POPULATION AND HARVEST TRENDS OF MOOSE IN SASKATCHEWAN

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ABSTRACT: Moose are an integral species of the boreal forest and highly valued by Indigenous peoples and licensed hunters in Saskatchewan. Information from 27 aerial surveys (1998–2022) indicate moose populations are generally declining (range: $\lambda = 0.96$ to 1.02) across much of the southern boreal forest and may be stable in the non-forested areas of the province. Provincial resident licensed harvest of moose declined from 5,466 in 2015 to 3,449 in 2023 while hunter effort remained relatively stable. The composition of the licensed harvest was 65% ± 11(SD) bulls, 27% ± 8(SD) cows and 8% ± 3(SD) calves during this period. The southern boreal forest has been a long-standing traditional area for Saskatchewan licensed moose hunters where harvest has declined approximately 40% from 2015 to 2023 (range: 677–1195) with highly variable harvest rates (5% ± 4.3SD) among Wildlife Management Zones (WMZs). In 2022, in non-forest WMZs antlerless seasons were removed and quotas reduced in response lower moose numbers. These regulatory adjustments lowered the percent of cows in the harvest from 39% ± 2(SD) in 2015-2021 to 16-17% in 2022–2023. While data were limited, maintaining ≤ 20% cows in the total harvest may allow moose populations in non-forested areas to remain at or near current levels. Other factors impacting moose populations in the province are habitat loss, increased road and trail access facilitating harvest by hunters and predators, parasites and disease.

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Moose (*Alces alces*) remain an integral species of the boreal forest in North America (Telfer 1984, Kelsall 1987, Karns 2007) and in recent decades have established in some non-forested landscapes (Laforge et al. 2016, Bjorge et al. 2018). Moose play an important ecological role as food for wolves (*Canis lupus*) and black bears (*Ursus americanus*) and co-exist with other ungulates, such as deer (*Odocoileus* spp.), elk (*Cervus elaphus*) and caribou (*Rangifer tarandus*). Moose are highly valued by hunters and are a primary food source for many Indigenous people. Ensuring moose are available for Indigenous people is crucial to maintaining their traditional way of life and part of their cultural and spiritual connection to the species (Popp et al. 2019). Moose abundance has been declining in many parts of Canada since the mid-2000's (Timmermann and Rodgers 2017, Kuzyk et al. 2020). There are multiple factors leading to moose population declines, including elevated mortality due to increased road access for hunters and predators (Rempel et al. 1997, Francis et al. 2020, Boucher et al. 2022), parasites (Samuel 2007, Jones et al. 2017, Ditmer et al. 2020), and climate change (Murray et al. 2006, Rempel 2011), all of which may act in combination with anthropogenic landscape

change (Brown 2011, Johnson and Rea 2023).

In Saskatchewan, moose abundance has been declining in the boreal forest (the forest, hereafter) in recent years (Arsenault et al. 2019) causing public concern on impact to hunting opportunities and food security for Indigenous peoples. Trend surveys flown in fixed-wing aircraft from 1958–1988 in the southern forest found that moose populations generally cycle every 9–11 years (Stewart and Gauthier 1988). Forestry remains a prominent industry in the southern boreal forest of Saskatchewan. Forest harvesting and linear disturbance can influence the spatial relationships between moose, their predators and other ungulates (Brown 2011, Gagne et al. 2016). Improved travel efficiency of hunters and predators facilitated by roads and trails increases mortality risk to moose (Francis et al. 2020, Boucher et al. 2022). Long-term changes in forest harvest patterns, silviculture (Boucher et al. 2025), reduced natural wildfire, and agricultural expansion into the boreal forest fringe may also be influencing moose populations in forested landscapes.

Throughout western Canada, in forested areas where predators are lightly hunted, moose density is typically <400 moose/1000 km^2, and bull-only hunting is the recommended harvest strategy (Hayes et al. 2003, Kuzyk 2016). In forested landscapes where moose co-exist with wolves and bears, it is recommended that harvest rates do not exceed 5% to maintain sustainable moose populations (Hatter 1999, Hayes et al. 2003, Kuzyk et al. 2018). In remote areas, moose abundance may fluctuate over time regardless of hunting pressure (Gasaway et al. 1983).

In non-forested areas of the province (non-forest, hereafter), moose historically occupied the aspen (*Populus tremuloides*) parkland and portions of the grassland. Soon after European settlement, moose range contracted northward to portions of the boreal forest fringe due to extensive hunting and land clearing. In the early 1990s, moose observations increased in southern Saskatchewan and today moose occur in all ecoregions of the province (Fig. 1). Factors underlying moose re-colonization of the non-forest appear to be a combination of optimal forage, lack of predators, and favorable climatic conditions (LaForge et al. 2016). Moose in the non-forest have few to no predators. and populations may sustain higher harvest rates of up to 10–20% (Hatter 1999, Bjorge et al. 2018) whereas hyper-abundant moose populations may tolerate up to 50% cows in the harvest (Rettie 2010). A liberal harvest strategy was implemented in 2008 within the non-forest to reduce moose populations to align with levels of social tolerance. By 2022, moose populations had been reduced and the management objective shifted to maintaining moose populations at or near current levels. Antlerless seasons were removed and quotas reduced to align with this objective, and moose abundance was qualitatively assessed by information from resource professionals and hunters.

Periodic updates of moose abundance and licensed harvest provide a better understanding of population fluctuations over time and help guide harvest strategies. An evaluation of population and harvest trends, as well as sustainable harvest levels (Hatter 1999) are required to ensure an accurate and current assessment of the status of moose. The purpose of this paper is to provide an overview of population trends (1998–2022) and recent licensed harvest (2015–2023) of moose in Saskatchewan to help guide future management direction.

STUDY AREA

Saskatchewan is an ecologically diverse province with landscapes ranging from the boreal shield in the north to grasslands in

the south (Padbury et al. 1998). For wildlife management purposes the province is divided into Wildlife Management Zones (WMZs) and Big Game Management Units (BGMUs) that group WMZs with similar geographic features and follow ecological boundaries (Fig. 1). Managing moose using BGMUs is appropriate because moose are generally homogenous on the landscape, though their distribution is largely driven by large-scale landscape changes (Brown 2011, LaForge et al. 2016,

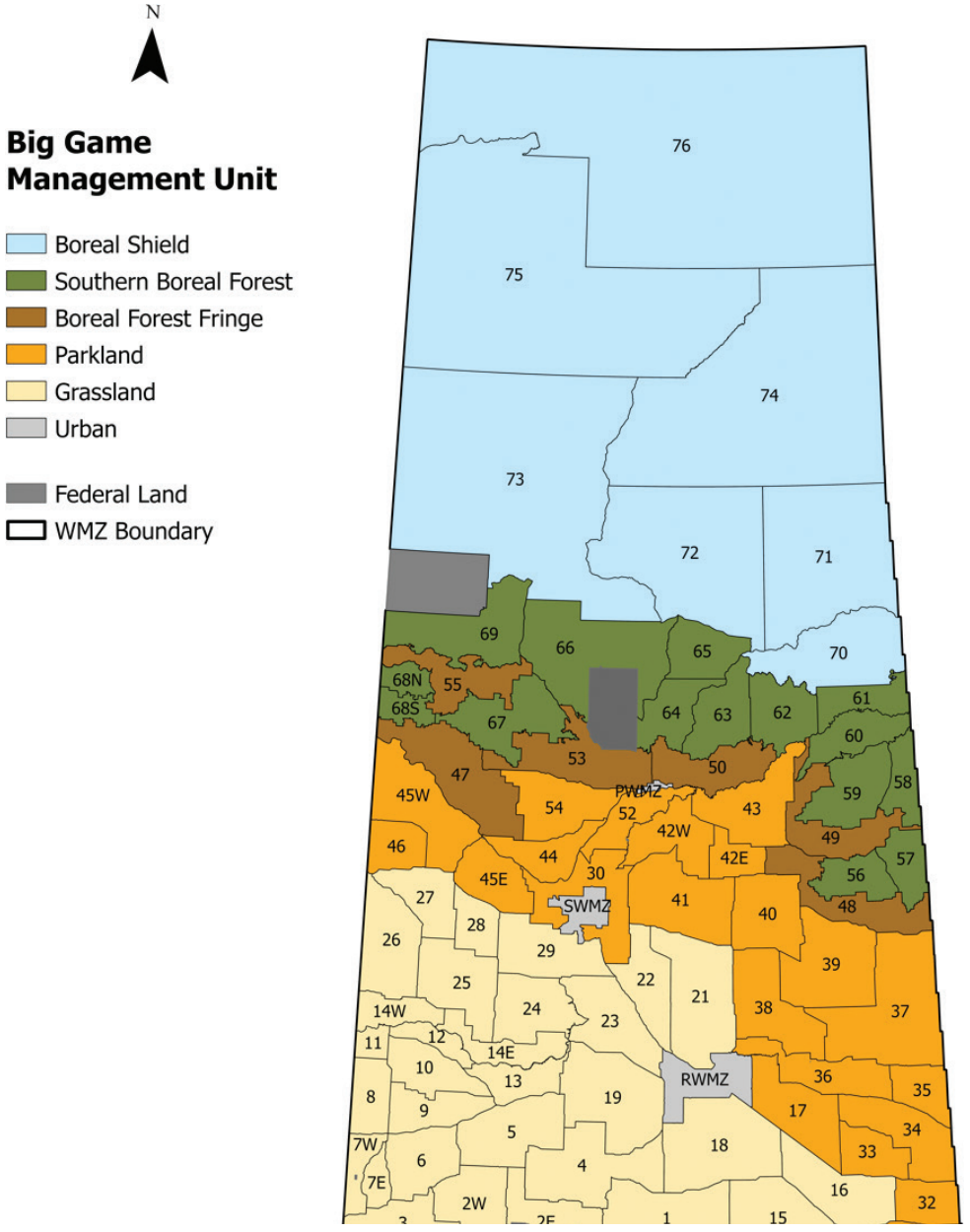

Fig. 1. Distribution of Big Game Management Units in which moose are managed in Saskatchewan. Big Game Management Units (BGMU's) are a collection of Wildlife Management Zones (WMZ's) that are ecologically similar.

Johnson and Rea 2023). Moose management in Saskatchewan is grouped into non-forest WMZs (WMZ 1-55) which consist largely of agricultural crops and livestock grazing in the grassland, parkland, and boreal forest fringe (Fig. 1). Forest WMZs (WMZ 56-76) are a mixture of deciduous and coniferous trees in the southern boreal forest and mostly coniferous in the boreal shield (Fig. 1). Moose occupy all zones in the province and co-exist with other ungulates, including white-tailed deer (*Odocoileus virginianus*), mule deer (*O. hemionus*), elk, and caribou. The main predators of moose are wolves and black bears.

In the non-forest, habitat is limited, and moose capitalize on tree-ringed wetlands, shelter belts, and farmyards. Most of the non-forest consists of agricultural landscapes with annual crops of oilseed and cereal with some hay production. Livestock grazing is common in terrain unsuitable for crops. The lack of habitat for moose in the non-forest has likely contributed to variable home range sizes, increased seasonal movements, and increased human conflict (Laforge et al. 2016).

In 2021 all regular licensed moose hunting seasons in forested WMZ's were standardized to bulls only. Licensed hunting seasons in forest WMZs began September 1 and ended November 30. Hunting was regulated with open seasons or draws (i.e., hunters were required to draw an appropriate draw authorization). Hunting seasons in non-forest WMZs had either-sex seasons between October 1 and November 14, whereas the 3 urban zones (i.e. Saskatoon, Regina, Prince Albert) had both either-sex and antlerless seasons. In 2022, in response to an apparent decline in moose numbers within non-forested WMZs, antlerless seasons were removed.

METHODS

Aerial surveys were used to estimate moose population size, density, and composition. Twenty-seven aerial surveys for moose were conducted during 1998–2022, each of which followed provincial standards based on defensible scientific methods (Beveridge 2006). Twenty-one aerial surveys were conducted in the southern boreal forest and 6 in the non-forest (5 parkland, 1 boreal forest fringe; Fig. 1). Eighteen stratified random block surveys (Gasaway et al. 1986) with 5 km X 5 km survey units (Lynch and Schumaker 1995) were conducted during 1998–2020. In 2021, survey methodology was changed to distance-sampling (Peters et al. 2014), and 6 distance-sampling surveys were conducted in 2021 and 2022. Stratified random block and distance-sampling surveys conformed to provincial standards for accuracy and precision (+/- 25% with 90% confidence intervals (CIs); Beveridge 2006). Three total coverage surveys in the non-forest (in Moose Mountain Provincial Park) during 2009–2023 did not account for sightability and were used as minimum counts. Four areas in the southern boreal forest (Fig. 1) had high hunter interest and repeat surveys in separate years (n = 4–7) from 1998 to 2022. The frequency of surveys was based on available funds and normally rotated from the east to west side of the province every 4–7 years.

Licensed resident moose hunter harvest, hunter days and hunter numbers, including 95% CIs, were estimated annually in every WMZ from 2015 to 2023 using a provincial hunter harvest survey administered through Saskatchewan's online hunting, angling, and trapping licensing system. These estimates were produced from voluntary hunter surveys (2015–2019) and mandatory hunter surveys (2020–2023). Both surveys employed the same method of surveying, however the latter were formalized as a condition of the hunting license, changing the requirement

for hunters. Mean response rates were 24% for voluntary surveys and 59% with mandatory surveys for regular licenses, and 34% for voluntary surveys and 69% with mandatory surveys for draw licenses. In the southern boreal forest, harvest rates were assessed using licensed resident harvest estimates, and moose abundance estimates were derived from aerial surveys and expert opinion. Moose harvest by Indigenous harvesters exercising their rights was not captured in the provincial hunter harvest survey and was unknown

RESULTS

Moose densities in the southern boreal forest WMZs with repeat aerial surveys evidently declined ($\lambda < 1$) from 1998 to 2022 in 3 of the 4 (WMZ 57: $\lambda = 0.96$, WMZ 67: $\lambda = 0.97$, WMZ 59: $\lambda = 0.98$) (Fig. 2). One forest WMZ with repeat surveys had an estimated λ of 1.02 (WMZ 56). There were 21 surveys conducted in the 4 repeat survey areas in the southern boreal forest, and 6 surveys in the non-forest that provided information on moose density and composition (Table 1). The number of bulls per 100 cows (40, SD = 10) and calves per 100 cows (44, SD = 9) seen during repeat surveys were generally constant from 1998–2022 (Table 1).

The annual provincial resident harvest declined from 2015 to 2023, and averaged 4,656 (SD = 658; Fig. 3). While total harvest declined during this period, hunter effort (mean days hunted) remained relatively stable because hunters were able to hunt moose every year during the regular season (Fig. 3). The mean number of resident licensed moose hunters (10,883, SD = 1,870) and hunter days (51,071, SD = 12,262) declined from 2015 to 2023 (Table 2). Composition of the estimated provincial harvest was 65% (SD = 11) bulls, 27% (SD = 8) cows, and 8% (SD = 3) calves (Fig. 4). In the southern boreal forest, annual resident moose harvest (1,025, SD = 183) declined by

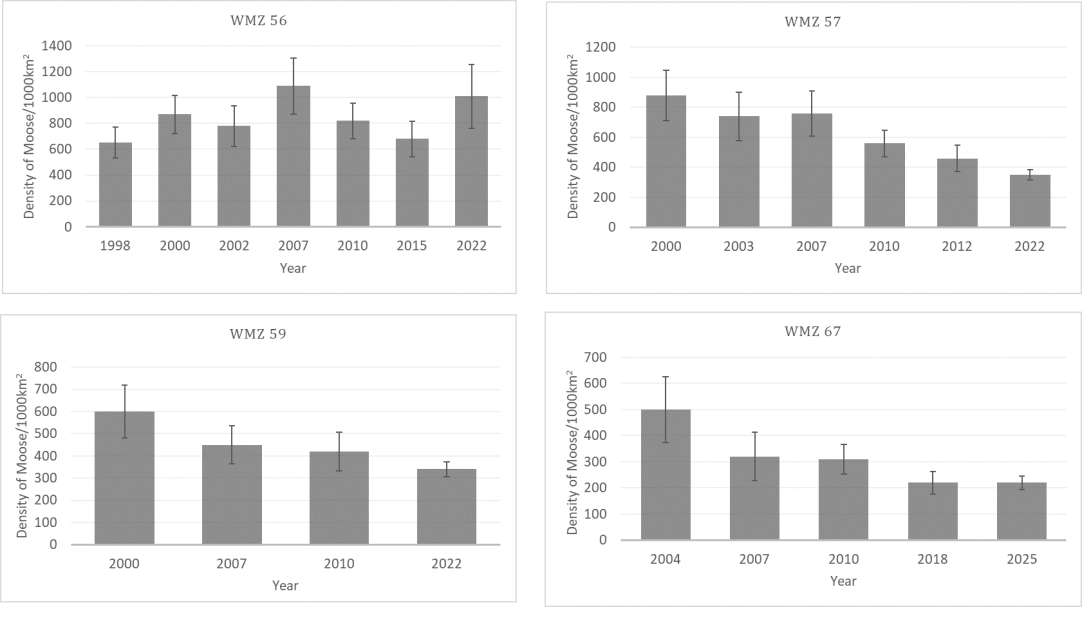

Fig. 2. Moose population densities with 90% confidence intervals (CIs) derived from repeated aerial inventories on the west and east side of Saskatchewan within the southern boreal forest, 1998–2022.

Table 1. Aerial moose survey estimates and population composition in Saskatchewan from 1998–2022.

Survey Area	Year	Population Estimate ± Confidence Limits	Density (1,000 km^{-2})	Bull:Cow:Calf Ratio
WMZ 56	1998	2,013 ± 18.4%	650	21:100:52
	2000	2,696 ± 17.1%	870	31:100:53
	2002	2,420 ± 19.9%	780	25:100:54
	2007	3,380 ± 19.8%	1,090	52:100:51
	2010	2,490 ± 16.6%	820	21:100:53
	2015	2,064 ± 20.1%	680	34:100:52
	2022	3,115 ± 24.6%	1,010	52:100:55
WMZ 57	2000	2,218 ± 19.1%	880	37:100:44
	2003	1,853 ± 21.6%	740	30:100:37
	2007	1,898 ± 19.7%	760	34:100:43
	2010	1,529 ± 15.7%	560	37:100:42
	2012	1,257 ± 28.9%	460	47:100:35
	2022	961 ± 9.8%	350	56:100:38
WMZ 59	2000	2,915 ± 19.9%	600	38:100:39
	2007	2,181 ± 18.8%	450	41:100:28
	2010	1,985 ± 20.9%	420	42:100:35
	2022	1,750 ± 9.7%	340	48:100:33
WMZ 67	2004	3,099 ± 25.1%	500	46:100:43
	2007	2,021 ± 18.9%	320	42:100:55
	2010	1,860 ± 18.4%	310	43:100:36
	2018	1,340 ± 19.4%	220	59:100:59
Moose Mountain Provincial Park	2009	869	500	70:100:55
	2013	1202	700	56:100:57
	2017	699	410	N/A
WMZ 37	2020	2,119 ± 24.8%	180	41:100:78
WMZ 50	2022	169 ± 11.92%	90	35:100:53
WMZ 55	2022	2,903 ± 2.6%	610	35:100:60

approximately 40% from 2015 to 2023 (Fig. 5). Estimated harvest rates of moose by licensed resident moose hunters in the southern boreal forest were 5% (SD = 4.2%) from 2015 to 2023. Seven of 15 WMZs had estimated mean annual harvest rates ≥ 5% during 2015–2023 (Fig.6). In the non-forest, the percentage of cows in the harvest declined from 39% (SD = 2) during 2015–2021 to 16-17% during 2022–2023 (Fig. 7), following removal of antlerless seasons and reduction of draw quotas.

DISCUSSION

It is important for resource managers to maintain sustainable moose populations and inform Indigenous harvesters, licensed hunters, stakeholders, and the public about the status of moose in Saskatchewan. Twenty-one surveys were conducted in the forest and 6 in the non-forest from 1998–2022. Using insight from these 27 aerial surveys, 9 years of hunter harvest data, and additional public and professional reports, it appears moose populations are

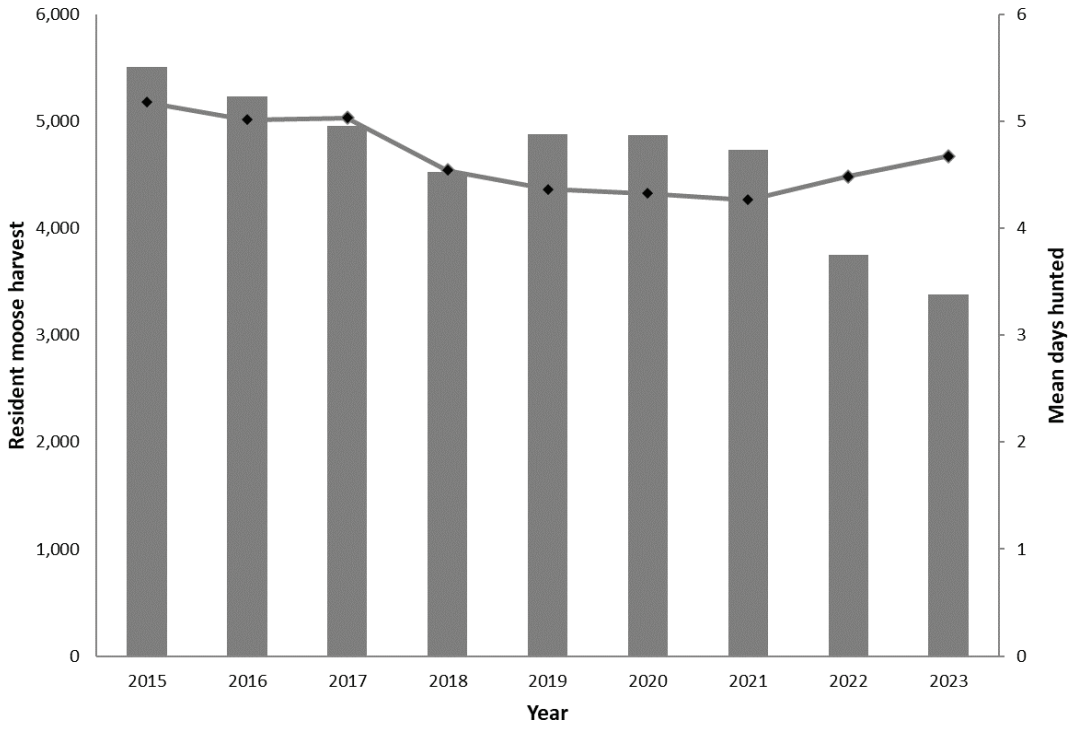

Fig. 3. Annual estimates of provincial moose harvest (left axis) and hunter effort (mean days hunted) (right axis) by resident licensed hunters in Saskatchewan, 2015–2023.

Table 2. Annual estimates of resident licensed hunters, hunter days and resident moose harvest in Saskatchewan, 2015–2023.

Year	Resident Hunters	Resident Hunter Days	Resident Harvest
2015	13,984	72,413	5,466
2016	13,183	66,108	5,224
2017	12,297	61,860	4,986
2018	9,921	45,025	4,524
2019	9,943	43,369	4,845
2020	10,779	46,615	4,893
2021	10,289	43,882	4,752
2022	8,846	39,665	3,762
2023	8,706	40,706	3,449
Mean (±SD)	10,883 ± 1,870	51,071 ± 12,262	4,656 ± 658

generally declining in the forest and stable in the non-forest. The quality of data used to determine moose population estimates could be improved with more aerial surveys over a broader area of the province. Hunter interest and effort for moose gauged through days hunted appeared stable, even though hunter opportunity and harvest had been declining.

The southern boreal forest of Saskatchewan has been a long-standing traditional hunting area for both Indigenous peoples and licensed resident moose hunters. Moose populations have been declining in the southern boreal

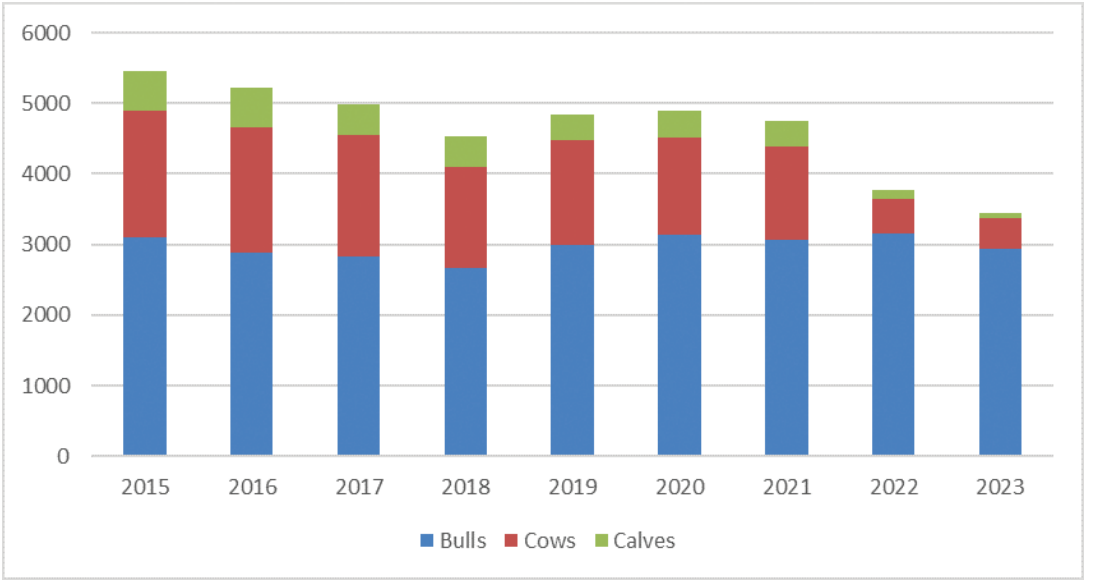

Fig. 4. Annual estimates of provincial bull, cow, and calf harvest by resident licensed hunters in Saskatchewan, 2015–2023.

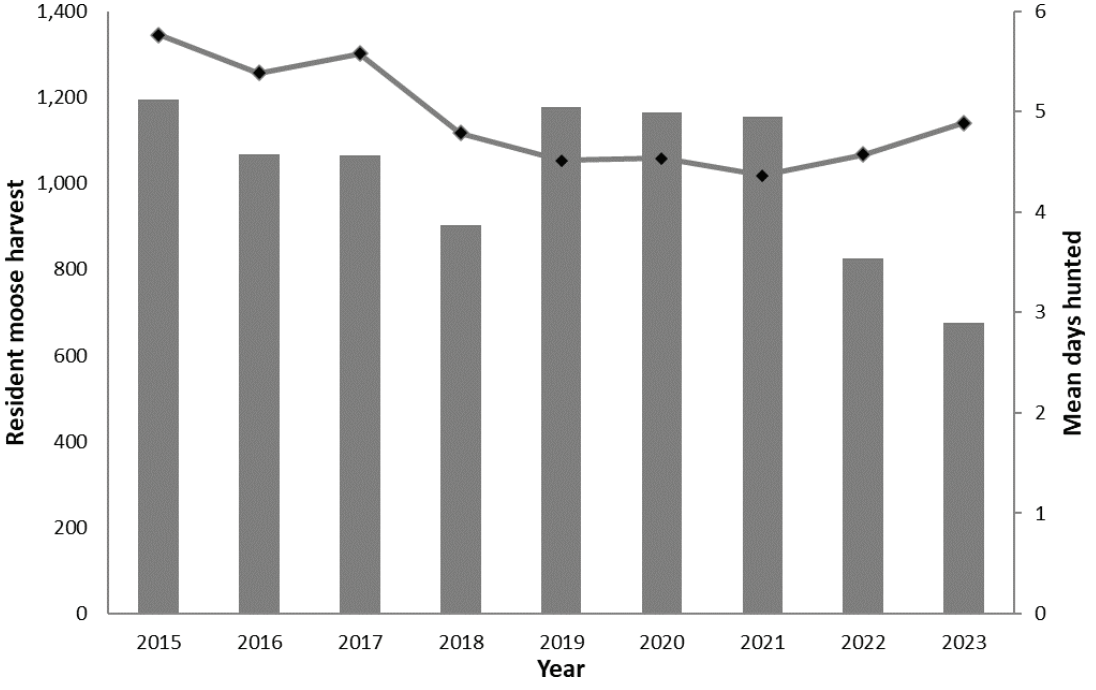

Fig. 5. Resident licensed moose harvest (left axis) and hunter effort (mean days hunted; right axis) in the southern boreal forest of Saskatchewan, 2015–2023.

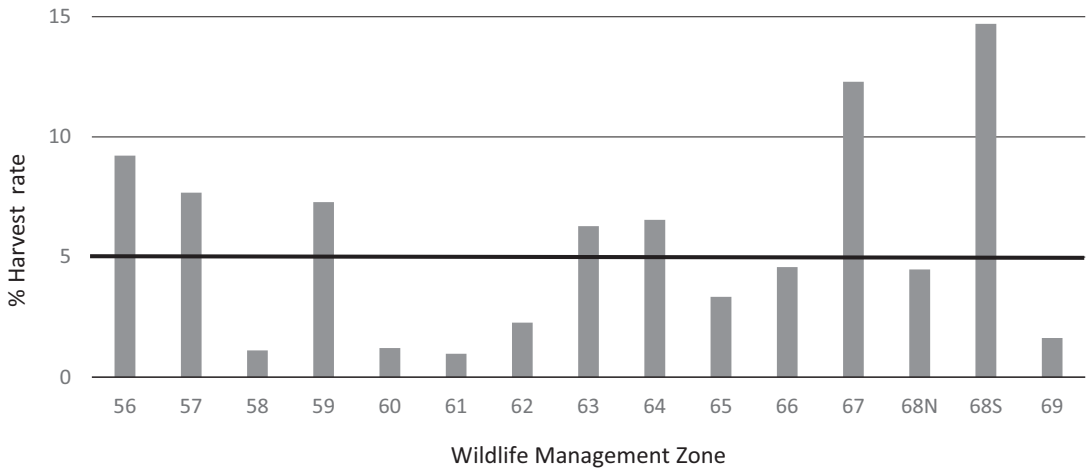

Fig. 6. Mean annual moose harvest rates in the southern boreal forest (WMZs 56-69) of Saskatchewan, 2015–2023. The solid line represents 5% harvest rate.

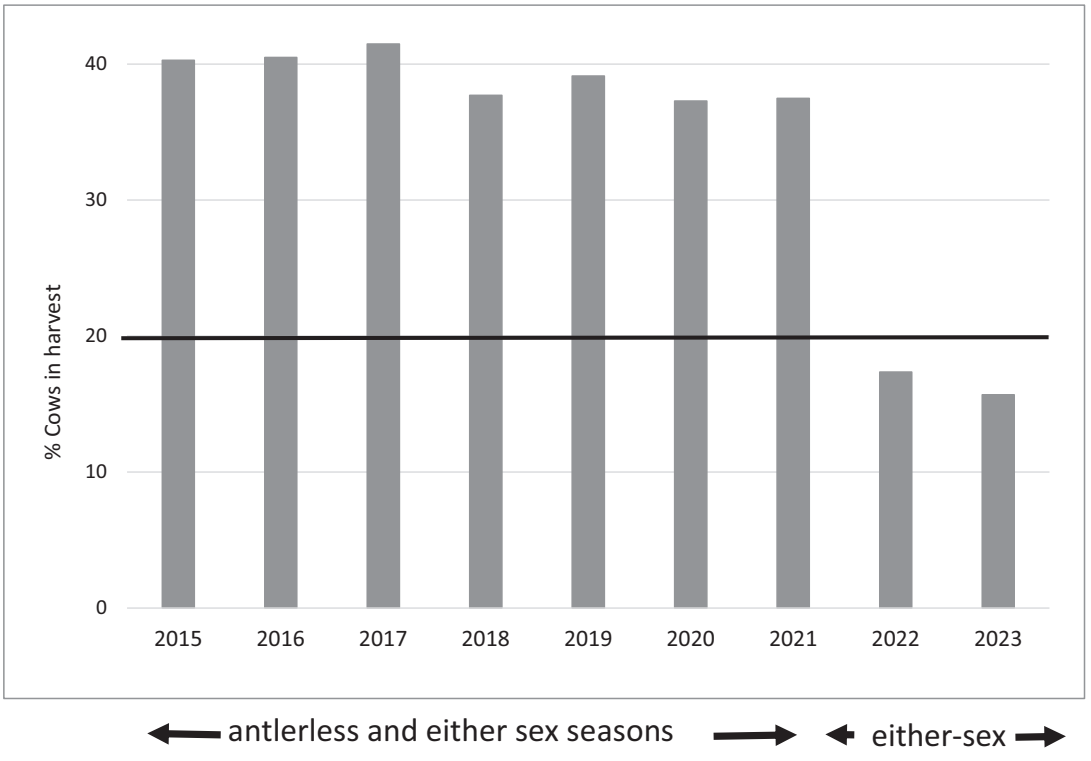

Fig. 7. The percentage of cow moose in total resident licensed harvest (bulls, cow, calves) in non-forest of Saskatchewan, 2015–2023. Antlerless seasons were removed in 2022–2023, and quotas reduced by 12%. The solid line represents a plausible threshold of cows in the total harvest (20%), below which moose populations are assumed to be stable.

forest in 3 of 4 areas with repeat aerial surveys, as has licensed harvest. Of note, the composition of bulls and calves per 100 cows determined during surveys remained relatively stable over time, although the overall density declined, which is similar to findings in British Columbia (Kuzyk et al. 2018).

Variation in moose population estimates in the forest may reflect the impact of human-altered landscapes (Rempel et al. 1997, Mumma et al 2021, Johnson and Rea 2023), or varied abundance of predators over time (Ballard and Van Ballenberghe 2007, Marrotte et al. 2022, Boucher et al. 2025). Improved technology and the ability for off-highway vehicles to access previously remote parts of the landscape likely have increased hunter success for moose over the past several decades even though moose populations were declining. Wolves and hunters have increased travel efficiency on linear trails and through cutblocks, which can lead to increased harvest and predation on moose (Neumann and Ericsson 2018, Loosen et al. 2021, Boucher et al. 2022). Black bears may be attracted to increased forage quality and quantity in young cutblocks (Schwartz and Franzmann 1991) and to emergent vegetation associated with linear features (Tigner et al. 2014), which can lead to increased probability of encountering moose. A high degree of spatial overlap with black bears can result in increased bear predation on moose calves, particularly during the first 6 weeks after birth (Patterson et al. 2013). In a small area (90 km^2) of east-central Saskatchewan, black bear numbers were reduced from 1983 to 1984 which led to a significant increase in moose calf survival (Stewart et al. 1985). Moose in the southern boreal forest of Saskatchewan co-exist with white-tailed deer whose abundance fluctuates with winter severity. Increased abundance of white-tailed deer may support an increase in predator populations (Ballard et al. 2001; Latham et al. 2011), which can increase predation risk to moose, particularly following a white-tailed deer population decline (Barber-Meyer and Mech 2016).

Bull-only hunting is normally the best option to maintain sustainable moose populations in the forest where predators are lightly hunted and moose density is typically low (<400 moose/ 1000 km^2; Gasaway et al. 1992, Boertje et al. 1996, Hayes et al. 2003). In Saskatchewan a 5% harvest rate for moose is used in the southern boreal forest, similar to guidance from British Columbia (Kuzyk et al. 2018) and Yukon (Hayes et al. 2003) where moose co-exist with wolves and bears. At present, harvest rates vary among WMZs, with some having harvest rates exceeding 5% likely due to high hunter numbers and ease of road and trail access. It will be important in the future to ensure harvest rates are ≤ 5%, and that the composition of bulls, cows and calves in the harvest is adjusted based on calf recruitment and population growth rates (Kuzyk et al. 2018).

In the non-forest, moose have few or no predators, and adequate forage from agricultural crops (Laforge et al. 2016). In these areas there were limited aerial surveys for moose (n = 6), and licensed harvest was the primary tool to manage moose populations. From 2015 to 2020 the main objective for moose in the non-forest was to reduce populations to align with human social tolerance. Antlerless and either-sex seasons, combined with liberal draw quotas, appear to have successfully reduced populations, as the percent cows in the harvest was near 40%, which can lead to population declines at moderate-to-high harvest rates (Rettie 2010). However, the high harvest, especially of cow moose, and gradual loss of habitat led to public concern for sustainable moose populations in non-forest WMZs where in 2021 antlerless seasons were removed and

quotas reduced. Maintaining ≤ 20% cows in the total harvest, as occurred in 2022 and 2023 may allow moose populations to remain at or near current levels, but more study is needed to confirm this.

Wildlife managers are often challenged to maintain harvest of ungulates in systems with multiple factors influencing population levels (Fryxell et al. 2014), especially when populations are declining (Kuzyk et al. 2018). Our assessment of licensed harvest and aerial surveys suggest that moose populations are generally declining in the forest but may be stable in the non-forest. We acknowledge our assessment did not account for Indigenous harvest of moose. A study in Ontario found provincial moose harvest may be underestimated by up to 40% due to unknown Indigenous harvest (LeBlanc et al. 2011). We concur with LeBlanc et al. (2011) for the need to seek perspective and meaningful collaboration with Indigenous peoples to benefit moose populations. Going forward, collaborating with Indigenous peoples on moose management strategies and reducing the number of roads and trails in forest landscapes to minimize mortality risk to moose will likely benefit the long-term sustainability of moose populations in Saskatchewan.

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