Wildlife Society Bulletin; DOI: 10.1002/wsb.732

Tools and Technology

Moose Survey App for Population Monitoring

MARK S. BOYCE,[1] *Department of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9, Canada*
ROB CORRIGAN, *Alberta Environment and Parks, 9920 108 Street, Edmonton, AB T5K 2M4, Canada*

ABSTRACT We developed a smart phone app for hunters to report the number of moose (*Alces alces*) observed while hunting in Alberta, Canada, during 2012–2014. Excessive costs of aerial surveys often result in infrequent estimates of moose abundance, whereas hunter observations can be obtained for minimal expense. Correlations of the number of moose observed by hunters with hunter success, moose harvests, and aerial survey estimates of abundance suggest that the method offers promise as an alternative to aerial ungulate surveys. Engaging hunters with the Moose Survey app has potential to increase the spatial extent and temporal frequency of monitoring with benefits for harvest management. © 2017 The Wildlife Society.

KEY WORDS aerial survey, Alberta, *Alces alces*, citizen science, monitoring, moose, population estimation, smart phone app.

Monitoring of wildlife populations is necessary for sound harvest management. Yet monitoring can be expensive, especially for large mammals using helicopter surveys (Peters et al. 2014). Determining the appropriate amount of effort for monitoring becomes an optimization process balancing costs with competing needs for conservation, enforcement, and management (McDonald-Madden et al. 2010, Boyce et al. 2012). Economically viable alternatives for monitoring might use citizen science, enlisting volunteers who participate in collecting data (Belt and Krausman 2012, Paul et al. 2014, Johnston et al. 2015).

In Scandinavia, moose (*Alces alces*) populations have been monitored for >30 years using hunter observations of the number of moose seen by hunters, reported daily at check stations or through hunting group team leaders (Ericsson and Wallin 1999, Solberg and Saether 1999). We considered how such a system might work in North America where there is no comparable local organization of hunters and check stations are not widely used. Use of a smart phone app was identified as a possible solution, engaging moose hunters in the collection of data. Not all hunters have smart phones, but we believed that a reasonable sample of hunters might be obtained because Alberta, Canada, has the highest frequency of smart phone ownership in Canada, and use of smart phones is increasing rapidly everywhere (Smith 2013).

METHODS

We programmed an app for iPhone (Apple, Inc., Cupertino, CA, USA) and Android-based (Google, Inc., Mountain View, CA, USA) smartphones that hunters could use to record the number and classification of moose observed and the number of hours spent hunting at the end of each day when they hunted (Fig. 1). Observations were to be recorded only when hunting within the Wildlife Management Unit (WMU) where they held a license to hunt for moose. Data entered through the app were transmitted to a server at the University of Alberta where they accumulated in a spreadsheet through the duration of the hunting season. If the hunter was out of range for cell phone service, data were stored on the smartphone until the hunter returned to an area with cell phone coverage when data were then transmitted. The app prompted the moose hunter daily at 2000 hours to record the number of moose seen during that day. The ringtone prompt that we programmed into the app was the bellowing call of an adult female moose in heat. Recording moose sightings on the same day is important because hunters might forget what they saw in days past (Schmidt et al. 2015).

Before each moose hunting season began in early September of 2012–2014, a letter was sent by Alberta Fish and Wildlife Division (currently under the Ministry of Environment and Parks) to each hunter who drew a limited-quota moose Special License encouraging them to download the app from the Apple App Store for hunters with iPhones or from a link on a website for those with Android systems. The letter identified the following rules for volunteer participants to reduce biases in the reported data (Schmidt et al. 2015):

1. Record the number of hours spent in the WMU when moose might be seen, whether in a vehicle or on foot.
2. Only record moose seen on that day.
3. Do not record observations of tracks, spoor, or moose beds. Only report moose actually seen.
4. Only record moose observed within the WMU for which a hunting license was issued. Do not report moose observations in other WMUs.
5. Record the number of adult male moose, adult female moose, and calves observed during the day as well as any moose for which age/sex classification was not possible. If uncertain whether the moose was a female or a calf, report "unidentified" on the app form.

Received: 29 March 2016; Accepted: 10 January 2017

[1]*E-mail: boyce@ualberta.ca*

Figure 1. App icon (a), registration page (b), and data input screen (c) for Moose Survey iPhone app, requesting daily observations of the number of adult males, adult females, calves, and unidentified moose observed and the number of hours spent hunting during that day. WIN stands for Wildlife Identification Number required of all hunters in Alberta, Canada, and WMU is the Wildlife Management Unit for which a hunting license has been issued.

6. Record moose observations even if outside the range of cellular communication. The date-stamped observations will be transmitted when the hunter returns to an area with mobile phone or WiFi coverage.

Aerial surveys were conducted by provincial biologists (Ministry of Environment and Parks), following a modified Gasaway method as detailed by Lynch and Shumaker (1995). Hunter postharvest surveys were conducted on-line under contract by the hunting license providers IBM (2012–2013), Active Networks (2014), LLC. Postharvest surveys were used to estimate the total harvest of moose in each WMU. However, harvest data alone could create biased estimates of density if not corrected for hunting effort (Imperio et al. 2010); thus, 2 additional metrics were obtained that corrected for variation in effort in each WMU: 1) hunter success (i.e., the percentage of hunters who successfully harvested a moose); and 2) the number of days required to harvest a moose within each WMU. The Alberta Conservation Association (Sherwood Park, Alberta, Canada) provided technical support by telephone for hunters with questions about how to download and use the app. To explain the justification for the app and encourage participation by hunters, we published articles explaining the program in periodicals of interest to hunters including the *Alberta Outdoorsmen*, Boone & Crockett's *Fair Chase*, and the Alberta Conservation Association's *Conservation*.

RESULTS

We compiled only records from hunters with Special Licenses that were limited quota hunting licenses on draw. Special Licenses allowed hunting with rifle for moose hunting in Alberta; General Licenses were restricted to bowhunters. We did not include in our analysis reports from hunters with General Licenses who were bowhunters because of low total annual kill (e.g., only 157 moose harvested in 2014), and effort by bowhunters was much greater than for rifle hunters. Also, First Nations hunters were not licensed and there was no record of their harvests.

Our initial trial year, 2012, was frustrating because Apple released its new iOS6 operating system on 19 September 2012, which coincided with the opening day of moose season. Apple returned our app for revisions to make it compatible with the new operating system, delaying the release of our app by 3 weeks. Hunters owning an

Android-based operating system were able to participate as planned but iPhone users missed the early part of the hunting season. This was significant because the majority of reporting smart phone users had iPhones (73%). Nevertheless, once the app was up and running, we had hunter participation and large numbers of reported moose.

The next 2 full seasons with the app, 2013 and 2014, were revealing with 21,497 hr of moose hunting reported and 7,080 moose (one-third were adult males) observed while hunting. The number of hunters using the app increased each year of our trial, but participation was less than half of what we had hoped (Table 1). Approximately 5% of licensed hunters submitted reports of moose observed while hunting by 2014.

During the 3 years that we have monitored the Moose Survey app, Alberta Fish and Wildlife has conducted aerial surveys estimated density of moose on 18 WMUs. Of those WMUs for which population estimates were available, we recorded counts by app participants on 14 WMUs. To use the moose app counts as an index of abundance, counts must be corrected for survey effort (Imperio et al. 2010); thus, we calculated the daily number of moose reported per hour hunting. As validation of the moose app as an index of abundance, we found that the number of moose seen per hour was correlated with moose density estimated by aerial survey (Fig. 2; $r = 0.69$, $n = 14$, $P < 0.01$). We had a limited sample size of aerial surveys, so we also inspected data on hunter harvests as an indirect measure of moose abundance. Again, we corrected moose observations by hunters for effort by calculating the total number of moose seen per hour hunting to compare it with hunter harvests. Moose seen per hour was correlated with percent hunter success in a WMU (Fig. 3; $r = 0.57$, $n = 111$, $P < 0.001$). Another index of harvest rate is the number of days to kill a moose, which we found to be inversely correlated with the number of moose reported by the Moose Survey app ($r = -0.46$, $n = 111$, $P < 0.001$). The number of days to kill a moose showed greater variance, especially at low values; thus, hunter success appears to be a more reliable index (Boyce et al. 2012). Harvest-based metrics as well as aerial survey estimates were correlated with counts from the Moose Survey app, giving us an independent measure of relative moose abundance based on those seen by hunters.

DISCUSSION

The moose app provides an inexpensive source of data on relative abundance of moose that can complement other sources of monitoring data. We derived relative moose density by the daily number of moose seen per hour hunting; thus, we required data on both the counts of moose and the number of hours each day that the hunter was in the field. We encountered challenges because in some instances, hunters entered zeroes on days that they did not hunt and others entered counts but failed to indicate how much time they hunted. We deleted all such records prior to analysis. Beginning in 2014, we reprogrammed the app so that hunters could only report moose observations when the number of hours hunted per day had been entered.

Generally hunters found the moose app easy to use; we have had reports that it works well in remote areas where there is no cell phone coverage. When the hunter was within range of a cell phone tower or had access to WiFi, data were transmitted to our computer server. The most common complaint that we received was from hunters who wanted to participate but owned a Blackberry device (BlackBerry Limited, Waterloo, Ontario, Canada). Indeed, we have not programmed the app for the old Blackberry platform but the new BB10 Blackberry 10.2.1 and later devices are compatible with the Android app.

If the frequency of duplicate counts of individual moose was high, counts of moose observed might be biased high as an index of abundance. We might be able to assess whether

Table 1. Hunter participation and moose reported as observed by hunters with the Moose Survey App in Alberta, Canada, 2012–2014.

Year	2012	2013	2014
Hunters participating	221	645	695
Moose reported	1,836	3,532	3,580
Cumulative days of reports	1,477	1,700	4,920
Total hours of hunting reported	4,318	9,320	12,339
Hours hunting to observe a moose	2.50	2.64	3.45
WMUs[a] with moose app data	43%	80%	72%

[a] Wildlife Management Units.

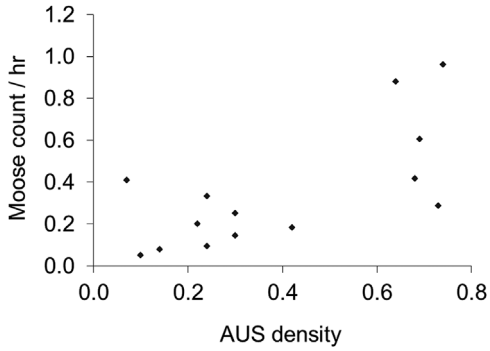

Figure 2. Total number of moose observed that were reported using the Moose Survey app per hour of hunting as a function of aerial ungulate survey (AUS) estimates of moose density in a Wildlife Management Unit for 2012–2014 in Alberta, Canada ($r = 0.69$, $n = 14$, $P < 0.01$).

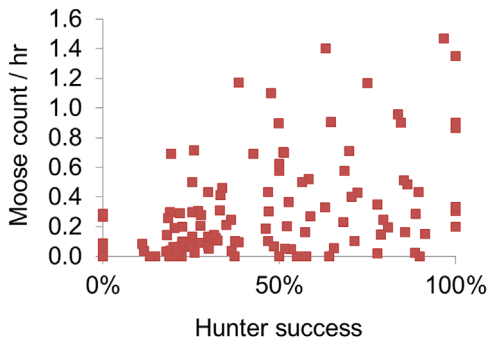

Figure 3. Number of moose observed by hunters per hour in the field as a function of % hunter success from the same Wildlife Management Unit in 2014 in Alberta, Canada ($r = 0.57$, $n = 111$, $P < 0.001$).

there were duplicate counts of moose if hunters were to record the locations of moose sightings during the hunt. We recorded Global Positioning System (GPS) locations from each smart phone in an initial version of the app, but we realized that monitoring GPS locations rapidly used battery power. Therefore, we removed this feature because it might discourage hunters from participating. Also, we requested hunters to report observations at the end of the day because recording locations of each sighting could interfere with the hunt, again potentially discouraging participation.

The level of participation in the Moose Survey app by hunters has been insufficient to warrant cessation of aerial surveys to estimate moose abundance and density. In Scandinavia, where hunter observations are used to index moose populations for management, participation in hunter surveys is mandatory and observations by most hunters are reported. In contrast, we have obtained a sample of $<5\%$ of Alberta hunters; thus, sampling error is large, especially for WMUs with few moose hunters. Participation can be expected to increase over time as a greater proportion of hunters acquire smart phones and more hunters are encouraged to participate. Incentives might be offered to encourage participation. For example, a point system exists in Alberta with additional points accumulating each year that a hunter applies but does not draw a license. Linking participation in the Moose Survey app to hunter preference points might be an effective incentive. We believe that it was important that the request for participation came from the managing agency endorsing the program. Affirming a connection that could contribute to wildlife management is recognized by most hunters to be in their best interests (Organ et al. 2010, Cooper et al. 2015).

Although the Moose Survey app offers promise as an index of relative abundance, the gold standard for estimating moose density remains aerial surveys (Lynch and Shumaker 1995, Peters et al. 2014). These surveys are expensive, averaging CAD$60,000/WMU (R. Anderson, Alberta Conservation Association, personal communication); because of the cost, WMUs are scheduled for an aerial survey only once every $\geq$10 years, on average. Although aerial surveys can yield reliable estimates of moose population density, the sampling frequency in Alberta has been inadequate for moose management (Boyce et al. 2012). In fact, this was motivation for the development of our moose app. The best validation of the app is the correlation between population density estimated by aerial survey and number of moose reported per hour of hunting (e.g., Belt and Krausman 2012). Unfortunately, our sample size of aerial surveys was low (6 WMUs in both 2014–2015 and 2013–2014, and 7 in 2012–2013); thus, we further evaluated the method based on the distribution of hunter harvest, reinforcing our assessment that the app is working to yield an index of moose abundance.

High cost of aerial ungulate surveys often results in few data with which to set harvest quotas. We found that hunter observations of the number of moose seen while hunting and reported by smartphone app was correlated with aerial surveys, hunter success, and hunter harvest by WMU, indicating that hunter observations could be used as an index of relative abundance. Aerial surveys remain the best method for estimating population density, but hunter observations can supplement the spatial and temporal extent of monitoring at low cost.

ACKNOWLEDGMENTS

T. Zimmerling suggested the idea of an app for monitoring moose hunters. We thank L. LeClair, K. Garbrah, and especially D. Chui for assistance with programming the app and making arrangements with the Apple App Store. J. Allen and R. Bjorge from Alberta Environment and Parks provided administrative support for the project and requested participation from hunters. We received support from the Department of Biological Sciences at the University of Alberta and the Alberta Conservation Association. Thanks to R. Harris, N. Koper, and 2 anonymous reviewers for comments on the manuscript.

LITERATURE CITED

Belt, J. J., and P. R. Krausman. 2012. Evaluating population estimates of mountain goats based on citizen science. Wildlife Society Bulletin 36:264–276.

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

Cooper, C., L. Larson, A. Dayer, R. Stedman, and D. Decker. 2015. Are wildlife recreationists conservationists? Linking hunting, birdwatching, and pro-environmental behavior. Journal of Wildlife Management 79:446–457.

Ericsson, G., and K. Wallin. 1999. Hunter observations as an index of moose *Alces alces* population parameters. Wildlife Biology 5:177–185.

Imperio, S., M. Ferrante, A. Grignetti, G. Santini, and S. Focardi. 2010. Investigating population dynamics in ungulates: do hunting statistics make up a good index of population abundance? Wildlife Biology 16:205–214.

Johnston, A., D. Fink, M. D. Reynolds, W. M. Hochachka, B. L. Sullivan, N. E. Bruns, E. Hallstein, M. S. Merrifield, S. Matsumoto, and S. Kelling. 2015. Abundance models improve spatial and temporal prioritization of conservation resources. Ecological Applications 25:1749–1756.

Lynch, G. M., and G. E. Shumaker. 1995. GPS and GIS assisted moose surveys. Alces 31:145–151.

McDonald-Madden, E., P. W. J. Baxter, R. A. Fuller, T. G. Martin, E. T. Game, J. Montambault, and H. P. Possingham. 2010. Monitoring does not always count. Trends in Ecology and Evolution 25:547–550.

Organ, J. F., S. P. Mahoney, and V. Geist. 2010. Born in the hands of hunters: The North American Model of Wildlife Conservation. The Wildlife Professional 4(3):22–27.

Paul, K., M. S. Quinn, M. P. Huijser, J. Graham, and L. Broberg. 2014. An evaluation of a citizen science data collection program for recording wildlife observations along a highway. Journal of Environmental Management 139:180–187.

Peters, W., M. Hebblewhite, K. G. Smith, S. M. Webb, N. Webb, M. Russell, C. Stambaugh, and R. B. Anderson. 2014. Contrasting aerial moose population estimation methods and evaluating sightability in west-central Alberta, Canada. Wildlife Society Bulletin 38:639–649.

Schmidt, J. I., K. A. Kellie, and F. S. Chapin III. 2015. Detecting, estimating, and correcting for biases in harvest data. Journal of Wildlife Management 79:1152–1162.

Smith, A. 2013. Smartphone ownership 2013. Pew Research Center, Washington, D.C., USA.

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

Associate Editor: Koper.