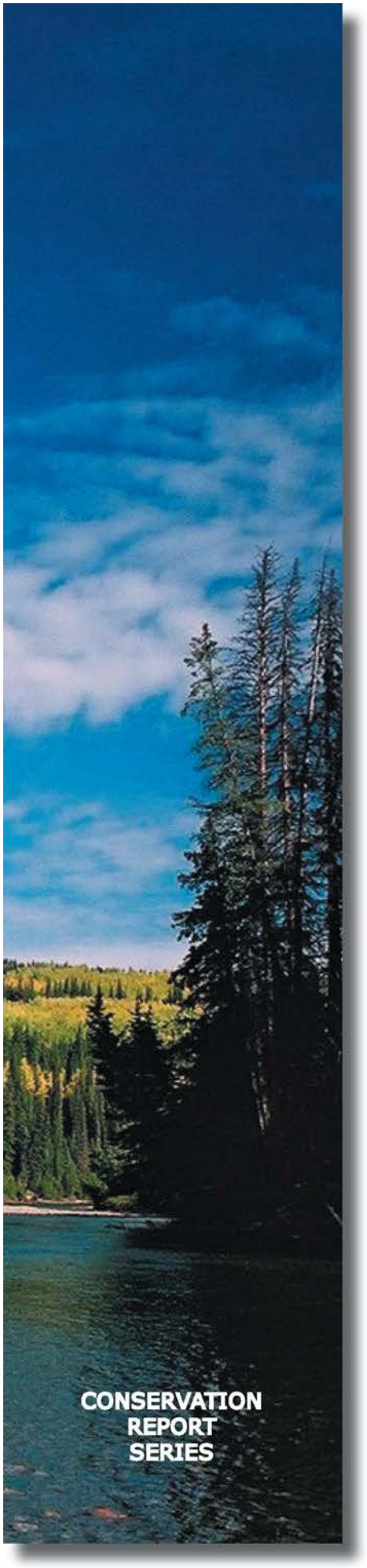


Assessment of the Alberta Moose Hunter Survey App, 2012 to 2016

Alberta Conservation Association

Assessment of the Alberta Moose Hunter Survey App, 2012 to 2016

Susan H. Peters, Paul F. Jones, and R.A. Anderson
Alberta Conservation Association
101 – 9 Chippewa Road
Sherwood Park, Alberta, Canada
T8A 6J7

Alberta Conservation Association

Report Editors

DOUG MANZER
Alberta Conservation Association
Box 1139, Provincial Building
Blairmore, AB T0K 0E0

GLENDA SAMUELSON
R.R. #2
Craven, SK S0G 0W0

Conservation Report Series Type
Technical

ISBN: 978-0-9959984-7-6

Suggested Citation:
Peters, S.H., P.F. Jones, and R.A. Anderson. 2018. Assessment of the Alberta moose hunter survey app, 2012 to 2016. Technical Report, produced by Alberta Conservation Association, Blairmore, Alberta, Canada. 23 pp + App.

Cover photo credit: David Fairless

Digital copies of conservation reports can be obtained from:
Alberta Conservation Association
101 – 9 Chippewa Rd.
Sherwood Park, AB T8A 6J7
Toll Free: 1-877-969-9091
Tel: (780) 410-1998
Fax: (780) 464-0990
Email: info@ab-conservation.com
Website: www.ab-conservation.com

EXECUTIVE SUMMARY

The Alberta Moose Hunter Survey App uses smartphone technology as a cost-effective method to collect hunter observation data on moose across Alberta. These data increase our understanding of moose populations and could become a tool for management of moose in Alberta in the future. Similar initiatives in Scandinavian countries have been used to support management of moose populations. This report summarizes the moose observation data collected from 2012 to 2016 in Alberta through the Moose Hunter Survey App.

Hunters who draw a moose tag in Alberta are invited to download the app to their smart phone and report their moose observations. They specify their Wildlife Identification Number (WIN) and the wildlife management unit (WMU) they are hunting in, as well as the number of moose (bulls, cows, calves, unidentified) they observed and the number of hours out hunting that day.

From 2012 to 2016, the app recorded moose observations within 145 WMUs, primarily within the Foothills, Northern Boreal and Parkland natural regions. The app received a total of 14,473 submissions; after data cleaning, 5,926 of these were considered valid submissions.

Across all years and natural regions, moose observation rates for WMUs were typically between 0 and 1.2 moose/hour (hr), based on all valid data. The Parkland region had the highest overall moose/hr, whereas the Mountain region had the lowest. The number of moose/hr was lowest in 2014 in Alberta, despite the highest number of valid submissions that year.

Considering only natural regions with data that met a minimum threshold for hunter submissions (20 valid submissions per year per natural region), similar trends held true; the Parkland region had the highest moose observation rates and recruitment rates (except for 2016), while the Mountain region had the lowest rates. Sex ratios were quite variable across years and natural regions. The Foothills, Parkland, and Northern Boreal regions had a minimum of 20 submissions for all five years of data collection, while the Prairie and Mountain regions met this threshold for only three of the five years.

Considering only the 13 WMUs that met a minimum threshold for hunter submissions (three or more years of data and at least 20 valid submissions in each year), there was a generally stable trend of fewer than 1.0 moose/hr observed by hunters in the Parkland, Foothills, and Northern Boreal regions; however, WMU 230 (Parkland) and WMU 348 (Foothills) showed a substantial

increase in moose/hr. There was tremendous variation in the calf:cow ratios across WMUs, and most calf ratios were well below a 100 calves:100 cows ratio. Bull:cow ratios tended to be skewed on the high side of what is considered typical, with moose hunters reporting ratios above 100 bulls:100 cows for some WMUs in the Parkland and Foothills regions.

The Alberta Moose Hunter Survey App has potential as a cost-effective monitoring alternative to aerial surveys, if there is a sufficient number of users and valid submissions. With enough hunter participation, the information produced has the potential to benefit moose population monitoring at a local, regional, and provincial scale. From 2012 to 2016, the submissions were well dispersed geographically; however, some WMUs had very few submissions, and the number of submissions was very small compared to the number of moose tags allocated each year.

Though there are limitations with the data collected so far, there is promise that the app and the data submitted by hunters can be of value for managers to monitor larger population-level issues and conservation concerns related to moose in Alberta. We explored the potential for the app to be a supplemental monitoring tool to aerial surveys by comparing yearly WMU app data to corresponding aerial survey data, and found relationships between moose observed by hunters to moose density, and the recruitment and sex ratios determined between the two methods. Additional years of data will allow us to quantify these relationships.

As the Alberta Moose Hunter Survey App program moves forward, we recommend that annual results and trends be summarized and made available online to maintain hunter interest in submitting data. In addition to maintaining the engagement of existing users, it will be important to broaden the participant base to increase the app utilization rate. As well, increasing the quality of the data through improvements to the app will further enhance the usefulness of the data as a tool for wildlife managers. Improvements to the app will also allow some assumptions associated with the data to be explored and evaluated. Further exploration of the app data in relation to aerial survey data will provide confidence in the use of citizen science, through hunter observation data, for managing moose in Alberta.

Key words: Alberta, *Alces alces*, bull, calf, citizen science, cow, hunting, moose, population, wildlife management unit.

ACKNOWLEDGEMENTS

Mark Boyce (University of Alberta) initiated and developed the Moose Hunter Survey App. Robb Stavne and Jennifer Baker (Alberta Conservation Association [ACA]) assisted with data filtering, cleaning, and compilation. Doug Manzer (ACA) provided direction during the analysis of the data, and edited an earlier draft of this report.

TABLE OF CONTENTS

LIST OF FIGURES

List of Figures cont.

LIST OF APPENDICES

1.0 INTRODUCTION

In Alberta, aerial surveys have historically been the primary method used to estimate the population size, trend, distribution, and herd composition for ungulates, including moose (*Alces alces*) (AEP 2016). As such, these surveys have been an important source of data for setting hunting allocations. However, aerial ungulate surveys are intermittent and are prohibitively expensive (averaging about $60,000 per wildlife management unit [WMU]), prompting the need for additional strategies for monitoring ungulate populations (Boyce et al. 2012; Boyce and Corrigan 2017). Hunter harvest rate (number of animals harvested relative to time spent hunting) has been suggested as a cost-effective alternative that could be used to adjust annual hunting quotas to prevent overharvest in Alberta (Boyce et al. 2012). Supplemental sources of information beyond hunter harvest rate could also be used to improve management decisions. In Norway, for example, hunter observations of moose have been used to predict population size (Solberg and Saether 1999).

Inspired by the success of hunter moose observation indices in Scandinavia, Mark Boyce initiated the Alberta Moose Hunter Survey App in 2012 (University of Alberta 2017a, 2017b). The survey uses smartphone technology as a cost-effective monitoring alternative to aerial surveys (University of Alberta 2017a, 2017b). The app allows hunters to submit the number of moose they observe while hunting in their designated WMU in Alberta. The intent of the app is to provide an alternative data source to assess population trends among years over a broad range of WMUs (Boyce 2012; Boyce and Corrigan 2017).

This report summarizes hunter-submitted moose observation data (hereafter "moose observations") from 2012 to 2016. The information presented in this report is summarized from the data submitted to the app and considered valid. We present these data in two formats: overall summaries based on all valid data submissions, and more detailed analysis for natural regions and WMUs where these data met minimum thresholds for the number of valid submissions. We discuss assumptions associated with these data, and highlight the potential value of hunter-submitted moose observation data.

2.0 STUDY AREA

Moose observations were well dispersed with valid submissions from 100% of Parkland WMUs, 95% of Foothills WMUs, 90% of Northern Boreal WMUs, 66% of Mountain WMUs, and 43% of

Prairie WMUs. The lower percentage of Prairie WMUs is partially due to the presence of WMUs that do not have a moose hunting season (AEP 2015). Of the 145 WMUs with valid submissions, the largest proportion are Foothills WMUs (28%; 40/145), followed closely by Northern Boreal WMUs (26%; 38/145), and then Parkland WMUs (24%; 35/145) (Figure 1). Mountain and Prairie WMUs compose a smaller proportion of all WMUs with valid submissions.

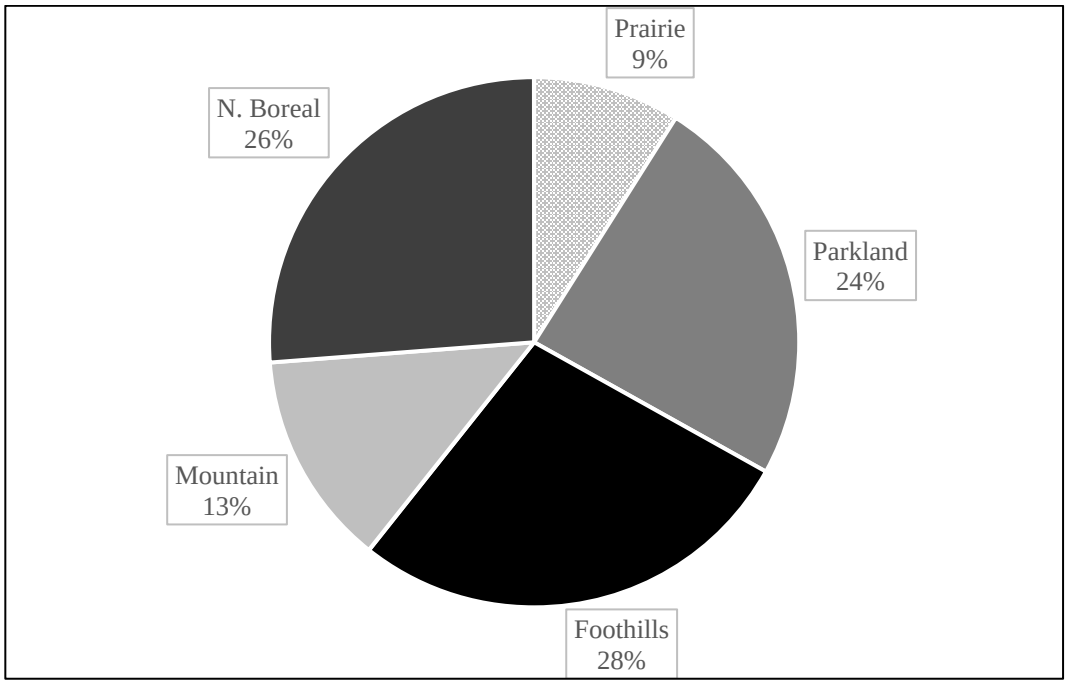


Figure 1. Proportion of Wildlife Management Units (N=145) with valid submissions to the Alberta Moose Hunter Survey App by natural region, 2012 to 2016.

3.0 MATERIALS AND METHODS

3.1 Alberta Moose Hunter Survey App

The Alberta Moose Hunter Survey App is available free of charge for both iPhone and Android phone users on the Moose Hunter Survey website (http://www.biology.ualberta.ca/moose/; University of Alberta 2017a). Hunters who draw a moose tag are invited to download the app to their phone and report their moose observations. After downloading the app, each hunter specifies their Wildlife Identification Number (WIN) and the WMU they are hunting in. Then at the end of each hunting day, the app is programed to remind hunters to enter how many moose (bulls, cows, calves, unidentified) they observed and the number of hours they were hunting that day. The resulting data are the number of moose observed per hunter per day within a

WMU. The app uses an established set of rules for hunters to follow (Boyce 2012; Boyce and Corrigan 2017):

- Record the number of hours spent in the WMU when moose might be observed, whether in a vehicle or on foot.
- Only record moose observed on that day.
- Do not record observations of tracks, spoor, or moose beds. Only report moose actually observed.
- Only record moose observed within the WMU for which a hunting license was issued. Do not report moose observations from other WMUs.
- Record the number of bulls, cows, and calves observed on that day. Report any moose for which age/sex classification was not possible as "unidentified".
- Record moose observations even if outside the range of cellular communication. The date-stamped observations will be transmitted upon return to an area with mobile phone or WiFi coverage.

The moose observation data are stored on the smart phone until cell service is accessed, and the data are instantly sent to a spreadsheet, which has been housed at the Department of Biological Sciences, University of Alberta since 2012. In 2017, Alberta Conservation Association (ACA) took over management of the app and the accompanying data.

3.2 Data cleaning

The data presented in this report have been filtered to reduce the number of submissions outside of the parameters of this study (e.g., outside of the moose hunting season), and remove erroneous data (e.g., 1,300 moose observed; the same data entered more than once by the same person on the same day; non-existent WMU). From 2012 to 2016, a total of 14,473 data entries were submitted; of those, 5,926 (41%) were considered valid submissions.

We took the following steps to filter the raw data:

- Observations outside of September 1 to November 30 were removed.
- Observations associated with incorrect WINs or non-existent WMUs were removed.
- Observations with >50 bulls, >50 cows, >50 calves, or >50 unidentified were removed.
- Number of bulls, cows, calves, and unidentified for each observation were re-tallied.

- Observations associated with 0 hours out hunting were removed. Note: beginning in 2014 the app was reprogramed so that hunters could only report observations of moose when the number of hours out hunting was > 0 (Boyce and Corrigan 2017).
- Observations associated with >15 hours out hunting were removed (longest days in early September: approximately 14 hr of daylight + 0.5 hr pre-sunrise + 0.5 hr post-sunset) to ensure data are number of moose observed per hunter per day.
- Observations associated with draw codes were converted to their corresponding WMUs (AEP 2017).
- Observations entered more than once (i.e., same WIN, same WMU, same number of moose, etc. with same entry date and time to the minute) were removed.

3.3 Data assumptions

There are several assumptions associated with using this type of citizen science data to make wildlife management decisions:

- Data submissions are from a random subsample of moose hunters in Alberta, throughout a random sample of moose habitat for a geographic area. Submissions are from a random subsample of hunters drawn for antlered, antlerless, and calf moose.
- Observer bias: 1) the ability to observe moose is the same among hunters (i.e., no effect of hunter experience; one hunter out for ten days has the same probability of observing moose, as 10 hunters going to the same place for 1 day each); 2) the ability to observe bulls versus cows versus calves is the same; 3) hunters have the same overall propensity to submit data if they observe a moose or don't observe a moose (e.g., 0 moose observed in 8 hours); 4) hunters have the same propensity to submit observations of bulls versus cows versus calves; 5) individuals that hunted for 1 hour or 10 hours in a day had the same propensity to submit data; 6) the willingness of hunters to submit observations was not influenced by the number, age, or gender of moose observed in a given day, and; 7) the willingness of hunters to submit data is not influenced by the draw type (i.e., antlered, antlerless, calf).
- Sample bias: 1) the sightability of moose was the same in all habitat types (e.g., prairie vs. parkland); 2) the sightability of moose was the same throughout the entire sampling period within a year (i.e., period of leaves on [early hunting season] vs. leaves off [late hunting season]), and; 3) the sightability of moose does not change throughout the hunting season (moose observed during early part vs. late part of season) as a result of hunting pressure.

3.4 Data analysis

There was large variability in the number of submissions for each WMU for any given year. Therefore, we provide summary statistics at three levels: 1) overall summaries of all valid data, regardless of WMU or natural region; 2) yearly summaries for each natural region with sufficient data, and; 3) yearly summaries for individual WMUs with sufficient data. Summary statistics were generated using JMP 13.1.0.

First, we provide overall summary statistics that highlight the use of the app by Alberta hunters over the first five years of its availability. In this section, we show several metrics including the number of submissions, the number of valid submissions after data cleaning, and the average number of hours spent hunting, combining all years and all WMUs.

Then we provide more detailed summary statistics (moose/hr, demographic rates) at the natural region level. We used the data only if it met a minimum data threshold of at least 20 valid submissions per year within a natural region. First, we summed: 1) the total number of moose; 2) total number of bulls; 3) total number of cows; 4) total number of calves observed, and; 5) the total number of hours spent hunting for each year for each natural region. Then we calculated a moose/hr index value and demographic rates (recruitment rates and sex ratio) using this data set. We used the number of calves per 100 cows (calves:100 cows) to represent our recruitment rate, and the number of bulls per 100 cows (bulls:100 cows) as our sex ratio.

Lastly, we calculated detailed summary statistics (moose/hr, demographic rates) at the individual WMU level. We used the data only if it met a minimum data threshold of at least three years of data, and within each year at least 20 valid submissions for the individual WMU. First, we calculated the mean and standard error of moose/hr for each year for each individual WMU. Then we calculated the recruitment rate (calves:100 cows ratio) and the sex ratio (bulls:100 cows) for each year for each individual WMU. The majority of the valid submissions were from WMUs in the Foothills, with smaller proportions from the Northern Boreal and Parkland regions (Figure 2). No WMUs in the Prairie or Mountain regions met the minimum data threshold.

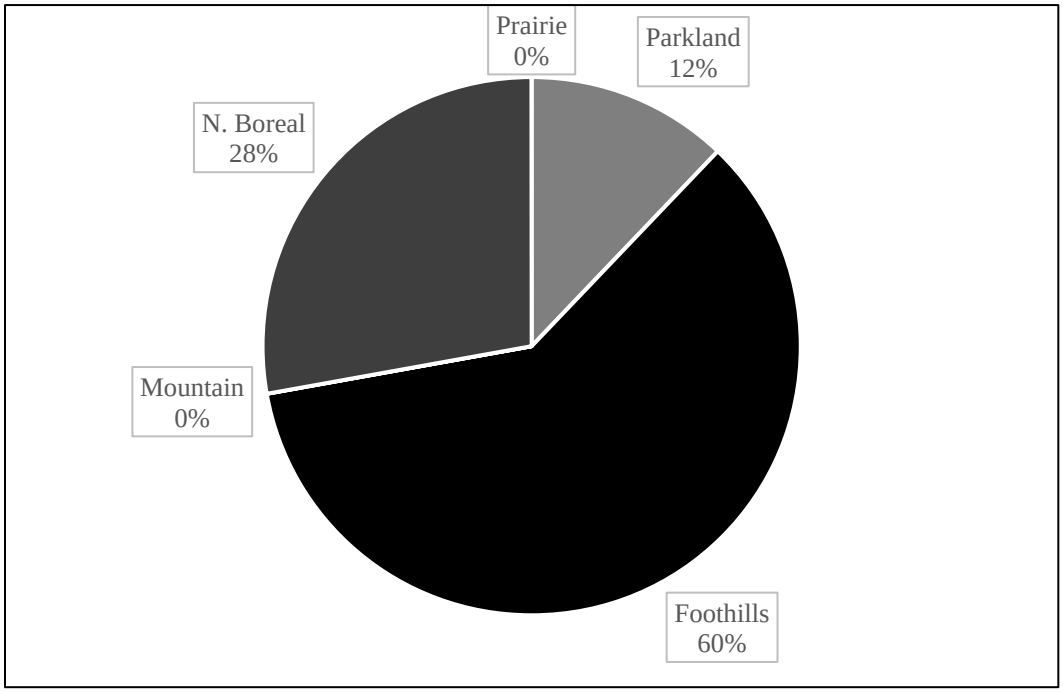


Figure 2. Proportion of the total number of valid submissions for WMUs with at least three years of data and at least 20 valid submissions per year, grouped by natural region.

4.0 RESULTS

4.1 Overall summary

The Alberta Moose Hunter Survey App recorded moose observations within 81% (145/178) of WMUs and five (of six) natural regions in Alberta. The app received a total of 14,473 submissions from 2012 to 2016; after data cleaning, 5,926 of these were considered valid submissions. The most common reasons for removing submissions were: the number of hours out hunting entered as zero; submission date outside of the hunting season; the same data entered more than once; and the WIN or WMU entered incorrectly. The number of submissions increased from a total of 1,476 (618 valid) in 2012 to 4,899 (2,098 valid) in 2014, and then decreased to 1,464 (276 valid) in 2016 (Figure 3). The total number of submissions is very small compared to the yearly tag allocation (Figure 3). Appendix 1 provides a summary of all valid data for moose/hr for each WMU for each year.

Hunters using the app reported spending on average 5.7 hr hunting each day. Hunters most commonly observed between 0 and 0.2 moose/hr, and WMU observation rates typically ranged

between 0 and 1.2 moose/hr (Figure 4). From 2012 to 2016, WMUs in the Parkland region generally had higher total moose/hr values, whereas WMUs in the Mountain region tended to have the lowest moose/hr. The moose/hr index was calculated by summing the total number of moose observed and the total number hunting hours in each natural region, and calculating a single moose/hr value for each natural region (Figure 5). Overall from 2012 to 2016, the number of moose/hr was lowest in 2014 in Alberta, despite the highest number of valid submissions that year (Figure 6).

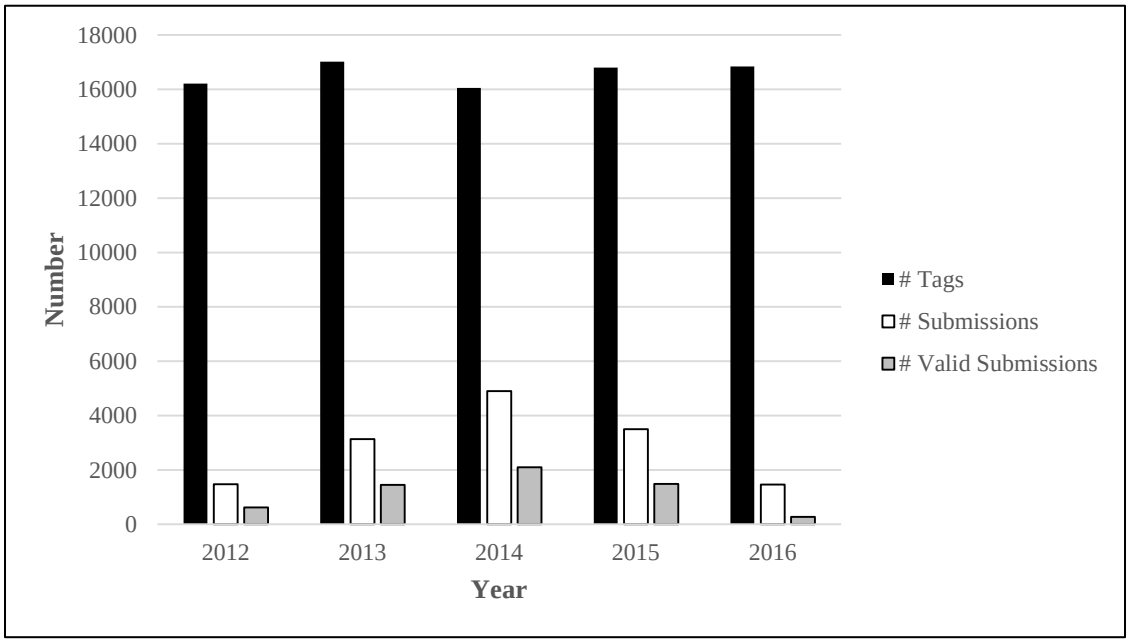


Figure 3. Comparison of the total number of moose tag allocations (antlered, antlerless and calf), the number of hunter submissions to the Alberta Moose Hunter Survey App, and the number of valid submissions, 2012 to 2016.

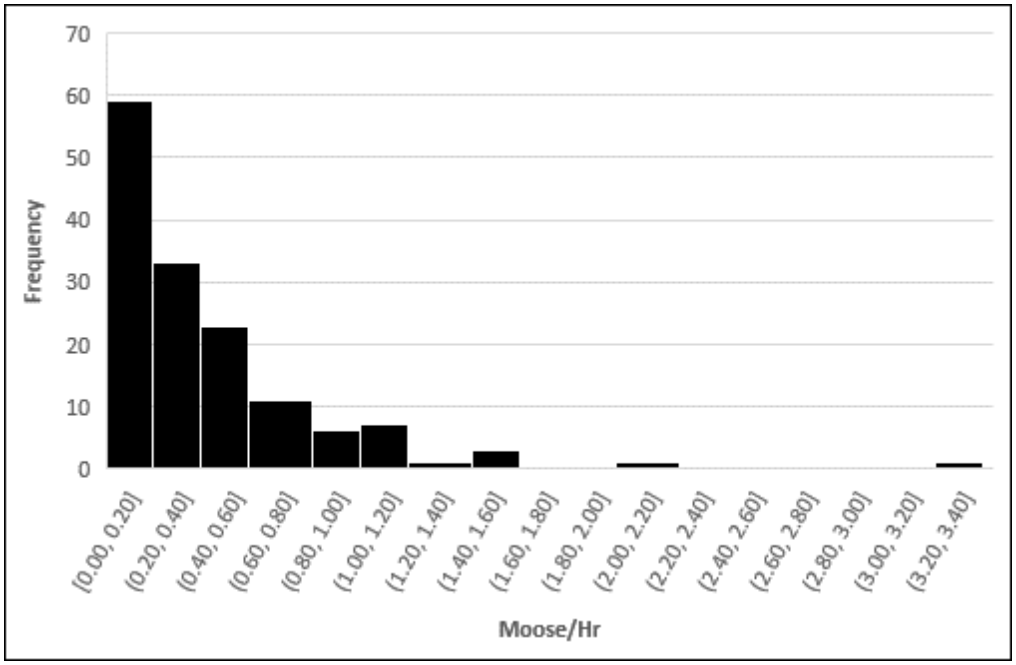


Figure 4. Frequency of WMU values for number of moose observed per hour, based on valid data submissions to the Alberta Moose Hunter Survey App, 2012 to 2016.

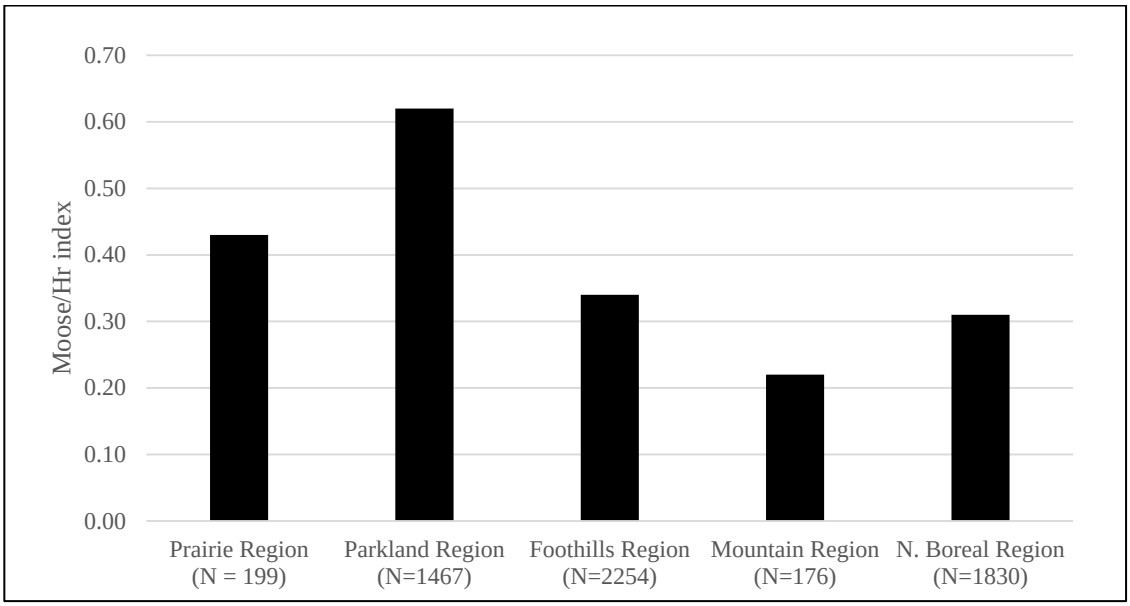


Figure 5. Number of moose observed per hour by natural region, based on valid data submissions to the Alberta Moose Hunter Survey App, 2012 to 2016. N = number of valid submissions.

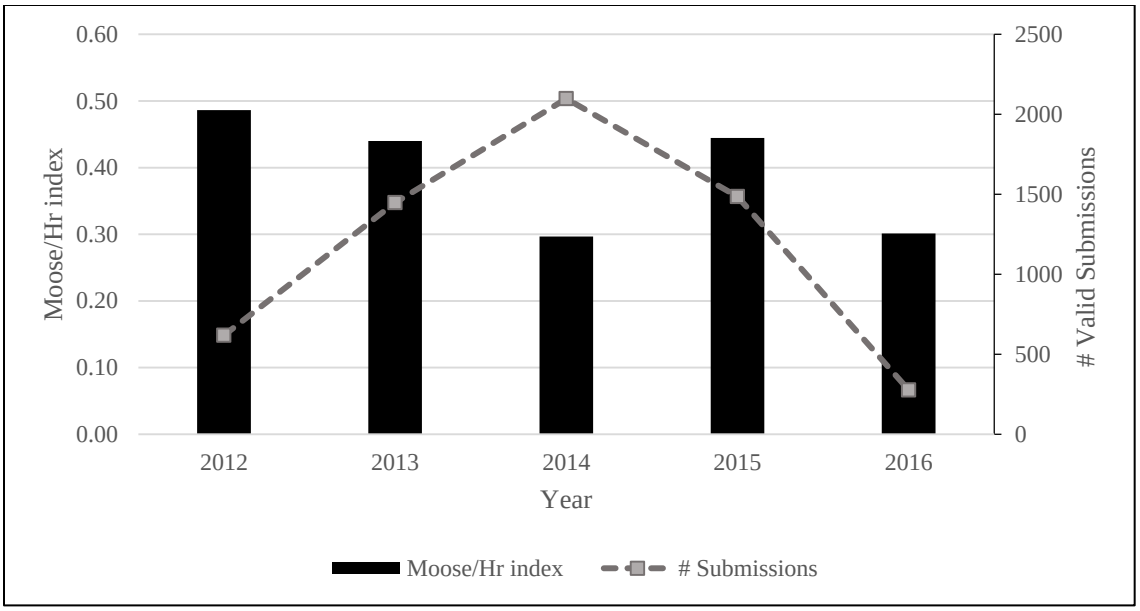


Figure 6. Comparison of moose observed per hour with valid data submissions to the Alberta Moose Hunter Survey App, 2012 to 2016.

4.2 Natural region summary

Three of the five natural regions had a minimum of 20 valid submissions for all five years of app data collection, while the Prairie and Mountain regions had a minimum of 20 valid submissions for only three of the five years (Appendix 2). For those years with at least 20 valid submissions, there were on average 451, 366, 293, 64, and 53 submissions/year for the Foothills, Northern Boreal, Parkland, Prairie and Mountain regions, respectively. For those years with at least 20 valid submissions, the number of hunting hours reported ranged from 198 to 4,257 hours (Appendix 2).

We only used data that met the minimum data threshold (≥ 20 submissions per year per natural region) from the total number of valid submissions to the Alberta Moose Hunter Survey App. The Parkland region had higher moose observation rates compared to the other regions, while the Mountain region had the lowest observation rates. The moose/hr index was calculated by summing the total number of moose observed and the total number of hunting hours in each natural region, and calculating a single moose/hr value for each year (Figure 7). The Parkland region generally had the highest recruitment rates (except in 2016, when Northern Boreal had the highest rate), while the Mountain region had the lowest rates. The ratio was calculated by summing the total number of calf and cow moose observed each year within each natural region and then calculating the number of calves observed per 100 cows (Figure 8). The sex

ratios (bulls:100 cows) varied yearly and between the five natural regions, from a low of 34 in 2012 in the Northern Boreal region to a high of 136 in 2014 in the Mountain region. The ratio was calculated by summing the total number of bull and cow moose observed each year within each natural region and then calculating the number of bulls observed per 100 cows (Figure 9).

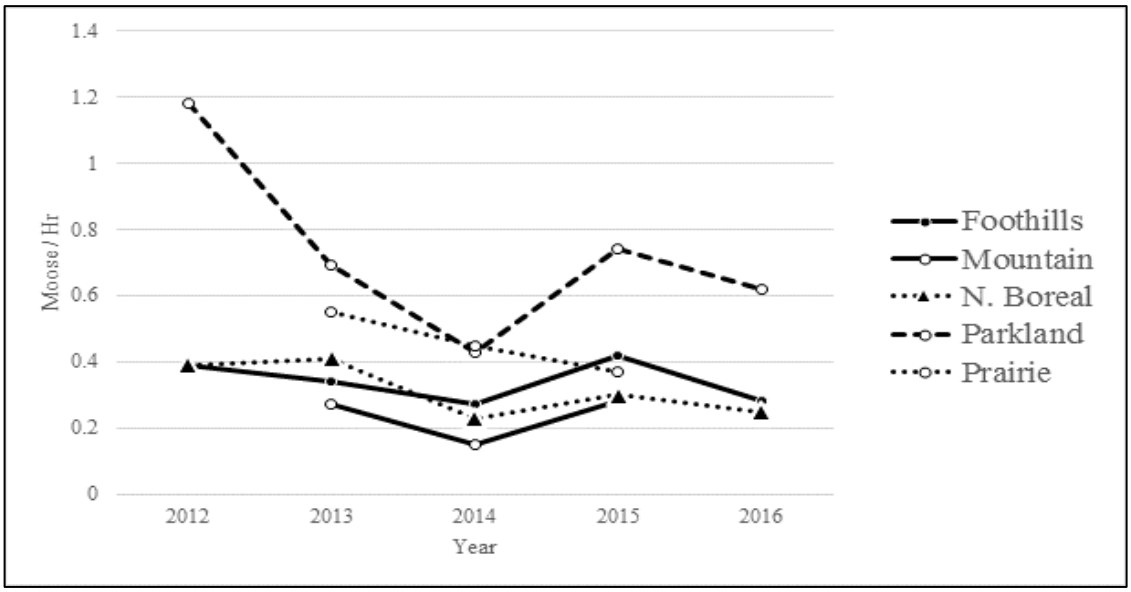


Figure 7. Number of moose observed per hour in the five natural regions of Alberta, 2012 to 2016.

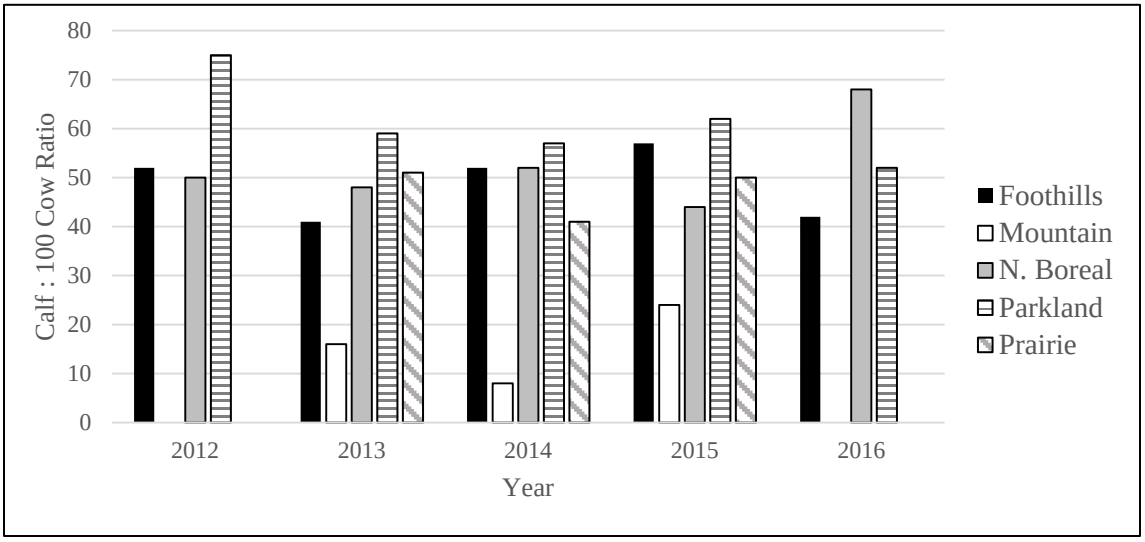


Figure 8. Moose recruitment rates (calf:100 cows) for the five natural regions of Alberta, 2012 to 2016.

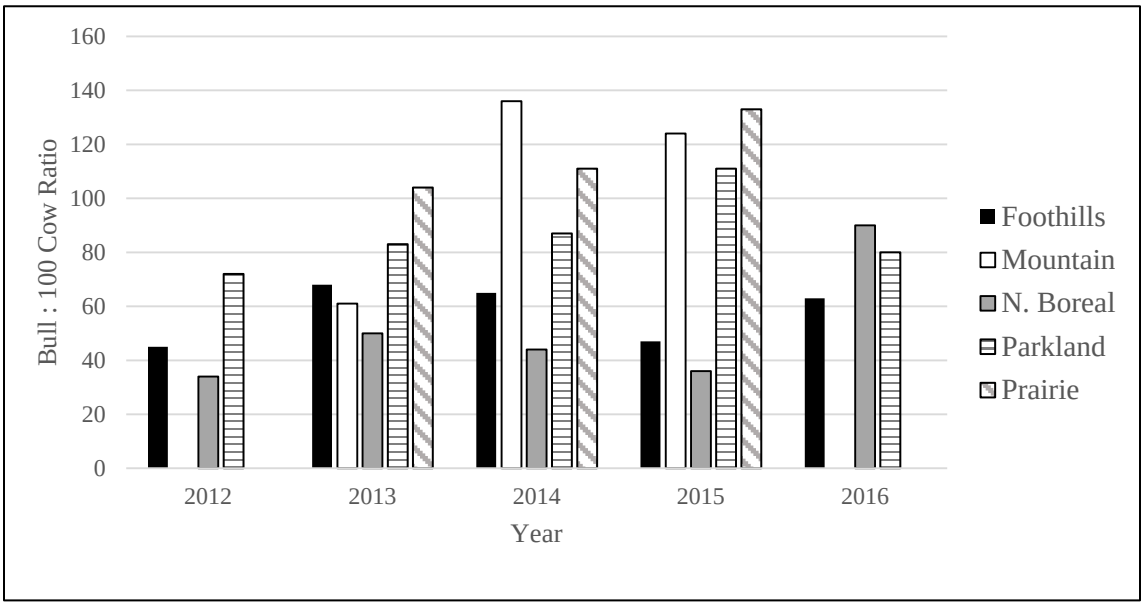


Figure 9. Moose sex ratios (bull:100 cows) for the five natural regions of Alberta, 2012 to 2016.

4.3 WMU summary

There were 13 WMUs with a total of 1,790 valid submissions that met the minimum data threshold of at least three years of data and at least 20 valid submissions for each year. These 13 WMUs were from the Foothills (n=8), Northern Boreal (n=3), and Parkland (n=2) regions. Moose observation rates for these 13 WMUs were typically between 0 and 1.6 moose/hr (Figure 10), similar to rates calculated from all valid submissions. There was generally a stable trend of less than 1 moose/hr observed by hunters in the 13 WMUs (Appendix 3). There were a few WMUs (e.g., WMU 230, WMU 348) that showed a substantial increase in moose observed per hour (Appendix 3).

There was tremendous variation in the recruitment rates (calf:cow ratios) across WMUs within a natural region and among natural regions, based on the minimum threshold data (Figure 11). Most recruitment rates were well below the 100 calf:100 cow ratio. The two lowest recruitment rates were for WMU 356 (Foothills) in 2014 and WMU 314 (Foothills) in 2013, where hunters reported a ratio of 11 calves:100 cows; in contrast, the greatest recruitment rate was for WMU 507 (Northern Boreal) in 2016, where hunters reported a ratio of 100 calves:100 cows (Figure 11).

Sex ratios tended to be skewed on the high side of what is considered typical, with ratios above 100 bulls:100 cows for WMUs in the Parkland and Foothills regions (Figure 12). Sex ratios

reported for the Northern Boreal region tended to be more in line with what is expected for bull:cow ratios (Figure 12).

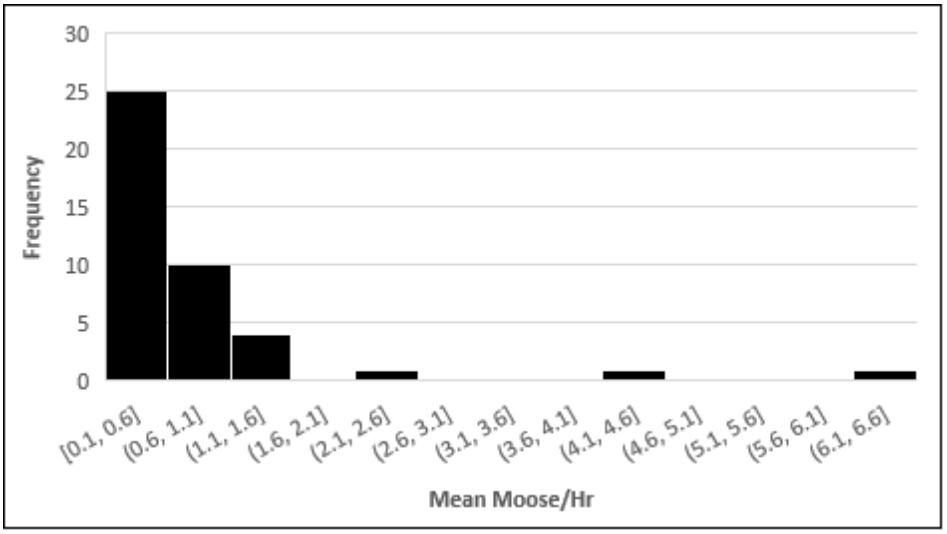


Figure 10. Frequency of moose observed per hour for WMUs that met the minimum data threshold for valid submissions to the Alberta Moose Hunter Survey App, 2012 to 2016.

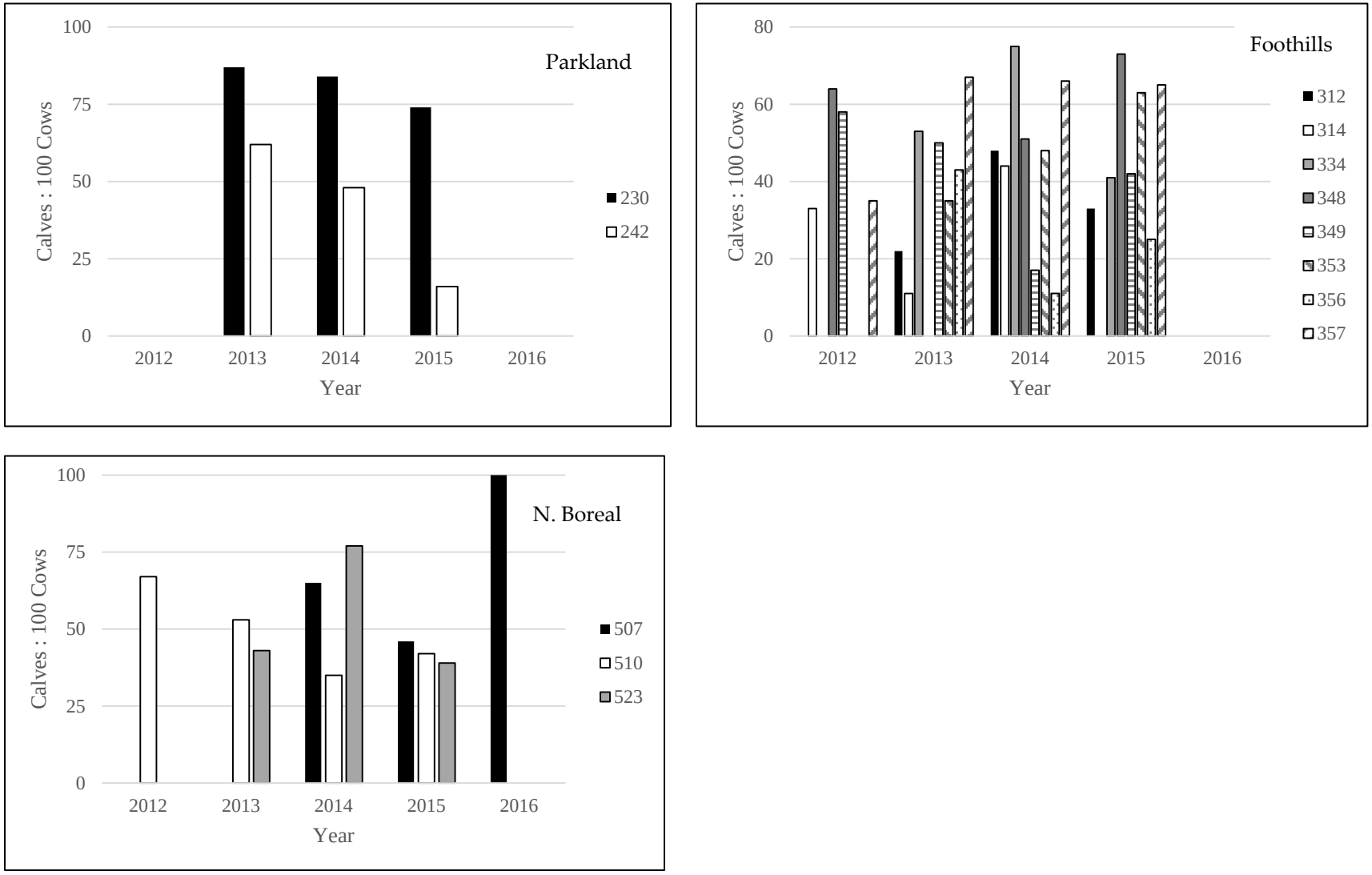


Figure 11. Moose recruitment rates (calf:100 cows) for WMUs in the Parkland, Foothills, and Northern Boreal regions that met the minimum data threshold for valid submissions to the Alberta Moose Hunter Survey App, 2012 to 2016.

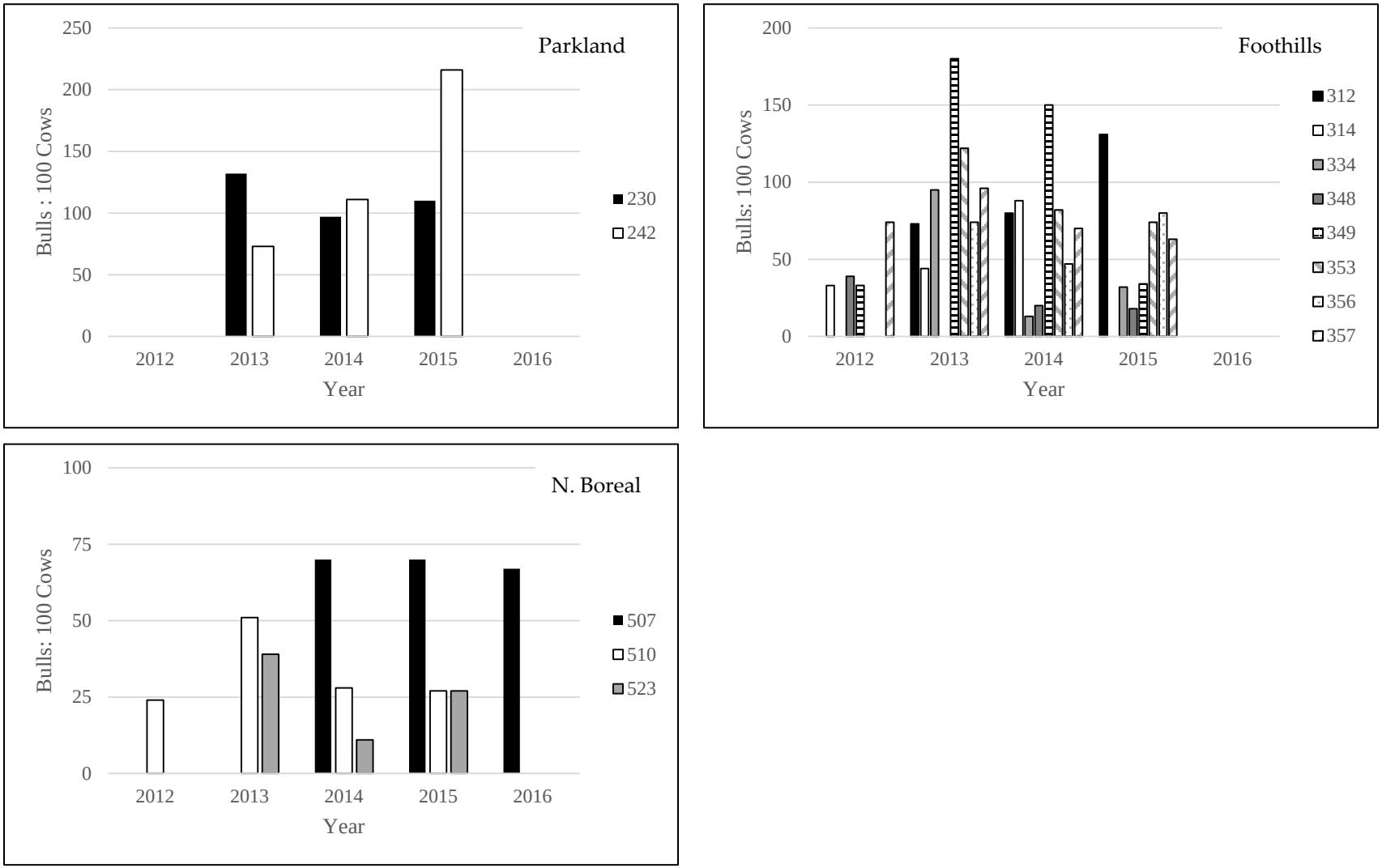


Figure 12. Moose sex ratios (bull:100 cows) for WMUs in the Parkland, Foothills, and Northern Boreal regions that met the minimum data threshold for valid submissions to the Alberta Moose Hunter Survey App, 2012 to 2016.

5.0 DISCUSSION

The intent of the Alberta Moose Hunter Survey App is to use smartphone technology to collect moose observation data from hunters, to create indices for the number of moose observed per hour, as well as moose recruitment and sex ratios. It is a cost-effective monitoring alternative to data collected from aerial ungulate surveys (Boyce and Corrigan 2017). The driving factor in the quality of valid data submissions via the app is the number of hunters participating in the survey and entering data correctly into the app. The submissions from 2012 to 2016 were well dispersed, representing 145 WMUs across Alberta; however, several WMUs have very few submissions (see N values in Appendix 1), so the data for those WMUs should be interpreted with caution. It is also worth noting that the number of submissions is small compared to the number of tags allocated each year. Furthermore, the number of submissions does not necessarily represent individual hunters as a single hunter may be responsible for multiple submissions. In future reporting, using unique WIN numbers will assist in determining the level of participation by Alberta hunters. Regardless, it appears that there is substantial room to grow the app participation rate among hunters receiving a moose tag in any given year.

The greatest limitation to the moose observation data is the small sample sizes in several WMUs. Where there are a sufficient number of participants and valid data submissions, the information produced has the potential to be very beneficial for monitoring moose populations at a local, regional, and provincial scale (Rönnegård et al. 2008; Boyce and Corrigan 2017). It is crucial, therefore, that existing moose hunter participation rates be not only maintained but also increased. Toward this end we suggest that results and trends be summarized and made available online on an annual basis to maintain interest from the hunters submitting these data. It is possible that hunter interest in participating waned after five years of data collection without results being reported back on a regular basis to hunters (Figure 1). This is highlighted by the fact that only one WMU (WMU 507 – Northern Boreal) had 20 or more submissions in 2016. Our experience with other citizen science initiatives suggests that the greatest levels of engagement and participation come when there is regular feedback to participants regarding what is being learned from their collective participation (Webb et al. 2017).

In addition to maintaining the engagement of existing users of the app, it will be important to broaden the participant base. Up to this point, hunters targeted to use the app were those that received a moose draw in a given year. It is not uncommon, however, to wait between four and eight years to successfully draw another moose tag. As a result, you can expect few repeat

participants during a five-year period and will need to continually engage new participants. Once again, this may be aided by providing regular online reports on what is being learned. On other projects we have experienced potentially-keen individuals to sit back and wait to see whether anything is going to come from a new citizen science effort before they choose to participate in it themselves. If, however, annual online reporting made it clear to the hunting public that participating would not only help the resource, but also their own future hunting plans, it could drastically increase interest in using the app. It may also be worthwhile considering ways to allow non-draw holders to submit moose observation data to the app.

5.1 Data assumptions

As with any data collected by citizen science (or other sources for that matter), there will be assumptions linked to the data that are important to consider while interpreting the results. We previously highlighted three general categories of assumptions with the moose observation data: 1) random subsample; 2) observer bias, and; 3) sample bias (sightability). It is beyond the scope of this report to critically evaluate each assumption; however, we will comment on the assumptions as it relates to the interpretation of our results.

Specifically, we discussed the sex ratio data, at the natural region or WMU level, in relation to the assumptions embedded in the app. At both the natural region and WMU levels, some of the reported sex ratios exceed 100 bulls:100 cows, which is above the upper limit historically observed for moose sex ratios. Unrealistically high bull ratios may be driven by the violation of at least two assumptions. The first being that a hunter's willingness to submit data was not influenced by their draw type (i.e., antlered, antlerless, calf). The second assumption that may have been violated is that a hunter's willingness to submit data was not influenced by the number, age, or gender of moose observed in a given day.

In any year, there are typically more antlered tags allocated than antlerless or calf tags, and therefore there are likely to be more bull moose hunting hours. Bull moose hunters may be more likely to observe and report sightings of bulls if their hunting approach favours the detection of a bull. For example, calling moose during the rut may be more effective at bringing in bull moose as opposed to cows or calves. As such, hunters using this approach may submit observations with higher bull ratios than actually occurs within the population. Hunters focused on bulls may also be more likely to recall bulls observed on a given day as compared to cows or calves. On the other hand, some hunters with antlerless or calf tags may be reluctant to

submit data if they assume these observations are less relevant to overall management, when in fact they are as valuable as observations submitted by antlered tag holders.

Moving forward, we recommend that some assumptions associated with moose observation data be evaluated. For example, having the hunter enter their draw type as part of their data submission will allow for the evaluation of the assumption that the willingness of hunters to participate is not influenced by the draw type (i.e., antlered, antlerless, calf). In addition, plotting the submission frequency of zero, one, two, three, etc. moose observations, will allow the evaluation of the assumption that hunters have the same propensity to report no moose observed as they are to report one or more moose observed.

5.2 Moose observation data value

To illustrate the potential value of the data submitted by hunters, we looked at trends in the number of moose observed by hunters relative to moose density determined during aerial ungulate surveys completed the winter immediately following the hunting season. We only included WMUs with ≥ 20 valid data submissions in the year of comparison. We were able to use aerial survey data from four Foothills region WMUs including WMU 349 (app data 2012 vs. aerial survey data in December 2012; Hermanutz 2013), and WMUs 334, 348, and 353 (app data 2015 vs. aerial survey data from December 2015 or January 2016; AEP 2016). We first plotted the relationship between moose observed per hour reported by hunters to moose density determined by aerial moose surveys (Figure 13) and there appears to be a relationship, but additional data are required to quantify it. A similar correlation between moose observed per hour reported by hunters and moose density determined from aerial surveys was reported by Boyce and Corrigan (2017) using the initial two years of app data and a larger set of WMU (n=14) aerial survey data. Solberg and Saether (1999) in Norway have shown that hunter observation data can be used to examine trends in moose populations, under the assumption that a change in hunter observations (observation rate) is directly correlated to a true change in the population. Understanding the direct relationship between moose observed per hour by hunters to moose density determined by aerial surveys will serve as an early detection system for declining or increasing moose populations. As more hunters submit observation data, completing a comparison with aerial survey data would show declines or increases in numbers of moose on an individual natural region or WMU level.

We also plotted the recruitment (Figure 14) and sex ratios (Figure 15) determined by moose observation data relative to the ratios determined from aerial surveys for the same four Foothills region WMUs as above. There appears to be a relationship for both recruitment (ignoring WMU 334 as a potential outlier) and sex ratio data. For WMUs where there was a higher number of calves or bulls observed during the aerial survey, there tends to be a higher number of calves or bulls observed by hunters. However, there are several factors that need to be accounted for when making these comparisons. Recruitment and sex ratios reported by hunters during the fall are likely higher than those ratios that would be determined the following winter during aerial surveys, because of hunter and predator mortality that occurs during and after the hunting season. In addition, the bull moose numbers observed by hunters are likely high because of the violation of two assumptions, as discussed above. Again, additional moose observation data would assist in quantifying the relationship between recruitment and sex ratios determined from hunter-submitted observations versus aerial surveys. As more moose observation data become available, a direct comparison to aerial survey data would enable a correction factor to be calculated that converts calf and bull numbers during hunting season to calf and bull numbers observed post-hunting season in the winter. This correction factor could provide an index of post-hunting season mortality rate.

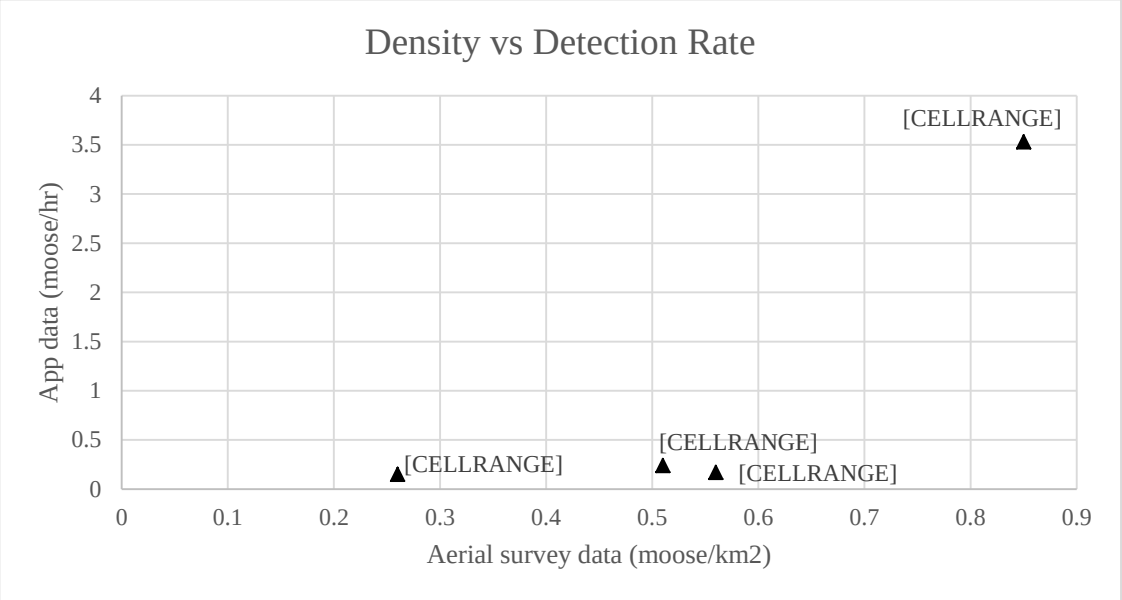


Figure 13. Comparison of moose observed per hour by hunters to moose per km² reported during aerial surveys for four WMUs in the Foothills Natural Region of Alberta.

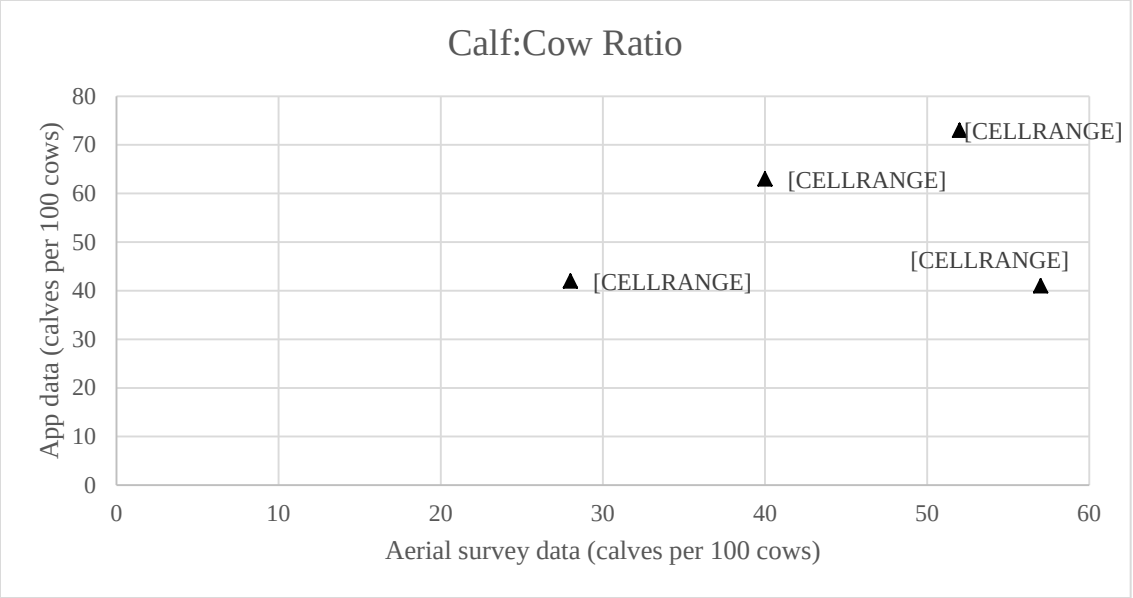


Figure 14. Comparison of moose recruitment rates (calves:100 cows) determined from hunter observation data to those determined from aerial surveys for four WMUs in the Foothills Natural Region of Alberta.

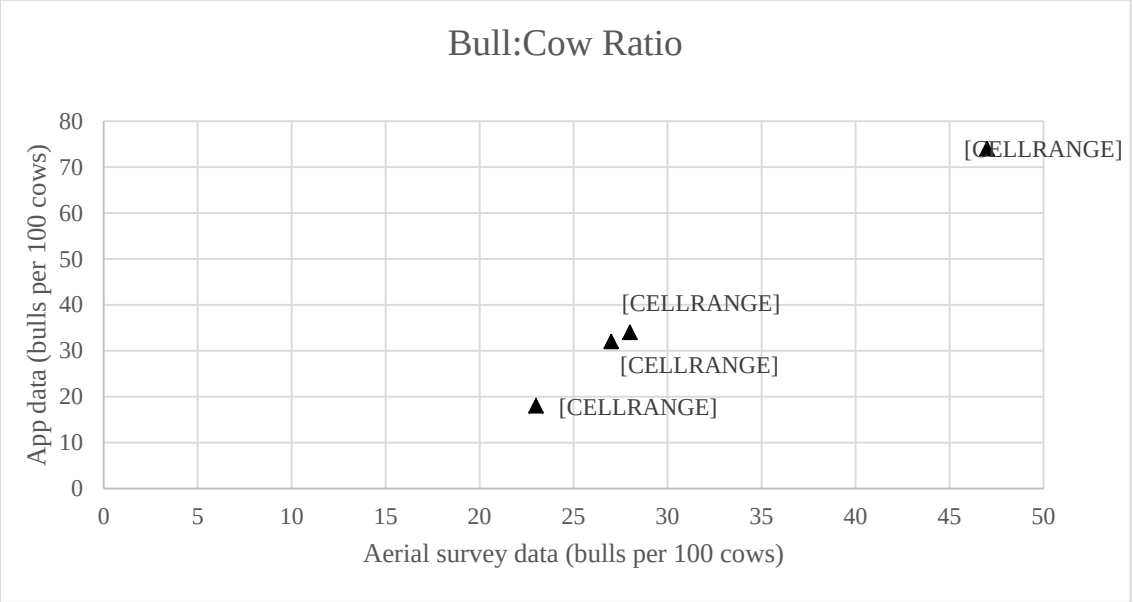


Figure 15. Comparison of moose sex ratios (bulls:100 cows) determined from hunter observation data to those determined from aerial surveys for four WMUs in the Foothills Natural Region of Alberta.

5.3 App modification recommendations

The Alberta Moose Hunter Survey App received over 14,000 submissions from 2012 to 2016. Of these submissions, approximately 6,000 were kept as valid, and were the basis for the summary statistics that are presented in this report. The fact that such a large amount of moose observation data was discarded is problematic. We recommend that changes be made to the app, to make it easier for hunters to enter valid moose observation data:

- Clarify that data submissions are per person and per day, and only while hunting in the designated WMU. Do not include moose observed while driving to the designated WMU. Do not compile observations for multiple people (e.g., 2 people observe 3 moose while hunting for 7 hours, should not be entered as 3 moose in 14 hours).
- Make "Date" a drop-down menu, which includes only August 25 to November 30 of the current year. Or design the app to only accept data during the hunting season.
- Make "WIN" a mandatory 10-digit number so that the app won't accept incorrect WIN numbers.
- Make "WMU" a drop-down menu so that the app can't accept draw codes, or incorrect WMUs.
- Make NumBulls/NumCows/NumCalves/NumUnidentified a maximum of 2 digits, to eliminate over-reporting.
- Make "Total" a self-tallying column, so math is not required.
- Make "HoursOut" a drop-down menu between 1-15 hr, to eliminate entries with 0 hunting hours or over-reporting of hunting hours.
- To reduce the likelihood of duplicate entries, have the app permit only 1 entry from the same phone on the same day. Alternatives include an automated message indicating "Data sent" or having the data form automatically re-set to zeros after data have been submitted.
- Make a drop-down menu to allow the hunter to indicate which draw they are hunting (antlered, antlerless, calf).

5.4 Conclusion

Countries in Scandinavia have successfully used hunter observation data to assist with the management of moose populations (Solberg and Saether 1999; Sylvén 2003; Rönnegård et al. 2008). The Alberta Moose Hunter Survey App is the first attempt to collect observations from

hunters as a means of assisting with the management of moose in Alberta. Though there are limitations with the data collected so far (e.g., inadequate sample size), overall the data submitted do hold strong promise to be of value for detecting trends in moose populations. In addition, we see value in hunter-submitted observation data as a means to monitor larger population-level issues and conservation concerns related to moose in Alberta. As the app program moves forward, increasing hunter participation and the quality of data submitted will further enhance the usefulness of the app. Further exploration of the relationships between moose observation data and aerial survey data will provide confidence in the use of hunter-submitted observation data for management purposes.

6.0 LITERATURE CITED

Alberta Environment and Parks (AEP). 2015. Wildlife management units. Available online at http://aep.alberta.ca/fish-wildlife/fishing-hunting-trapping/hunting-alberta/wildlife-management- units.aspx [Accessed 5 July 2017].

Alberta Environment and Parks (AEP). 2016. Aerial wildlife survey reports. Available online at http://aep.alberta.ca/fish-wildlife/fishing-hunting-trapping/aerial-wildlife-survey-reports.aspx [Accessed 5 July 2017].

Alberta Environment and Parks (AEP). 2017. Alberta Regulations: 2016 Alberta hunting draws. Available online at http://aep.alberta.ca/fish-wildlife/fishing-hunting-trapping/alberta-regulations/default.aspx [Accessed 23 May 2017].

Boyce, M.S. 2012. Moose survey app: hunters as citizen scientists. Fair Chase Winter: 72-75.

Boyce, M.S., P.W.J. Baxter, and H.P. Possingham. 2012. Managing moose harvests by the seat of your pants. Theoretical Population Biology 82(4): 340–347.

Boyce, M.S., and R. Corrigan. 2017. Moose survey app for population monitoring. Wildlife Society Bulletin 41: 125-128.

Hermanutz, R. 2013. Wildlife management unit 349 moose. Pages 37-41. *In:* M. Ranger and C. Rasmussen (eds.). Delegated big game surveys, 2012/2013 survey season. Data Report, D-2013-006, produced by the Alberta Conservation Association, Sherwood Park, Alberta, Canada.

Rönnegård, L., H. Sand, A.H. Månsson, and Å Pehrson. 2008. Evaluation of four methods used to estimate population density of moose *Alces alces*. Wildlife Biology 14: 358-371.

Solberg, E.J., and B.E. Saether. 1999. Hunter observations of moose *Alces alces* as a management tool. Wildlife Biology 5: 107-117.

Sylvén, S. 2003. Management and regulated harvest of moose (*Alces alces*) in Sweden. Dissertation, Swedish University of Agricultural Sciences, Uppsala, Sweden. 36 pp.

University of Alberta. 2017a. Moose hunter survey. Department of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada. Available online at http://www.biology.ualberta.ca/moose/ [Accessed 5 July 2017].

University of Alberta. 2017b. Moose tracking: There's an app for that. Faculty of Science, University of Alberta, Edmonton, Alberta, Canada. Available online at https://www.ualberta.ca/science/science-news/2017/april/moose-tracking-app-for-population-modeling [Accessed 5 July 2017].

Webb, S., B. Abercrombie, R. Anderson, B. Bildson, M. Jokinen, N. Kimmy, and D. Manzer. 2017. Wolverine distribution and habitat associations on registered traplines in Alberta Winter 2011/12 - 2015/16. Available online at http://www.ab-conservation.com/publications/report-series/wolverine-distribution-and-habitat-associations-on-registered-traplines-in-alberta-winter-2011-12-2015-16/ [Accessed 28 May 2018].

7.0 APPENDICES

Appendix 1. Summary of moose/hr for each WMU based on valid data submissions to the Alberta Moose Hunter Survey App, 2012 to 2016.

WMU = wildlife management unit; N = number of valid submissions; [1] Moose/hr averages were calculated by pooling all observations of moose (bulls, cows, calves, unidentified) and all hunting hours in each WMU, grouped by year and then averaged across all years; [2] Ratios were calculated by pooling all observations of calves, cows, bulls and unidentified across all years for each WMU.

			# Moose/Hr[1]							
Natural Region	**WMU**	**N (all years)**	**2012**	**2013**	**2014**	**2015**	**2016**	**WMU Average**	**Calves:100 Cows Ratio[2]**	**Bulls:100 Cows Ratio[2]**
Prairie Region	118	43				0.20		0.20	57	119
	119	1				0.20		0.20		
	148	9				0.05		0.05	0	100
	150	2				0.63		0.63	50	300
	151	1		0.30				0.30	0	200
	152	35		0.37	0.15	0.92	0.29	0.27	26	117
	156	18		0.40	0.61		0.18	0.37	50	90
	158	12		0.44		2.11		0.88	29	71
	160	20		0.69	1.35	0.91		1.15	54	131
	162	7		1.00	1.17	1.13		1.09	57	329
	163	9		0.00	0.90			0.45	100	100
	164	2				1.44		1.44	50	67
	166	40	2.00	1.14	0.35	0.75		0.61	52	118
Prairie Summary: (13 WMUs; 1154 Hrs)		**199**	**2.00**	**0.55**	**0.45**	**0.37**	**0.21**	**0.43**	**48**	**122**

Appendix 1. Continued.

Natural Region	WMU	N (all years)	# Moose/Hr[1] 2012	2013	2014	2015	2016	WMU Average	Calves:100 Cows Ratio[2]	Bulls:100 Cows Ratio[2]
Parkland Region	200	36		0.69	0.25	1.18		0.67	56	92
	202	49		4.63	0.56	0.83	0.39	1.12	71	95
	203	35	1.06	5.83	1.49	0.95		1.47	56	86
	204	80	0.33	1.95	0.72	1.16	0.46	0.93	57	85
	206	18			0.27	0.31	0.83	0.33	75	58
	208	53		0.32	0.25	0.56		0.31	75	206
	210	3		0.00	0.30			0.21	100	100
	212	10					0.63	0.63	22	78
	214	48	1.14	0.29	1.03	0.67	0.50	0.79	68	55
	216	49	2.00	0.27	0.11			0.17	57	62
	220	85	0.96	0.33	0.53	0.22	0.17	0.42	43	80
	221	28		0.17	0.16	0.21		0.17	29	157
	222	15	0.52	2.00				0.61	57	114
	224	64	0.04	0.27	0.26	0.36		0.27	43	74
	226	66	1.84	0.03	0.03			0.19	34	63
	228	25		0.42	0.89	1.31		0.83	70	370
	230	106	0.20	1.53	0.91	3.80	1.92	2.11	74	109
	232	24	0.30	0.62	0.96	0.40		0.71	59	119
	234	91	0.43	0.54	0.43	0.56	0.23	0.48	60	108
	236	4		0.13	0.50			0.20		
	238	43	0.50	1.00	0.27	0.64		0.42	35	85
	240	2			0.43			0.43	0	50
	242	124	0.65	0.80	0.27	0.26		0.40	50	111
	244	14		0.04	0.13	0.36		0.11	25	50
	246	45	0.38	0.35	0.19	0.32		0.27	24	46
	248	92	0.10	0.65	0.53	0.61	0.33	0.52	36	71

Appendix 1. Continued.

Natural Region	WMU	N (all years)	# Moose/Hr[1] 2012	2013	2014	2015	2016	WMU Average	Calves:100 Cows Ratio[2]	Bulls:100 Cows Ratio[2]
Parkland Region cont.	242	124	0.65	0.80	0.27	0.26		0.40	50	111
	244	14		0.04	0.13	0.36		0.11	25	50
	246	45	0.38	0.35	0.19	0.32		0.27	24	46
	248	92	0.10	0.65	0.53	0.61	0.33	0.52	36	71
	250	72	0.71	0.51	0.48	0.42	1.83	0.58	77	86
	252	42	0.44	1.58	0.25			0.82	75	70
	254	61	2.54	0.53	0.70	0.21		1.17	83	71
	256	10		0.17	1.40	1.27		0.58	143	129
	258	15		0.75		0.27		0.43	60	40
	260	3			0.20	0.50		0.30	100	500
	728	15		0.79	0.67	0.90		0.76	34	119
	730	6		0.50				0.50	67	50
	936	34		0.25	0.06	0.21		0.18	68	59
Parkland Summary: (35 WMUs; 7005 Hrs)		**1467**	**1.18**	**0.69**	**0.43**	**0.74**	**0.62**	**0.62**	**61**	**90**
Foothills Region	300	5			0.31	0.13		0.26	0	800
	302	7	0.33		0.87			0.58	88	50
	304	2		0.60		3.00		1.00	33	67
	306	1			3.33			3.33	67	167
	308	13	0.38	2.33				1.42	19	88
	310	19		0.93	0.70	1.36		1.18	44	38
	312	106	0.39	0.61	0.76	1.04	0.62	0.75	34	89
	314	116	0.04	0.27	0.29	0.25		0.23	31	77
	316	28		0.23		0.66		0.38	26	113
	318	1	0.60					0.60	33	67

Appendix 1. Continued.

Natural Region	WMU	N (all years)	# Moose/Hr[1] 2012	2013	2014	2015	2016	WMU Average	Calves:100 Cows Ratio[2]	Bulls:100 Cows Ratio[2]
Foothills	320	1		0.00				0.00		
Region cont.	322	20	0.24	0.47			1.28	0.85	31	69
	324	15			0.05		0.08	0.05	25	25
	326	19			0.04	0.63	0.07	0.09	0	57
	328	1	0.00					0.00		
	330	8	0.00		0.00	0.00		0.00		
	332	38		0.83	0.51	0.90		0.60	78	74
	334	154	0.27	0.21	0.11	0.15	0.19	0.17	51	51
	336	137	0.14	0.39	0.45	0.18	0.13	0.28	56	81
	337	46	0.22	0.10	0.00			0.09	43	50
	338	79	0.28	0.05	0.04	0.05		0.08	38	27
	339	17		0.29	0.13	0.02		0.09	40	80
	340	36	0.19	0.30	0.28	0.00	0.00	0.14	32	27
	342	15		0.00	0.05	0.52		0.23	57	100
	344	34	4.23	0.10	0.04	0.39	0.09	0.35	70	43
	346	43	0.60	0.35		0.16		0.44	61	45
	347	60	0.33	0.31	0.11	0.17	0.28	0.19	50	75
	348	119	0.55	0.98	0.34	3.53	0.47	1.22	66	21
	349	139	0.28	0.17	0.09	0.24	0.05	0.19	46	65
	350	104	0.22	0.18	0.13	0.11	0.00	0.16	25	23
	351	28		0.36	0.03	0.13		0.18	17	225
	352	20	0.50	0.27	0.25	0.36	0.22	0.26	31	94
	353	211	0.78	0.19	0.17	0.17	0.27	0.21	50	74
	354	41	0.88	0.13	0.21	0.35		0.31	62	23
	355	15		0.16	0.04	0.13		0.12	10	40
	356	89	0.33	0.35	0.21	0.27	0.00	0.28	29	67
	357	260	0.42	0.56	0.31	0.47	0.54	0.43	62	73

Appendix 1. Continued.

Natural Region	WMU	N (all years)	# Moose/Hr[1] 2012	2013	2014	2015	2016	WMU Average	Calves:100 Cows Ratio[2]	Bulls:100 Cows Ratio[2]
	358	48	0.46		0.92	0.15	0.00	0.46	52	44
	359	46	1.08	1.27	0.73	1.38	0.39	1.08	51	34
	360	113	0.63	0.30	0.64	0.16	0.00	0.41	72	50
Foothills Summary: (40 WMUs; 13,416 Hrs)		**2254**	**0.39**	**0.34**	**0.27**	**0.42**	**0.28**	**0.34**	**50**	**57**
Mountain Region	400	18		0.17	0.63			0.28	20	130
	402	2			0.00			0.00		
	404	6			0.19	0.00		0.07		
	406	66	0.46	0.61	0.20	0.47	0.11	0.38	12	71
	408	4		0.50		0.22		0.27	0	200
	412	8		0.11	0.00	0.00		0.08	0	300
	414	9	0.32	1.00	0.00	1.00		0.34	33	67
	422	3		0.21				0.21	0	100
	426	2			0.00	0.00		0.00		
	429	1	0.75					0.75	0	50
	430	3		0.00				0.00		
	436	3		0.16				0.16	0	0
	437	3			0.03			0.03		
	438	16	0.11		0.04			0.05	50	100
	439	3		0.00				0.00		
	440	5				0.42	0.00	0.11	100	100
	441	1				0.00		0.00		
	445	6			0.00	0.08		0.02		
	446	17		0.10	0.13	0.04		0.10	0	350
Mountains Summary: (19 WMUs; 1120 Hrs)		**176**	**0.34**	**0.27**	**0.15**	**0.28**	**0.02**	**0.22**	**15**	**85**

Appendix 1. Continued.

Natural Region	WMU	N (all years)	# Moose/Hr[1] 2012	2013	2014	2015	2016	WMU Average	Calves:100 Cows Ratio[2]	Bulls:100 Cows Ratio[2]
Northern Boreal Region	500	33	0.48	0.07		0.04	0.00	0.10	75	75
	501	16			0.19	0.40	0.00	0.21	100	13
	502	10			0.07		1.50	0.43	17	200
	503	50	0.09	0.33	0.14	0.46	1.00	0.23	52	17
	504	41		0.93	0.12	0.00	0.08	0.16	56	67
	505	20	0.25	1.65	0.50	1.67		1.05	78	60
	506	46	0.44	0.38		0.03		0.30	56	53
	507	169	0.56	0.55	0.40	0.44	0.08	0.36	48	61
	508	82	0.38	0.37	0.34	0.36		0.36	72	75
	509	26		0.20	0.10	0.54	2.33	0.25	18	32
	510	224	0.53	0.48	0.29	0.50	2.04	0.47	48	38
	511	69	0.45	0.07	0.02	0.09		0.16	36	42
	512	56	0.39	0.14	0.17	0.20	0.04	0.17	53	91
	514	25	0.08	0.14	0.15			0.13	88	38
	515	64	0.07	0.08	0.07	0.10		0.09	36	45
	516	11	1.00	0.06	0.00	0.00		0.05	0	33
	518	31	0.59	0.07	0.12			0.18	31	100
	519	44	0.39	0.16	0.06	0.15		0.11	38	38
	520	35	0.25	0.06	0.07	0.14	0.43	0.20	48	32
	521	86	0.75	0.32	0.32	0.23	0.29	0.36	42	39
	522	90	0.93	0.96	0.39	0.28	0.34	0.58	45	46
	523	145	0.50	0.93	0.78	0.55	0.56	0.75	53	27
	524	66	0.36	0.20	0.11	0.13	0.08	0.14	59	44
	525	29		0.22	0.05	0.05		0.12	36	45
	526	59	0.80	0.49	1.17	1.45	0.10	0.58	38	38
	527	113	0.30	0.36	0.69	0.40		0.49	48	24

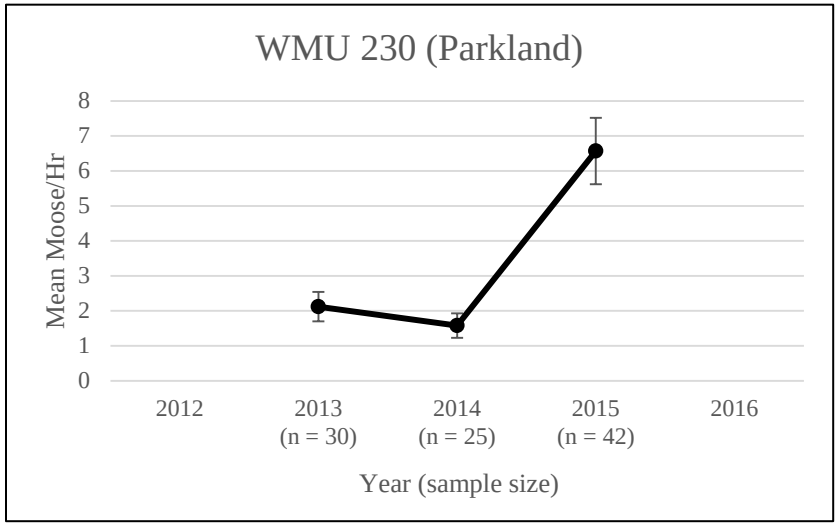
Appendix 1. Continued.

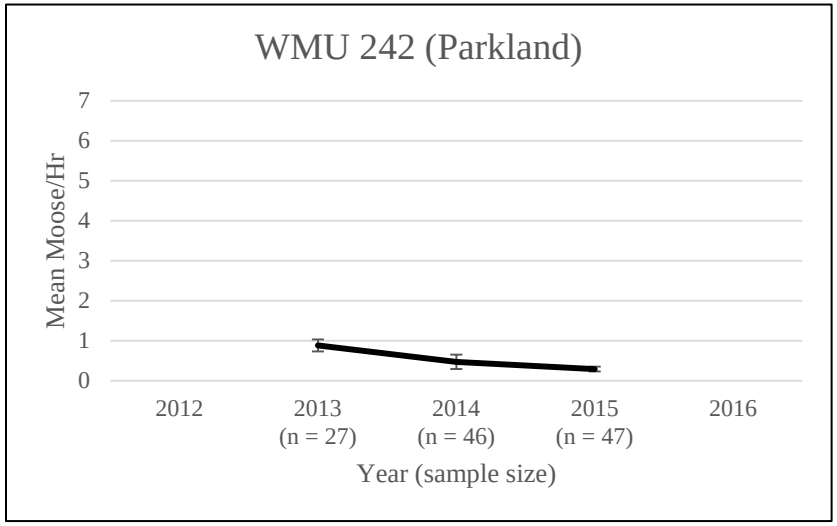
Natural Region	WMU	N (all years)	# Moose/Hr[1] 2012	2013	2014	2015	2016	WMU Average	Calves:100 Cows Ratio[2]	Bulls:100 Cows Ratio[2]
Northern Boreal Region cont.	528	16		0.11	0.29	0.00		0.22	73	55
	529	3			0.00			0.00		
	530	13		0.27	0.07	0.00		0.06	25	25
	531	3		0.44		0.50		0.46	25	150
	534	26		0.00	0.09	0.06		0.06	33	83
	536	5		0.00	0.04			0.03		
	537	32		0.00	0.02		0.00	0.02	33	0
	540	5		0.00	0.03			0.02	0	0
	541	5		0.00		0.40		0.09	50	50
	542	48	0.08	0.22	0.11	0.16		0.13	47	124
	544	25	0.00		0.20	0.03		0.07	50	13
	841	9	0.04	0.67	0.05			0.09	0	400
Northern Boreal Summary: (38 WMUs; 10,823 Hrs)		**1830**	**0.39**	**0.41**	**0.23**	**0.30**	**0.25**	**0.31**	**49**	**44**
Provincial Summary (145 WMUs; 33,518 Hrs):		**5926**	**0.49**	**0.44**	**0.30**	**0.44**	**0.30**	**0.39**	**52**	**66**

Appendix 2. Number of valid submissions per year by natural region to the Alberta Moose Hunter Survey App, 2012 to 2016.

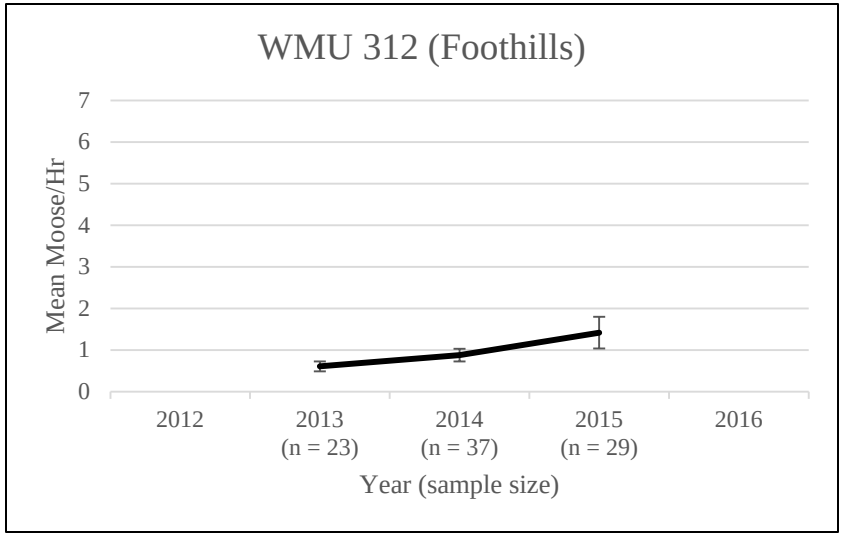
Natural region	Year	Valid submissions (N)	Total hours hunting
Foothills	2012	315	1,892
	2013	548	3,253
	2014	713	4,257
	2015	568	3,391
	2016	110	623
Mountain	2012	12	76
	2013	55	347
	2014	74	455
	2015	29	198
	2016	6	44
Northern Boreal	2012	205	1,233
	2013	470	2,502
	2014	627	3,918
	2015	423	2,450
	2016	105	720
Parkland	2012	84	435
	2013	341	1,653
	2014	620	3,036
	2015	373	1,664
	2016	49	217
Prairie	2012	2	6
	2013	34	247
	2014	64	346
	2015	93	502
	2016	6	53

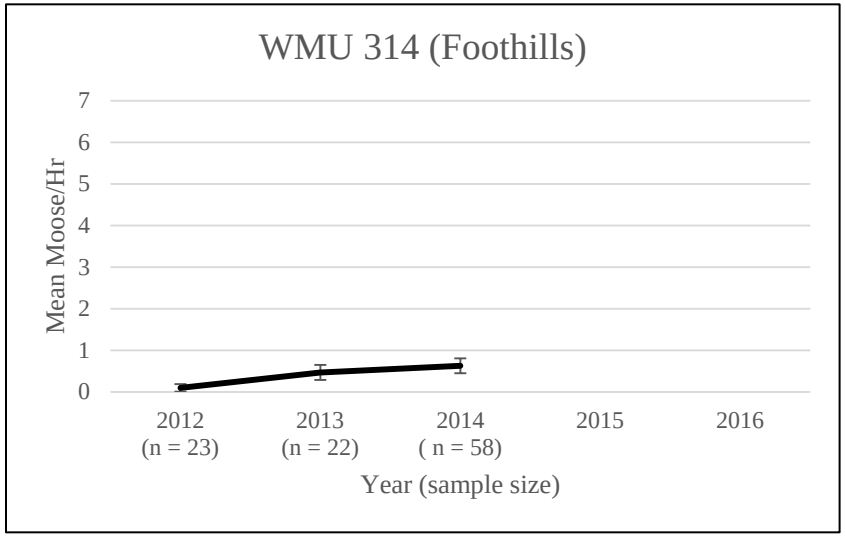
Appendix 3. Mean (± 1 SE) number of moose observed per hour in WMUs with ≥ 3 years data and ≥ 20 submissions per year to the Alberta Moose Hunter Survey App, 2012 to 2016.

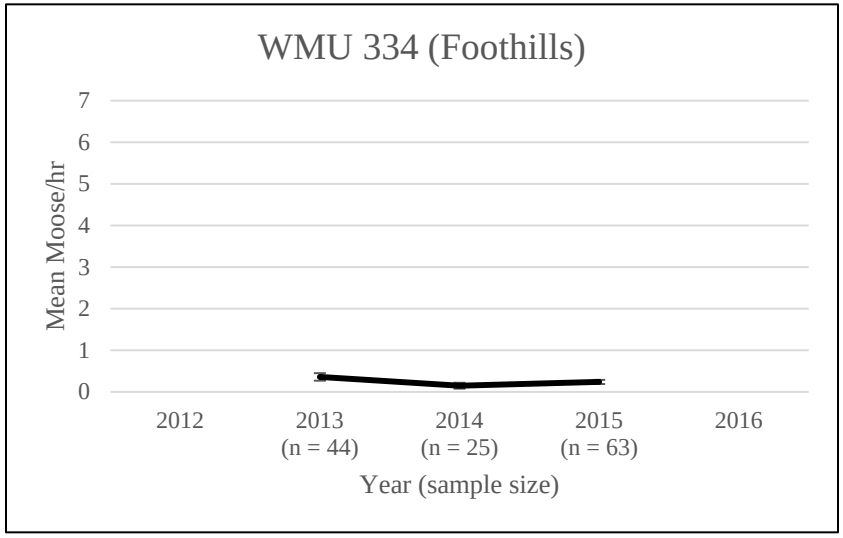


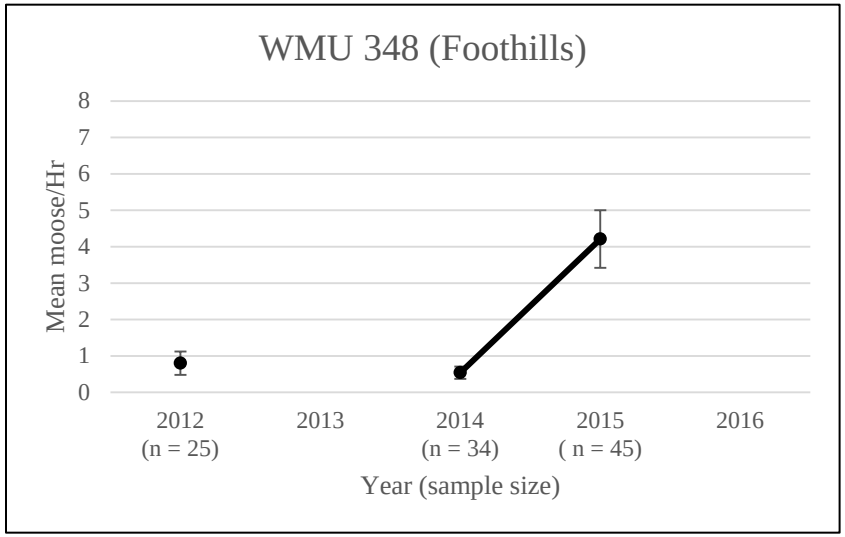


Appendix 3. Continued.

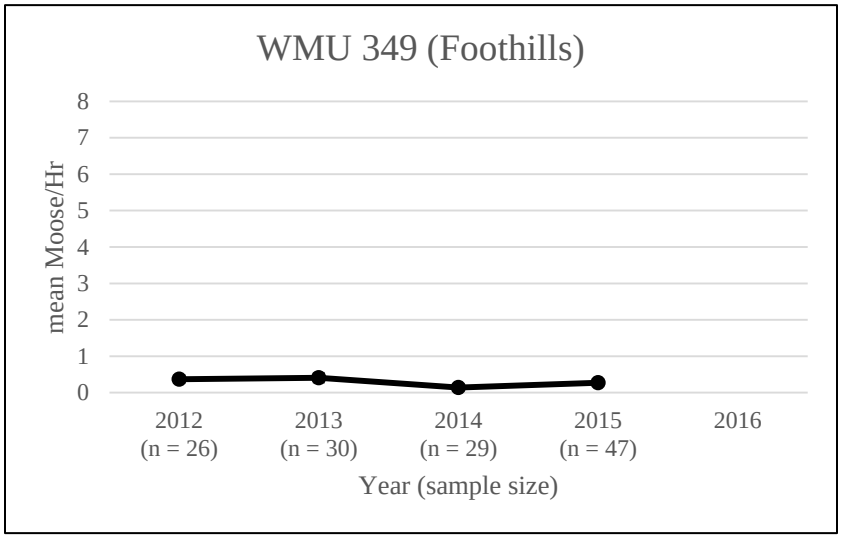


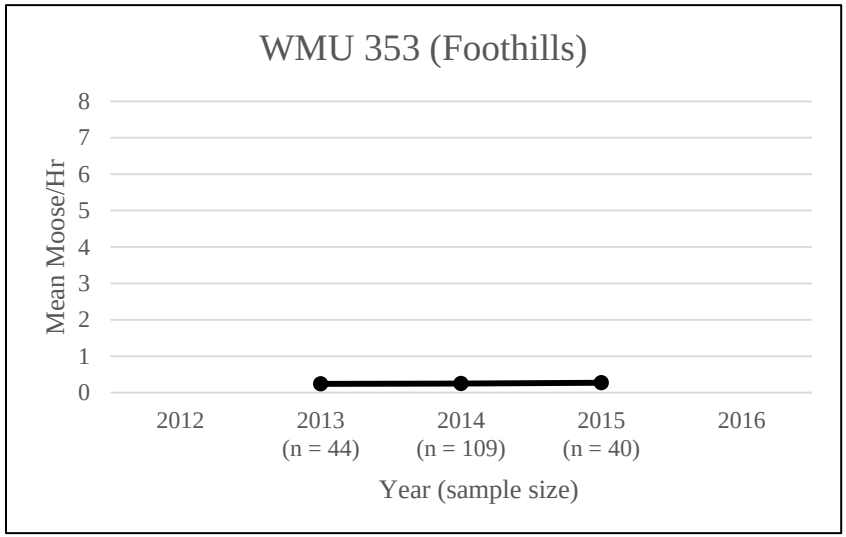


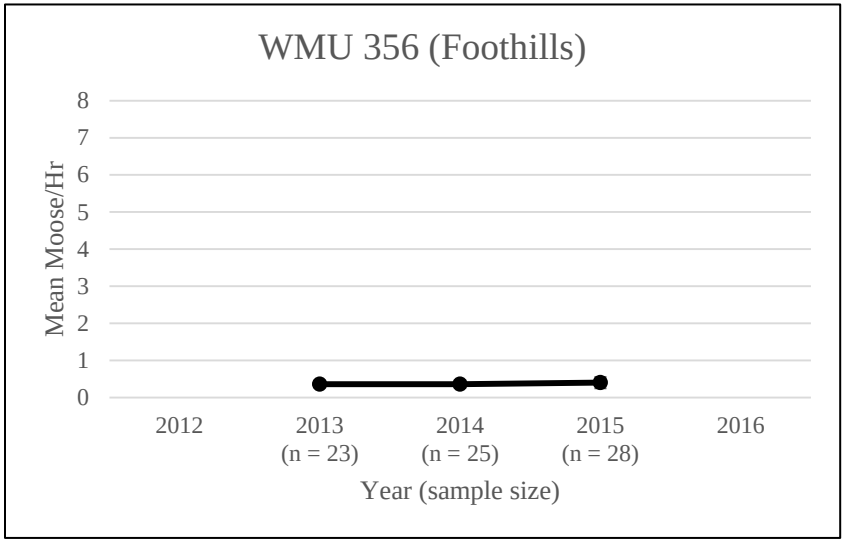


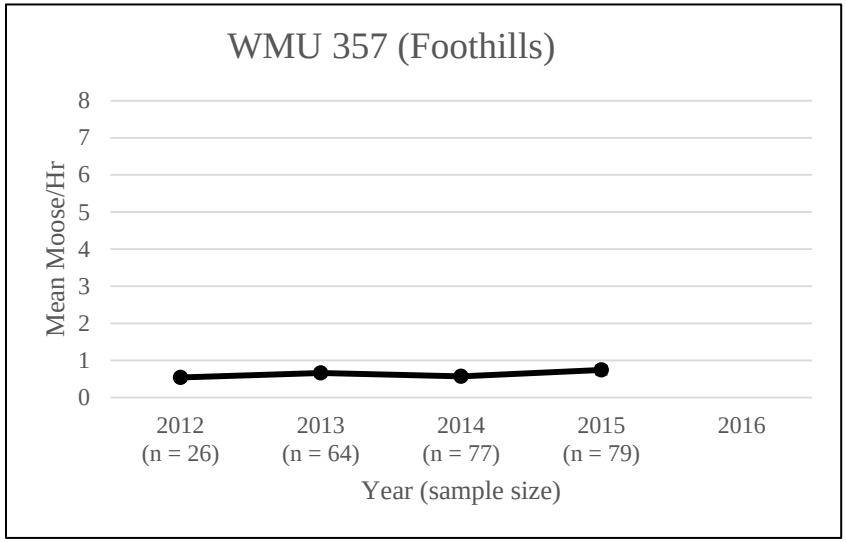


Appendix 3. Continued.

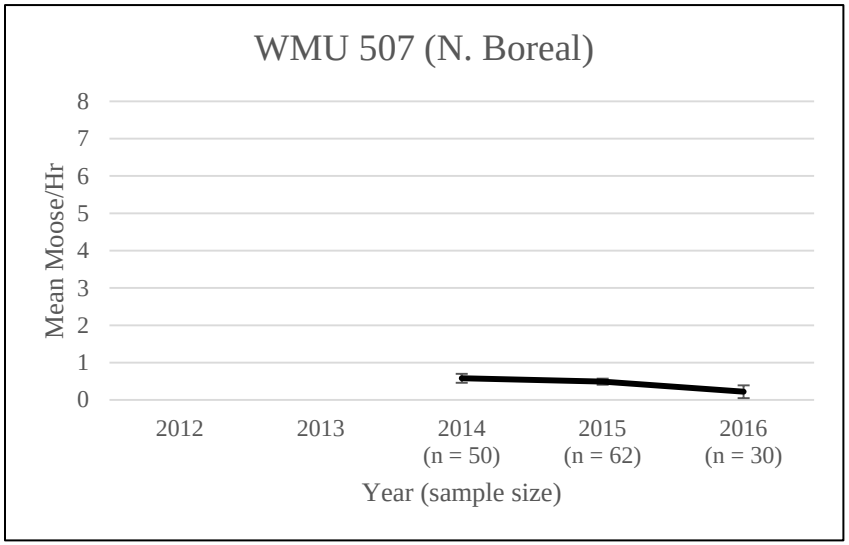


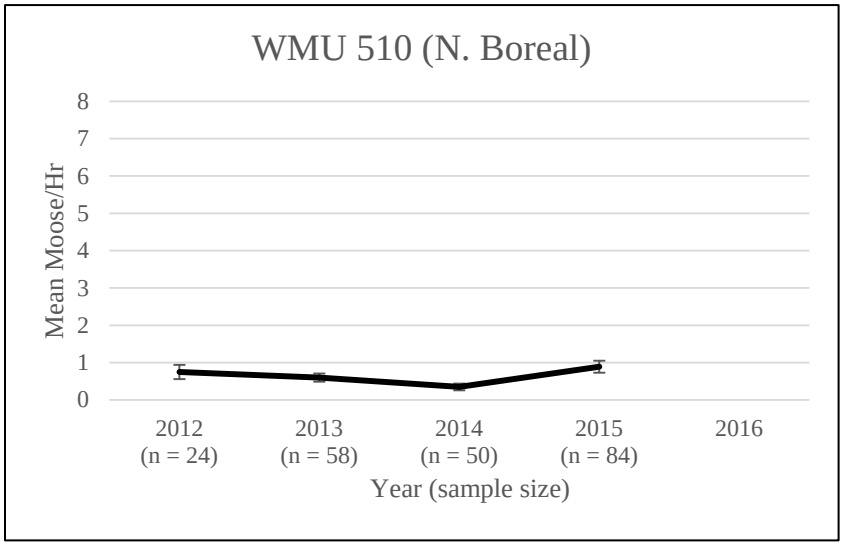


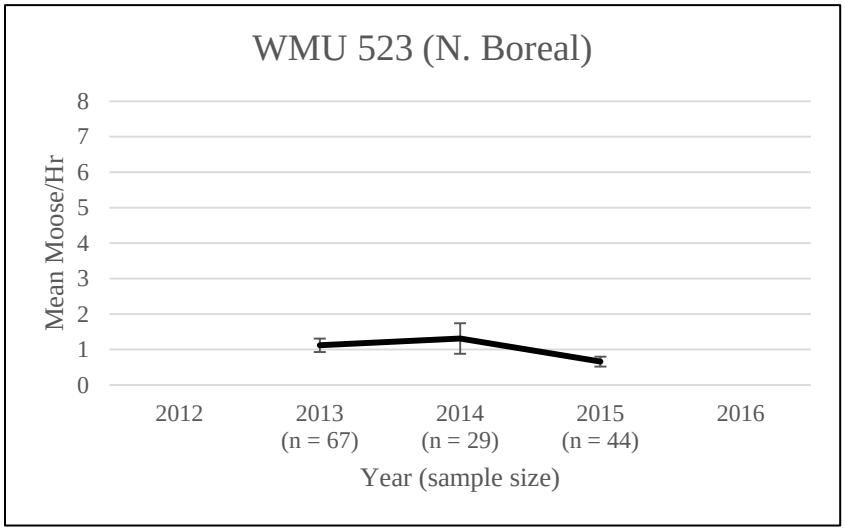




Appendix 3. Continued.







Alberta Conservation Association acknowledges the following partner for its generous support of this project:

Alberta

Alberta Conservation Association