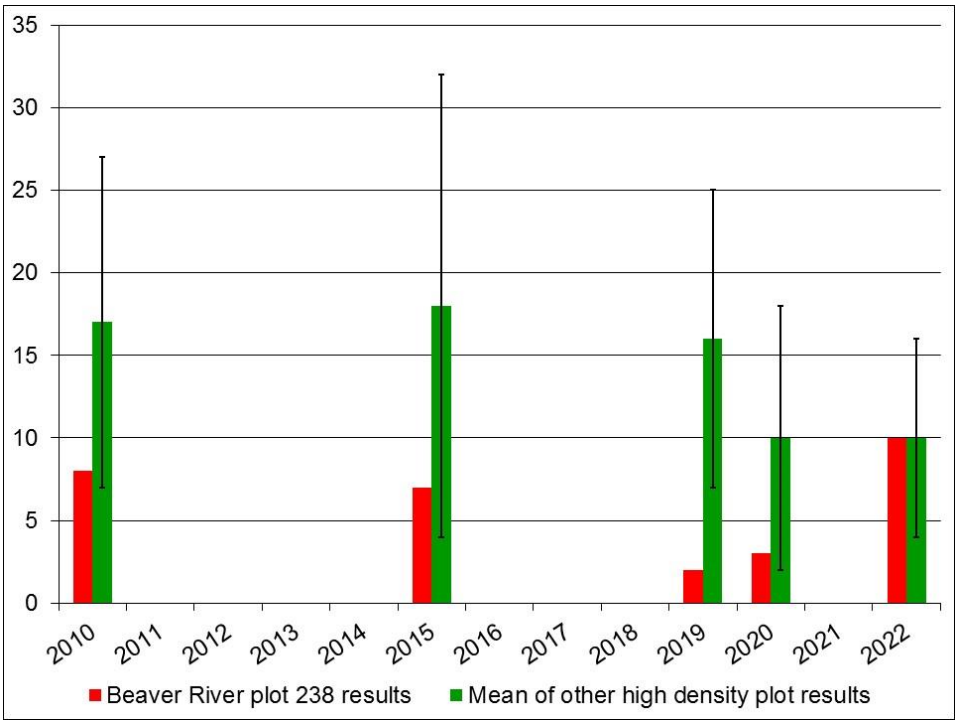

Figure 6. Beaver River plot 238 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

Plot 425: Lima Green Project Area

Plot 425 is located immediately southwest of Greenwood Lake in Cook County (Figure 7). Land ownership is 84% SNF, 15% State and 1% private or other. Habitat types are described in Table 5. Age data is known for 99% of the upland and lowland forest habitat types and these are described in Table 6.

Habitat types	Total Acres
Upland conifer	3,375
Upland deciduous	3,357
Lowland forest	1,227
Lowland non-forest	373
Open water	190
Upland shrub	-
Other/Non-habitat	9
Total acres	**8,530**

Table 5. Habitat types on plot 425.

Forest types, known ages only	Overall	0-5 years	6-20 years	21-50 years	50-80 years	80+ years
Upland conifer	42%	3%	4%	16%	10%	9%
Upland deciduous	42%	5%	6%	24%	2%	5%
Lowland forest	15%	0%	0%	2%	4%	10%
Total acres	**7,918**					

Table 6. Known age classes of forest types on plot 425.

Original Lima Green harvest plans for SNF lands in plot 425 included approximately 2,375 acres of various treatments, including 1,917 acres of clear-cut with reserves. Timber harvest on the Project began in April of 2014 and a few operations are continuing in 2022. 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 2022, 10 moose were seen on plot 425, part of the Lima Green Project Area (Figure 8). From 2012-14, up to the start of timber harvest associated with the Lima Green Project, results were lower than the mean of other high density plots. Since 2015, the first year after the start of timber harvest, the plot has been higher or equal to the mean of other high density plots in five of seven years.

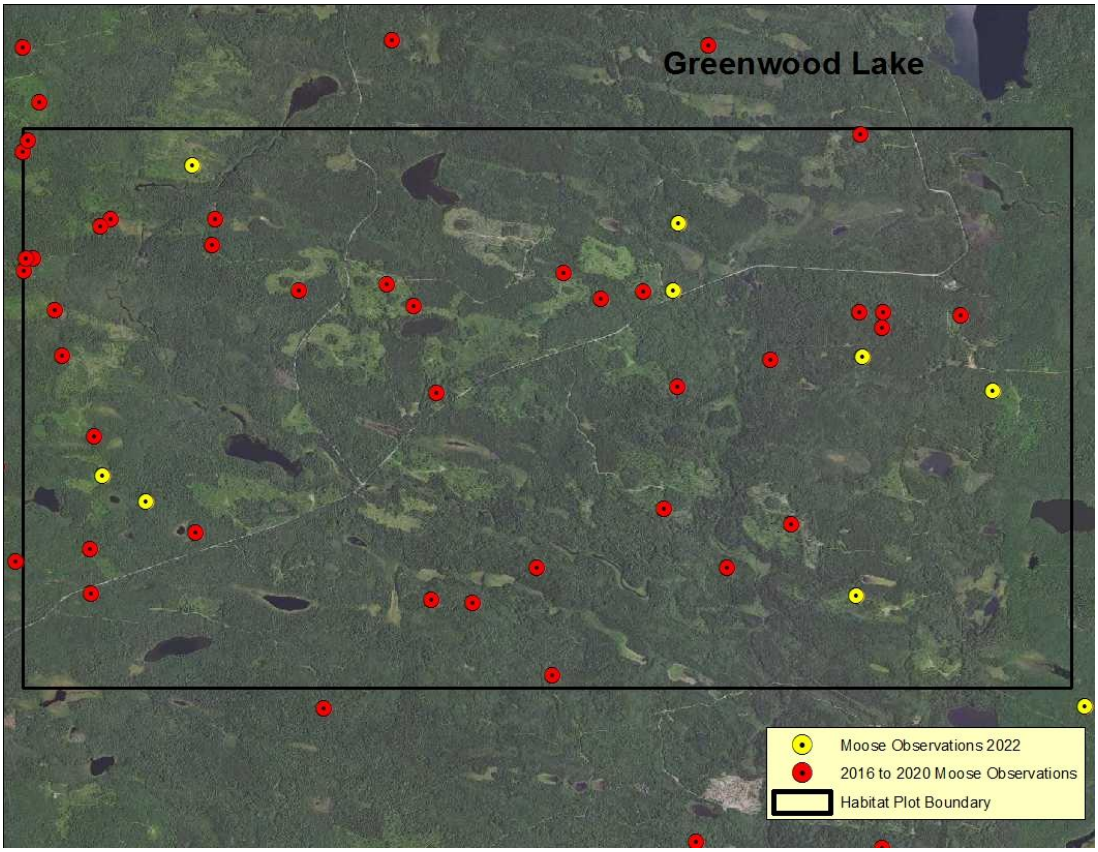

Figure 7. Plot 425 part of the Lima Green Project Area for timber management.

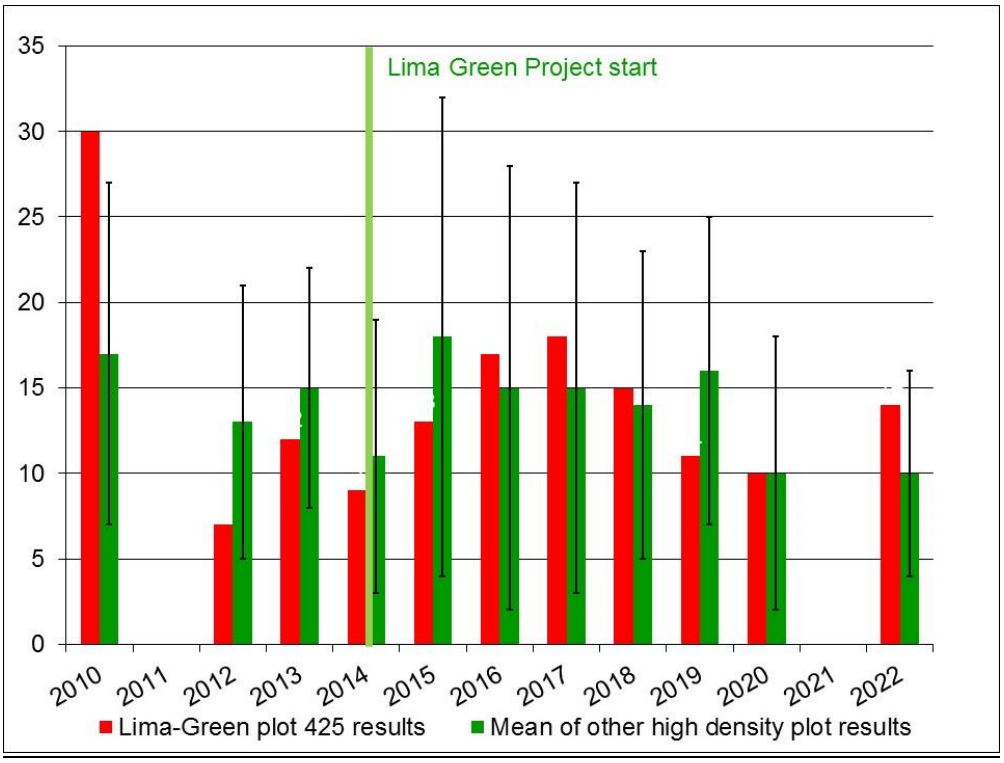

Figure 8. Lima Green plot 425 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

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 within 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 northwestern corner, plot 41 was entirely impacted by the blowdown with damage increasing in a generally west to east direction. Wind damage primarily on the western portion of the plot was estimated at 10-33% of the standing timber on 1,540 acres. 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. Habitat types are described in Table 7.

Habitat types	Total Acres
Upland conifer	4,120
Upland deciduous	215
Lowland forest	-
Lowland non-forest	1,816
Open water	2,215
Upland shrub	3
Other/Non-habitat	161
Total acres	**8,530**

Table 7. Habitat types in plot 41.

Almost all moose observations on this plot for the period of 2012-22 have been within the fire perimeter, likely indicating some attraction of the burned area over surrounding forest (Figure 9 and Schrage, 2017). Aerial observation suggests fire intensity across the plot was relatively light and contains a patchy diversity of live and dead post-fire vegetation. 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. 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 evidence of moose browse on all species except mountain ash.

In 2022, four moose, an unusually low number, were seen on plot 41. Since the fire in 2005, plot 41 has generally produced results close to or above the mean of other high density plots each year (Figure 10). In addition, two deer were observed. Since 2012 an average of two deer have been counted on plot 41 during each survey. This plot and the Twin Mitchell plot 117 are the only two habitat plots where white-tailed deer have been observed during the survey.

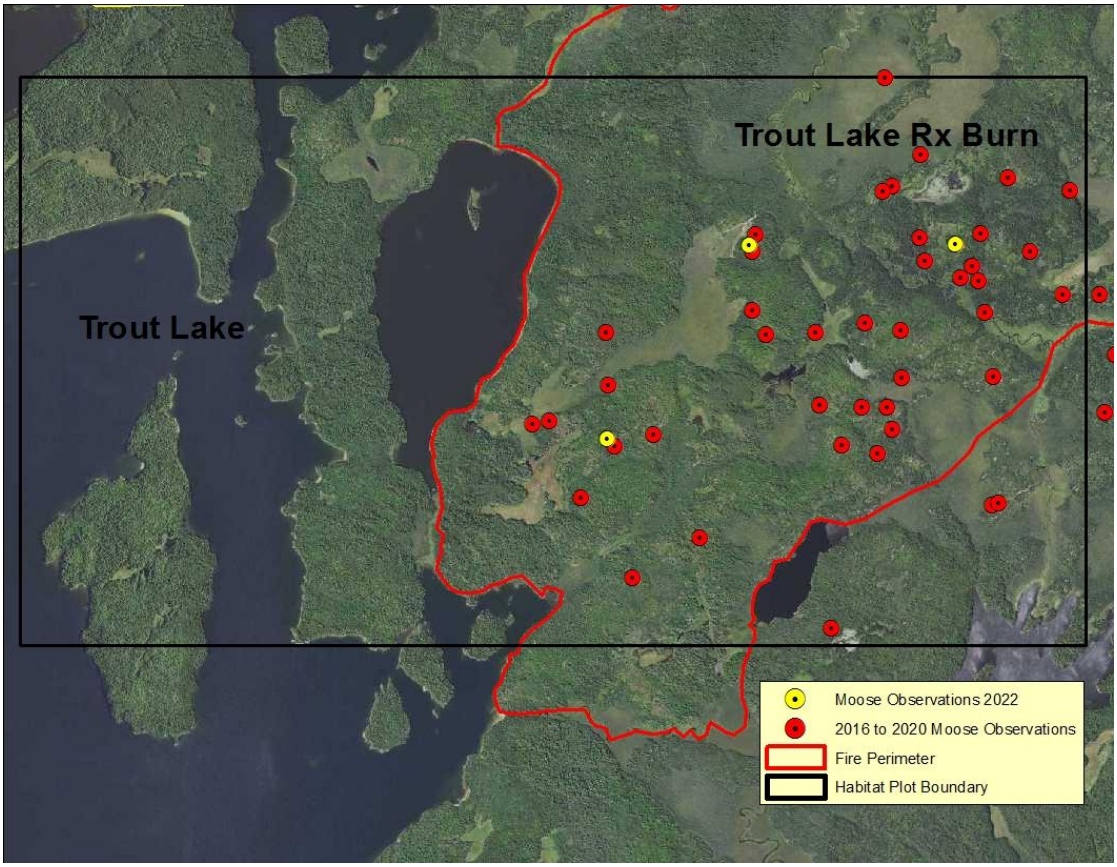

Figure 9. Plot 41 containing part of the 2005 Trout Lake Rx Burn.

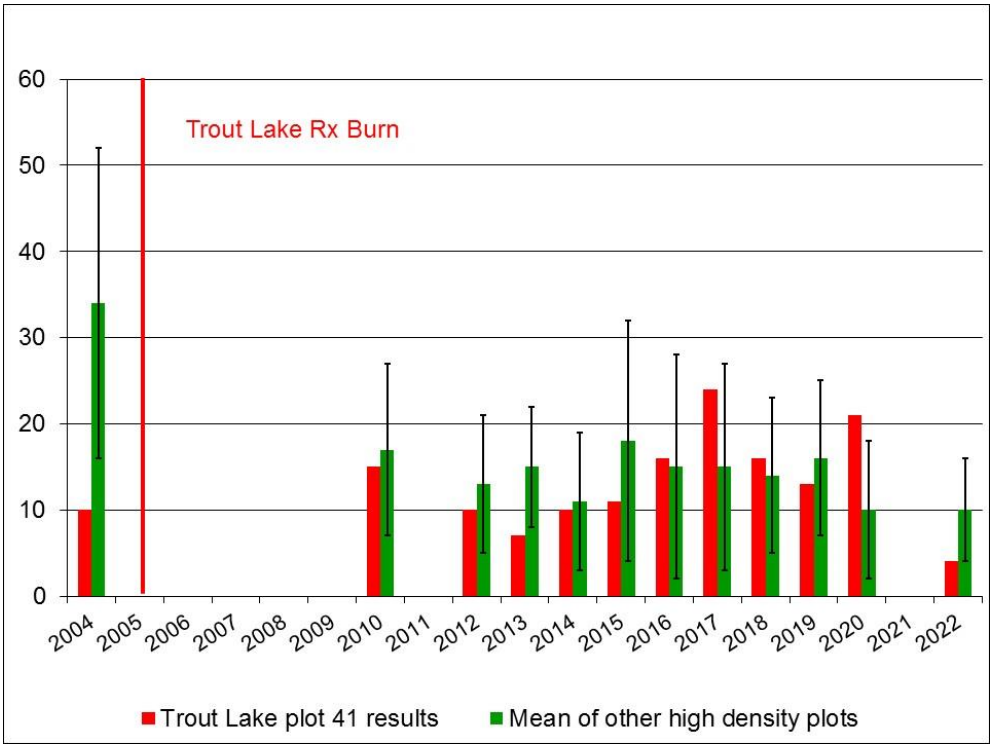

Figure 10. Trout Lake Rx Burn plot 41 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

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. Aerial observation suggests the fire burned with various intensities across the plot. Regeneration following the blowdown and the fire, is evident from the air during the survey and contains a strong conifer component. The topography of the plot is relatively rugged. Habitat types are described in Table 8.

Habitat types	**Total Acres**
Upland conifer	2,061
Upland deciduous	3,483
Lowland forest	-
Lowland non-forest	460
Open water	2,301
Upland shrub	-
Other/Non-habitat	223
Total acres	**8,529**

Table 8. Habitat types in plot 309

In 2022, 21 moose were observed on plot 309, part of the Kekspider Rx Burn (Figure 12). Similar to observations from the Trout Lake Rx Burn on plot 41, almost all of the moose observations since 2012 have been either inside or very close to the perimeter of the fire likely indicating some attraction of moose to the burn (Figure 11, Schrage, 2017).

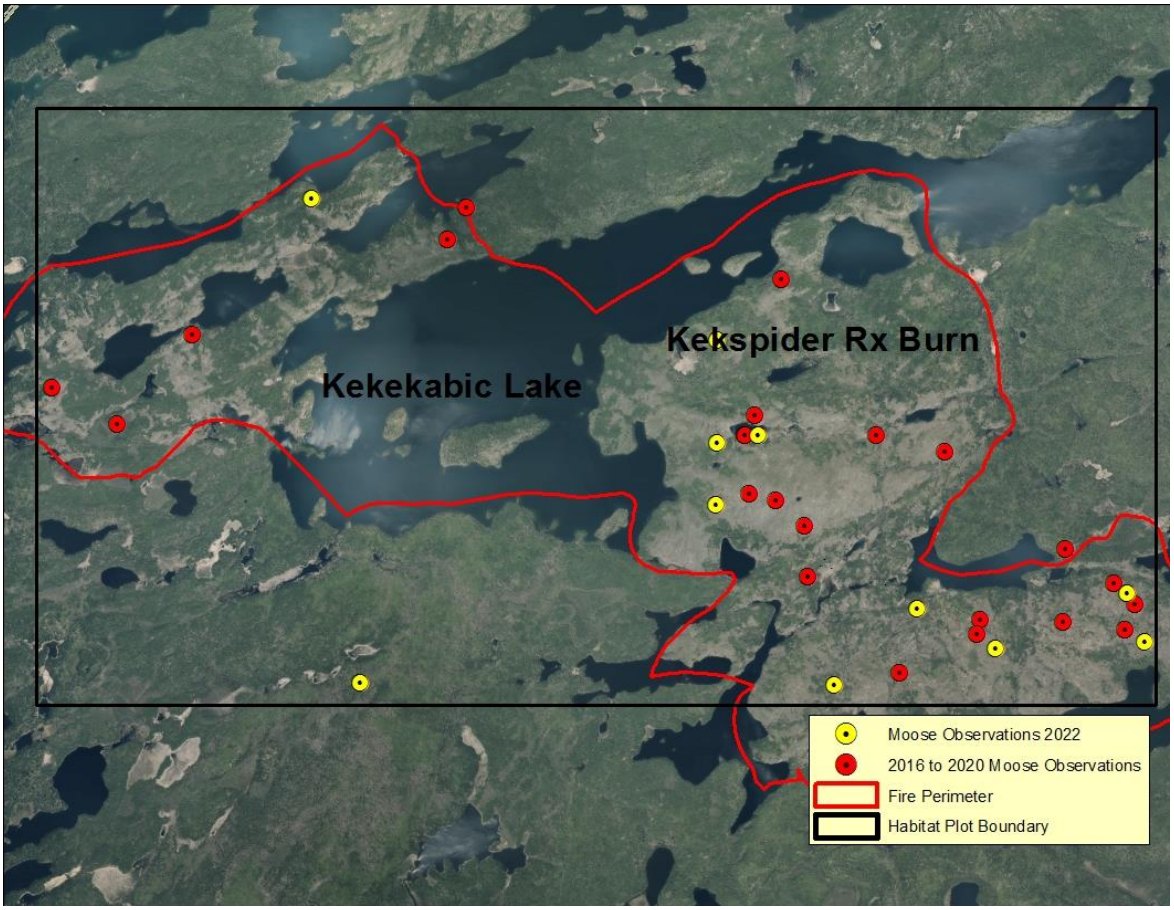

Figure 11. Plot 309 containing most of the Kekspider Rx Burn.

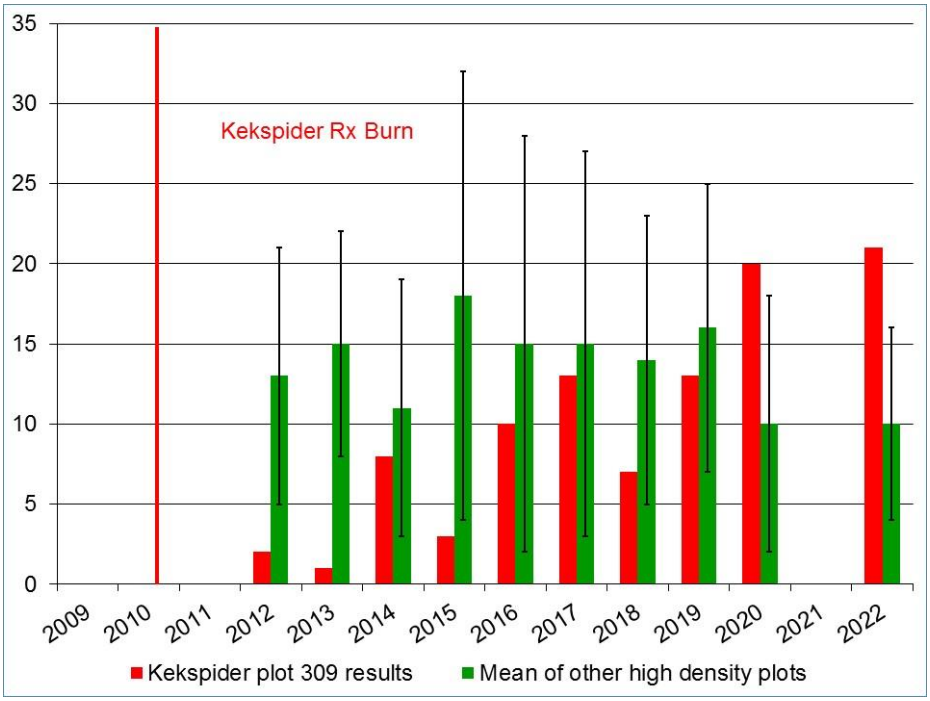

Figure 12. Kekspider Rx Burn plot 309 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

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 northwestern 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. Habitat types are described in Table 9. Most of the age data is unknown.

Habitat types	**Total Acres**
Upland conifer	3,700
Upland deciduous	1,609
Lowland forest	57
Lowland non-forest	263
Open water	2,122
Upland shrub	8
Other/Non-habitat	382
Total acres	**8,142**

Table 9. Habitat types in plot 403.

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 were 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 2022, eight moose were observed on plot 403, part of the planned Duncan Lake Rx Burn (Figure 14). Plot 403 results have been less 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.

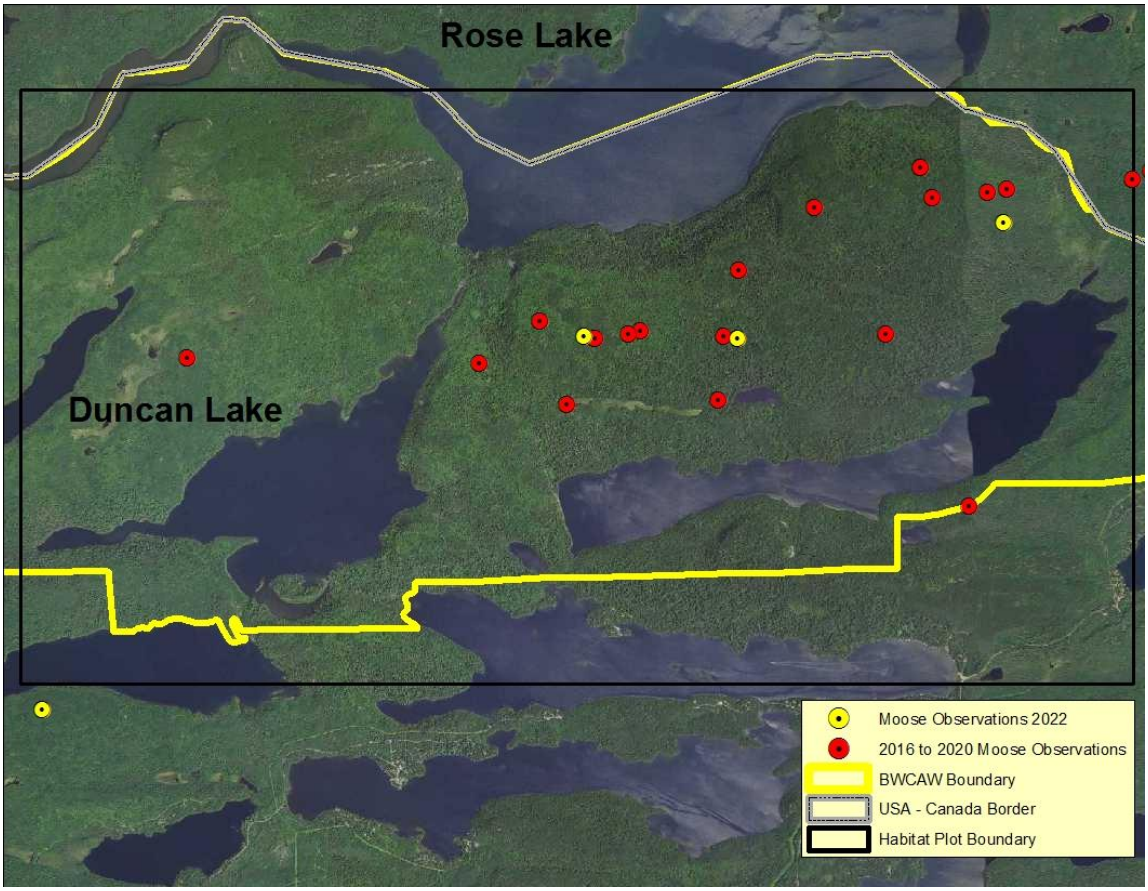

Figure 13. Plot 403, part of the proposed Duncan Lake Rx Burn.

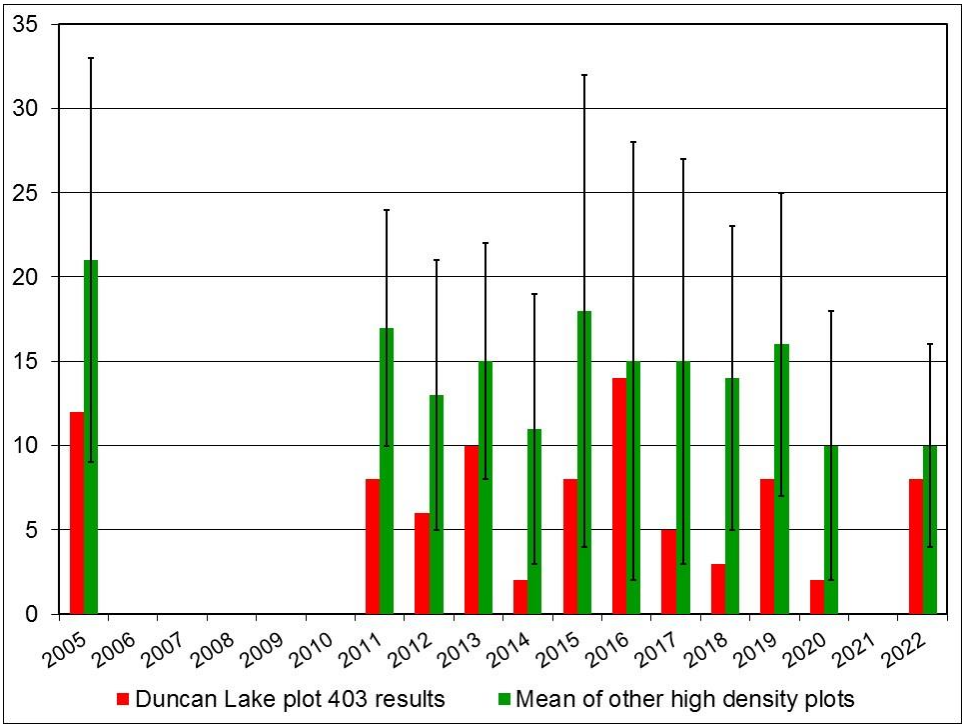

Figure 14. Duncan Lake proposed Rx Burn plot 309 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

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, was 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 2022, 14 moose were seen on the Pagami Creek Fire plot 262. Following the fire from 2012-2015, only one moose was 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 consistently been above the $\geq$8 moose observed threshold necessary to stratify it as a high density plot. While moose numbers have been consistently good on plot 262, they have failed to reach the levels observed in the past on plots 347 and 350 in the Cavity and Ham Lake fire perimeters. This may be due to the extensive jack pine regeneration observed on plot 262 vs an apparent trend towards deciduous vegetation on the Cavity Lake and Ham Lake Fire plots 347 and 350.

In 2022, one other plot overlapping the perimeter of the Pagami Creek Fire and five miles northeast of plot 262 was surveyed. Plot 304 contains Maniwaki Lake and is almost completely within the fire perimeter. In 2022, 11 moose were observed on plot 304, all within the fire perimeter.

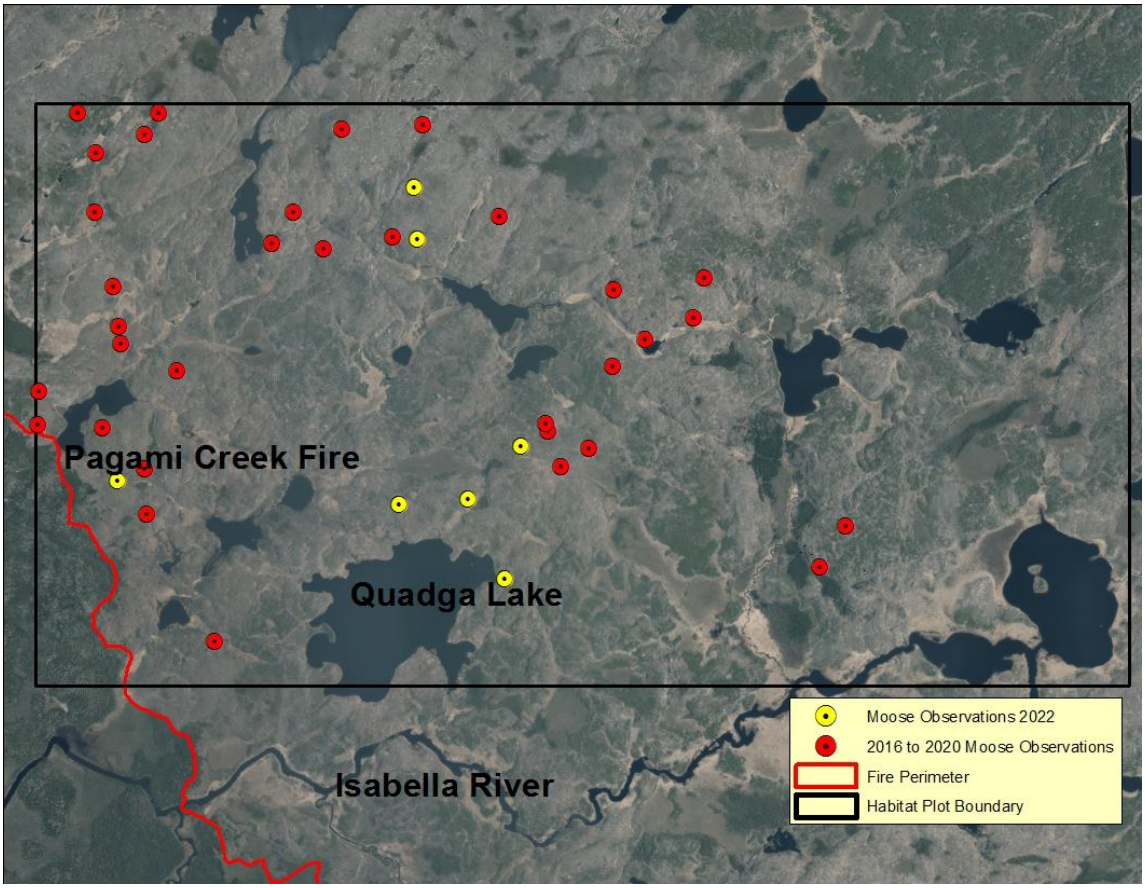

Figure 15. Plot 262, part of the Pagami Creek Fire.

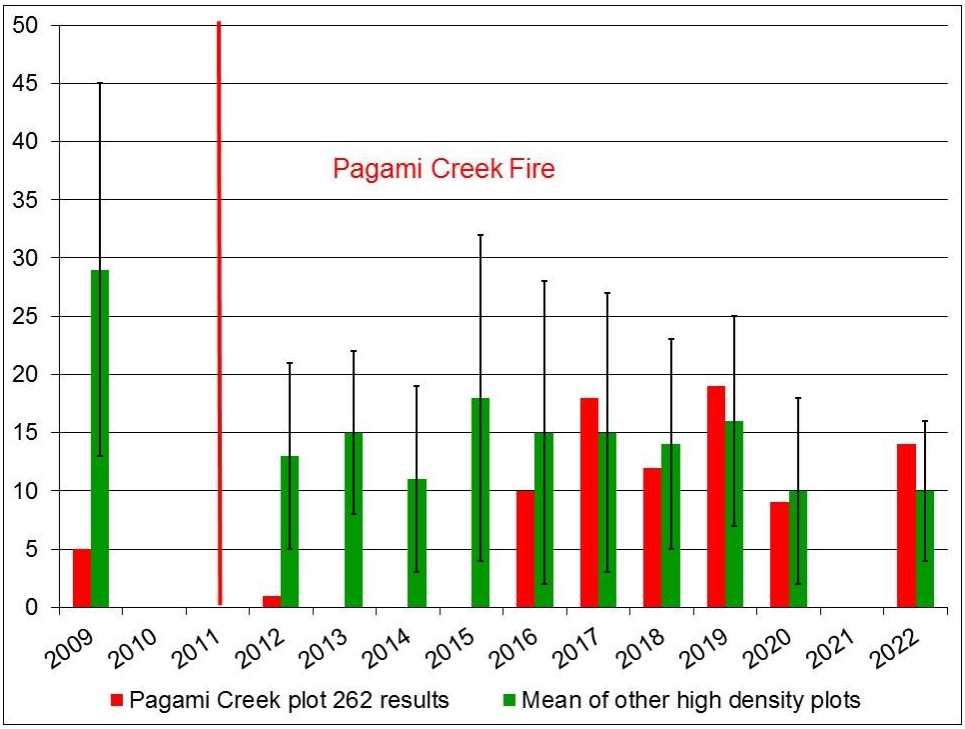

Figure 16. Pagami Creek Fire plot 262 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

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 the 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 regeneration 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 northwestern 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 also were noted in 2016 (personal observation).

In 2022, six moose were observed on plot 347, an unusually low number (Figure 18). In most previous years, plot 347 results have been higher the mean of other high density plots and substantially higher than the mean in most years. This result is especially noteworthy considering 40% of plot 347 is water. The size of the disturbance, the extensive brushfields intermingled with patches of remaining overstory cover and the mix of regenerating species 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 Threemile Island in plot 347 (Schrage, 2012).

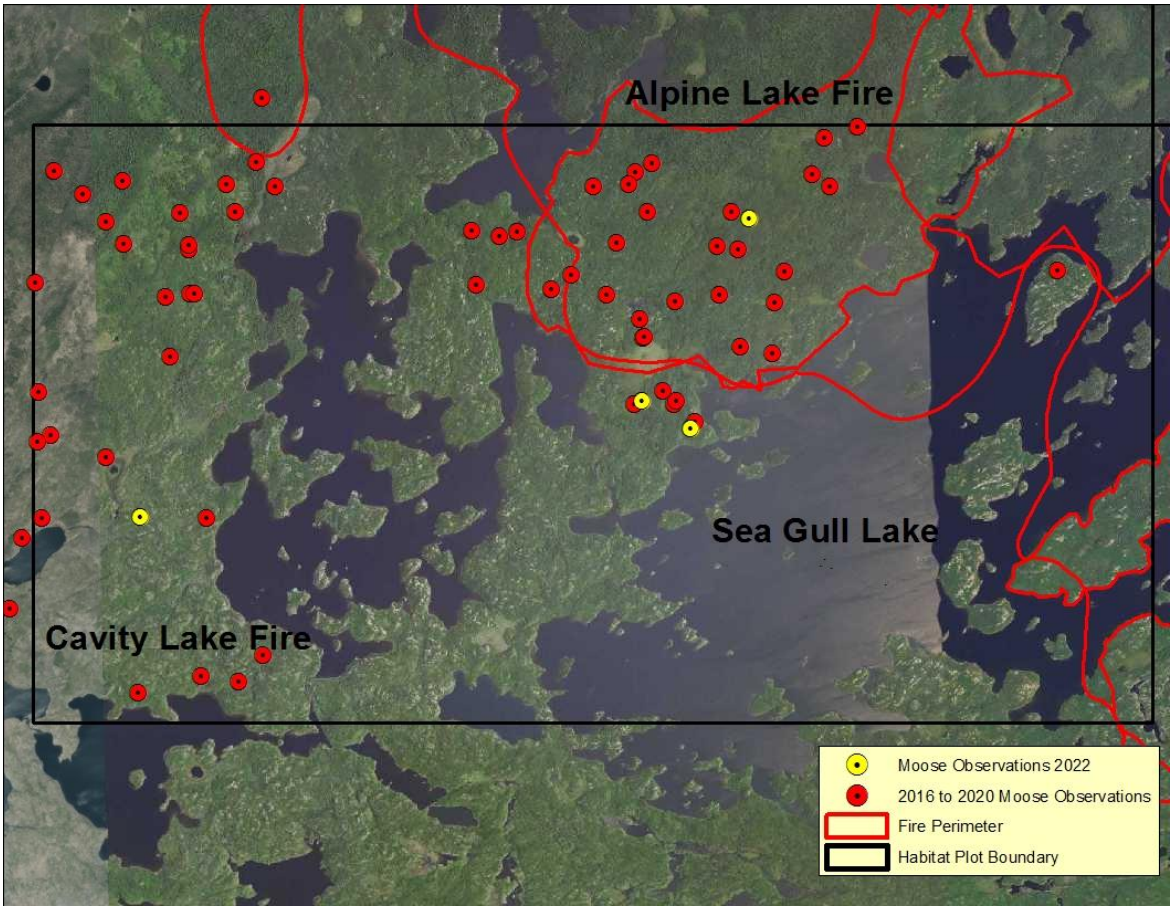

Figure 17. Plot 347, part of the Cavity Lake and Alpine Lake Fires.

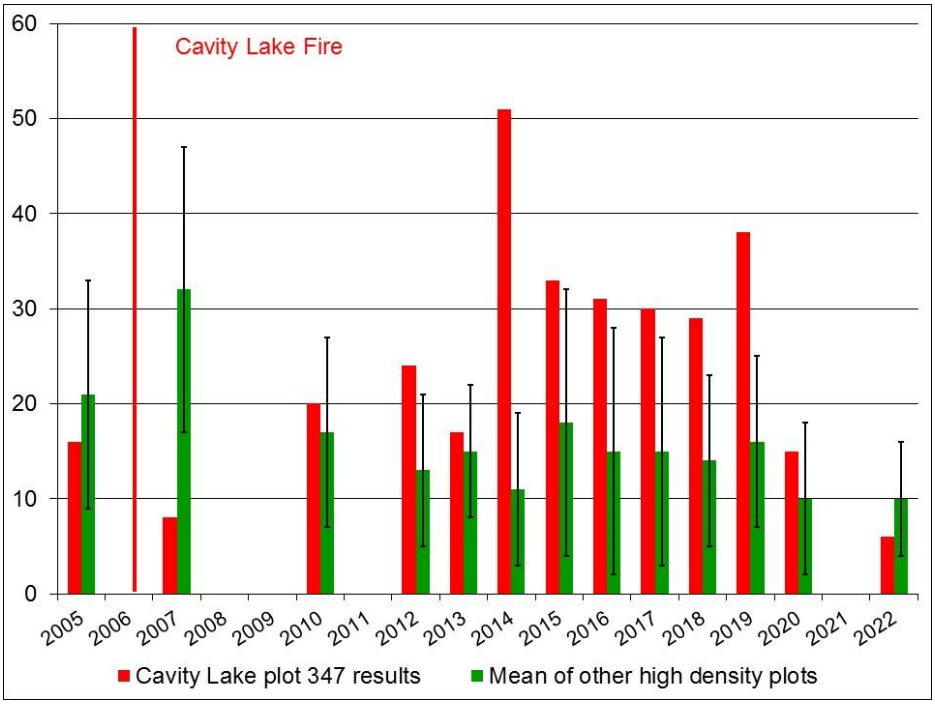

Figure 18. Cavity Lake Fire plot 262 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

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 two thirds of the plot which was impacted by the blowdown and burned in the Ham Lake Fire, has abundant regeneration. Many of the conifer swamps within the fire's perimeter survived and provide an interspersion of 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 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 third 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 2022, 16 moose were observed on plot 350, part of the Ham Lake Fire (Figure 20). In nine of the 10 years since this survey began in 2012 the results have been higher than the mean of other high density plots and substantially higher than 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 regenerating deciduous vegetation 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 dominated by mature jack pine. Although disturbed by both blowdown and fire, relatively fewer observations of moose have been made in those parts of the plot adjacent to the Gunflint Trail and its associated development.

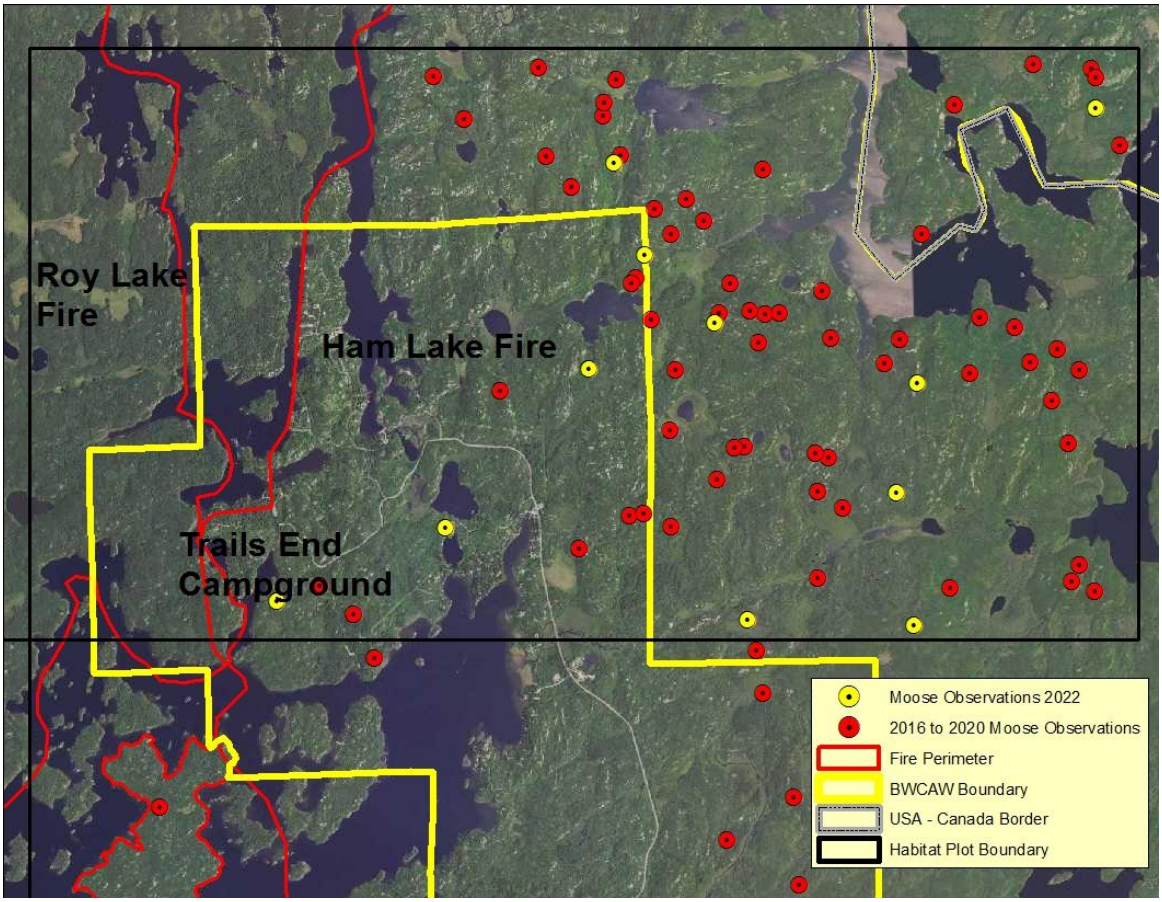

Figure 19. Plot 350, part of the Ham Lake Fire.

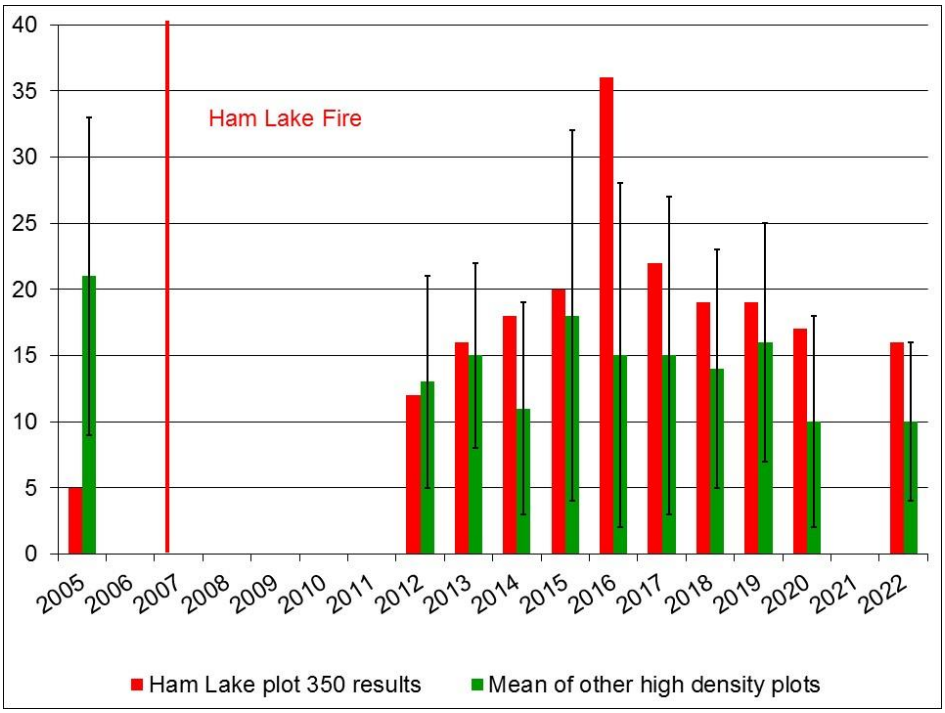

Figure 20. Ham Lake Fire plot 350 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

Plot 208 Greenwood Fire

Plot 208 is located on either side of Lake County Highway 2 between Sand and Stony Lakes (Figure 21). The Greenwood fire is believed to have been sparked by lightning and was first noted on 15 August, 2021. It burned almost 26,800 acres until 20 September by which time it was largely contained. Following the fire, DNR and tribal biologists elected to add a monitoring plot over the fire perimeter because of the high percentage of private land within the fire's perimeter, the publicity surrounding the fire and as the first major wildfire in recent times entirely outside of designated wilderness. Plot 208 was selected due to the number of acres impacted by the fire and the presence of data from two prefire moose surveys. In plot 208 the fire impacted approximately 5430 acres, largely on the east side of Highway 2. Fire severity was rated as low or moderate on almost all of the acres impacted in the plot. Land ownership in plot 208 is 65% private or other, 22% State, 12%, SNF and 1% Lake County. Only 36% of the timber was of known age before the fire with 75% ≥50 years old and 12% ≤20 years old. Prefire habitat types in plot 208 are shown in Table 10. Prefire age data is known for 69% of the upland and lowland forest habitat types and these are described in Table 11.

Habitat types	Total Acres
Upland conifer	2,377
Upland deciduous	281
Lowland forest	1,801
Lowland non-forest	2,633
Open water	512
Upland shrub	14
Other/Non-habitat	910
Total acres	**8,529**

Table 10. Prefire habitat types in plot 208.

Forest types, known ages only	Overall	0-5 years	6-20 years	21-50 years	50-80 years	80+ years
Upland conifer	32%	2%	8%	10%	4%	9%
Upland deciduous	9%	0%	0%	3%	0%	6%
Lowland forest	59%	0%	2%	1%	9%	47%
Total acres	**3,065**					

Table 11. Known prefire age classes of forest types on plot 208.

In 2022, the first winter following the fire, no moose were observed on plot 208. In addition, plots 209 and 231 were impacted by the Greenwood Fire and were randomly selected to be part of the 2022 moose population survey. No moose were observed on those two plots either.

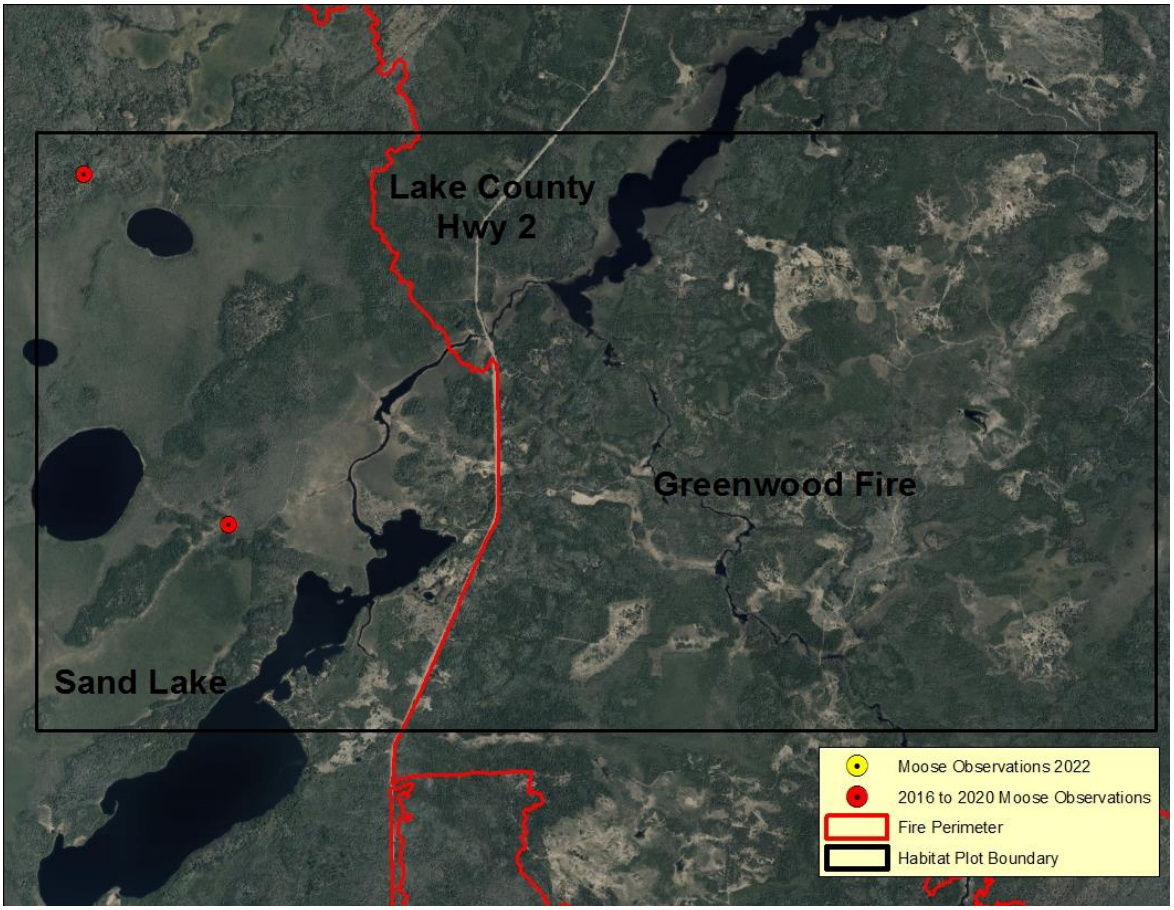

Figure 21. Plot 208, part of the Greenwood Fire.

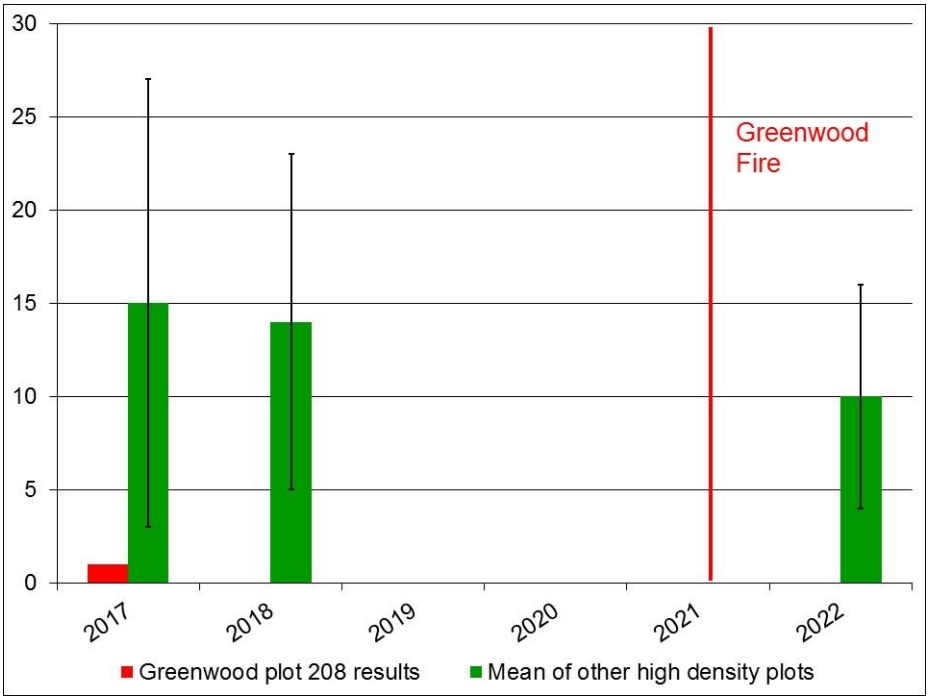

Figure 22. Greenwood Fire plot 208 survey results vs the mean of other high density moose plots for each year. The error bars represent 1 standard deviation.

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Figure 22. A trio of moose in the Kekspider Rx Burn.

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