Jasper National Park
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Feasibility of Volunteer Scat Collection as the Basis for Population Estimates of Black Bears and Grizzly Bears in Jasper National Park

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Abstract

Volunteers were used to collect black bear and grizzly bear scat in Jasper National Park (JNP) in 2015. The goal was to use DNA from scat as individual markers in spatially explicit capture-mark-recapture population estimates. Volunteer recruitment was good, volunteers were enthusiastic workers, and JNP received a lot of good publicity about bear ecology and citizen engagement. Unfortunately, we did not collect enough samples to produce population estimates. It is likely that the JNP situation does not lend itself to using scat DNA as a viable technique for population estimation – too few bears, too few volunteers, and a trail network that does not cover enough of the landscape. Opportunistically collected scat could however contribute as auxiliary data to a hair snag population estimate, or could be used for other purposes – e.g. genetic variability studies, relatedness to other populations, or identification of problem bears.

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Introduction

Obtaining precise population estimates of large mammals is fundamental for effective management of ecological integrity. However, gathering data for these estimates are usually quite expensive. For example, Jasper National Park (JNP) collaborated with fRI research (fRI) to estimate population size for grizzly bears in the south half of the park in 2014 using DNA from non-invasively collected hair (Stenhouse et al. 2015). The total cost of this project was $143,000 (Stenhouse G., pers comm). A black bear population estimate was produced post hoc using hair gathered during the grizzly bear study (Boulanger et al. 2016), costing another $8,000.

Another issue with scientific estimates is that the public may treat the resulting conclusions with mistrust, perhaps due to unfamiliarity with the field techniques and statistical analyses used. One idea to simultaneously lower costs and gain public trust has been to employ volunteers to gather data. Volunteers (by definition) work for free, and the hope is that by working on a project they will learn to trust the results and communicate that trust to others. Volunteer projects, also known as ‘citizen science’, do not produce usable data in all instances, so evaluation of the proposed project is advisable (Cohn 2008, Dickinson et al. 2010, Bonney et al. 2014).

After successfully completing the 2014 JNP grizzly bear (Stenhouse et al. 2015) and black bear population estimates (Boulanger et al. 2016), we decided to conduct a volunteer based collection of black bear scat in 2015 to assess citizen science as a way to produce low cost population estimates. The use of scat as a source of DNA is becoming a standard technique for population estimates (Lukacs and Burnham 2005, Luikart et al. 2010) and requires less in the way of setup costs and equipment for field work compared to hair snagging. As well, the spatially explicit estimation techniques (Efford 2011) employed for the JNP bear population estimates (Stenhouse et al. 2015, Boulanger et al. 2016) reduce costs by increasing the precision of estimates (i.e. smaller sample size and therefore lower expense to achieve the desired precision).

The JNP bear scat collection project was a collaboration with fRI. fRI also conducted a volunteer based scat collection project in 2015 (Sorensen et al. 2017). fRI recruited hunters to be volunteers on the provincial land base adjacent to JNP.

One objective of the program was to determine the feasibility of a volunteer program with little oversight and a small budget. We obtained the necessary funding for genotyping, but there were no dedicated staff to organize the volunteers, collect data or perform the necessary GIS and analytical work – these tasks were performed by staff with existing positions as time allowed.

Study Area & Methods

Study Area

We established our study area to be a subset of the area used by (Stenhouse et al. 2015). We reasoned that it would be impractical to expect volunteers to cover the same area that was used by paid field workers (also, the 2014 study involved some helicopter support). Because JNP managers are interested in bears that interact with people, we felt that the smaller study area would include mostly those bears that interact with people and would thus provide useful information.

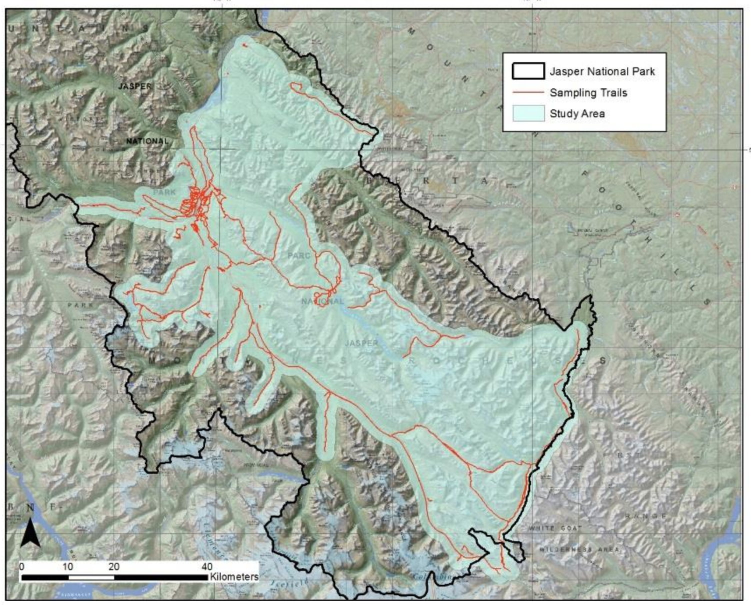

Figure 1. Study area, including trails that we expected to sample.

There are two approaches for spatially explicit population estimates – create a sampling grid with a sampling location within each grid cell (as was done for the JNP hair-based population estimates, (Stenhouse et al. 2015)) or sample along transects through a study area (Efford et al. 2009, Efford 2011, Efford and Fewster 2013). Because we wanted volunteers to sample scat as they hiked trails, we designed our study area for the transect approach (Figure 1). The study area was 4,682 km^2. There were approximately 1,332 km of trail available for sampling.

Field Methods

We used data collection kits supplied by fRI, consisting of sample vials with desiccant (Figure 2), short sticks (Popsicle sticks), and rubber gloves. The method consisted of volunteers hiking or biking trails and searching for bear scat while they were otherwise enjoying JNP. When a scat was encountered, they would use one of the Popsicle sticks to separate a thumbnail sized piece of scat and deposit the sample in the vial. Date, time, location (UTM or description) and volunteer name were recorded on the vial. Afterwards, volunteers could drop the samples off at the Interpretive Centre, or at the Resource Conservation Compound in the Jasper Townsite.

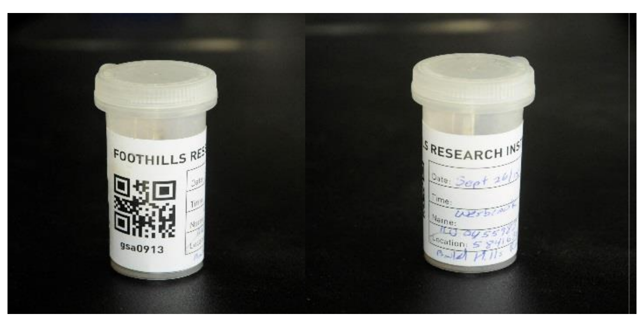

Figure 2. Sample vials used by volunteers.

To record volunteer effort, we used three different methods, depending on the volunteer's willingness to use cell phone or GPS technology. First, for volunteers who had smart phones (Iphone or Android), we asked them to use the fRI Scat App. The Scat App was developed by fRI – it was adapted from an app already used by transportation companies to track shipments. The app used the phone's GPS to record the route hiked by the volunteer. When a scat was sampled, the volunteer would hit a virtual button on the phone to record the location (UTM coordinates), and then scan the QR-Code on the vial label to pair the sample with the digital data (Figure 3). The volunteer would also take a photo of the scat. The app would record the location, gps track of the hike, and digital photo, and upload all to the fRI website. We would then download the data for incorporation into a JNP database.

The second method was for volunteers without smartphones – we gave these people small GPS units (IGotU brand, also supplied by fRI) that recorded their route and sample locations. Data would be uploaded to the JNP database after the GPS units were returned to us.

The third method was for volunteers that were unwilling to use either smartphones or GPS – we asked these volunteers to keep accurate notes on trails that they completed (effort) and sample locations. We would then manually create GIS files for these data.

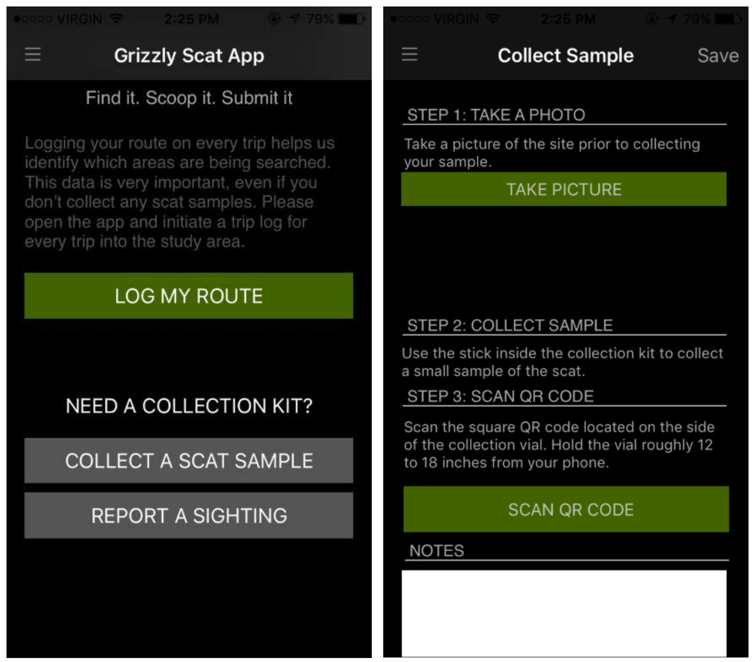

Figure 3. Screen shots of the fRI scat app.

We did not direct volunteer effort towards any particular places or trails. We wanted to maximize the number of volunteers and felt that directing people towards unpopular destinations would jeopardize participation rate.

We also asked staff to volunteer to collect scat while performing other duties (but only if it did not interfere with their normal duties), or while on non-work time. We considered most of these samples to be collected incidentally (i.e. without any recording of effort), so would not contribute to a population estimate (but could be used for other purposes).

We used data collected by both hikers and bikers. We also instructed staff to sample scat along roads and highways if time permitted.

Genotyping

Adapted from (Sorensen et al. 2017):

> Scat samples were sent to the Norwegian Institute of Bioeconomy Research (NIBIO) in Svanhovd, Norway for genotyping. Each DNA extract was first screened for species-diagnostic amplification with one microsatellite marker (G10P) to separate grizzly bear and black bear samples (Paetkau and Strobeck 1994). After this, nuclear DNA profiles to reveal individual identity and gender were established using nine Short Tandem Repeats (STR) microsatellite markers (G10B, GIOH, G10J, G10L, G10M, G1A, G1D, G10P and MU50) developed for bears ((Paetkau and Strobeck 1994, Paetkau et al. 1995, Taberlet et al. 1997) and one sex-specific marker (Bellemain and Taberlet 2004). A detailed description of the protocols for molecular analysis of scat samples from European brown bears *(Ursus arctos arctos)* for individual identification can be found in (Kindberg et al. 2011) and (Andreassen et al. 2012).

Volunteer Recruitment

Kevin Gedling, volunteer coordinator for JNP, used his contacts and skills to publicize the scat collection program. The program was named “Scat Seekers” in the advertising materials. The JNP website and JNP Facebook page contained descriptions of the program and how to get involved. Notices were posted around the Jasper townsite and with partners (e.g. Mountain Equipment Co-op, Camper’s Village in Edmonton). Word-of-mouth and relationships within the Jasper community were also important recruiting tools.

The scat project was also mentioned in passing by a Parks Canada spokesperson during a media interview for another story. News of the scat project was then picked up and publicized in both traditional and social media, greatly increasing the reach of our publicity efforts.

Volunteer training was conducted by Kevin Gedling, and included instruction on proper sample collection techniques, as well as conducting field work safely in bear habitat. Five Scat Seeker training sessions were held. Distance training was conducted for a group of staff working for the Canadian Forest Service in Edmonton and a bilingual distance version of the training deck was developed.

Results

Scat App and GPS Performance

The initial goal was that the Scat App would provide geographically accurate sampling transects that could be incorporated into a GIS system for quantification of effort, for use in a spatially explicit mark-recapture population estimate. In reality, route recording was inconsistent, due to user error and inadequate GPS performance of the phones. There were also issues with the app itself not working consistently on the Android operating system, and not always recording routes or transmitting routes to the website. Often, we would receive routes with only one or two points over several kilometres. In the end, we had to manually recreate a high proportion of routes based on route data from the website, plus information gathered by communicating with the volunteer. These tasks were considerably more onerous than we had anticipated.

The Scat App was ideal however for recording the individual sample locations with associated photos.

The IGotU GPS units worked well. Routes were generally recorded accurately, as were locations. Considerable time was required to clean data and input into our GIS system however.

Volunteer Participation

31 members of the public volunteered to collect bear scat for the program. 23 staff (4 fRI, and 19 JNP staff) also volunteered.

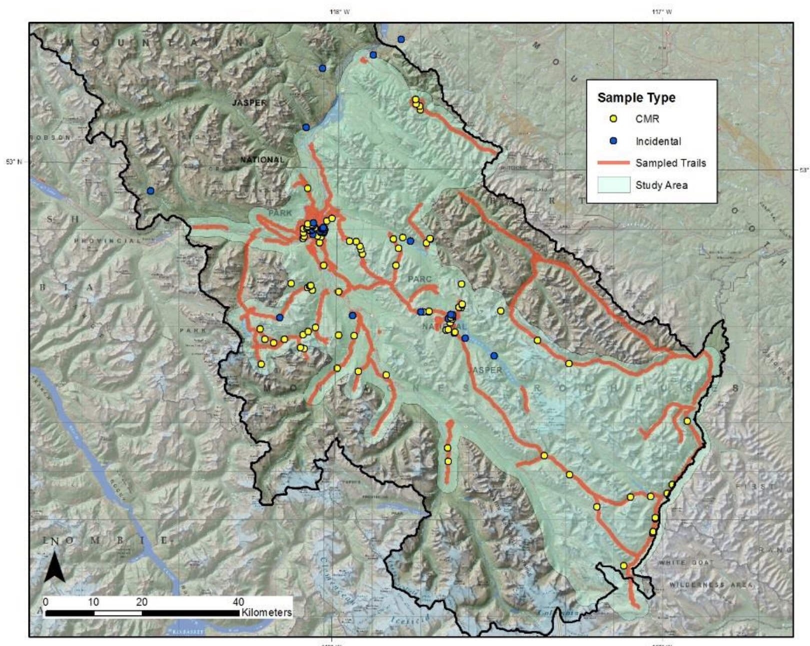

Figure 4. Location of samples collected, and trails hiked.

The 31 public volunteers walked approximately 511 km of trail, and collected 75 samples (Figure 4). Many of the popular trails were hiked several times, while most trails were hiked once or not at all.

The 23 staff volunteers walked approximately 338 km of trail, and collected 59 samples. Many of the staff samples were collected opportunistically, with no effort recorded.

Of the 31 public volunteers, just over half collected no samples (Figure 5). Five of the 31 volunteers collected 70% of the samples.

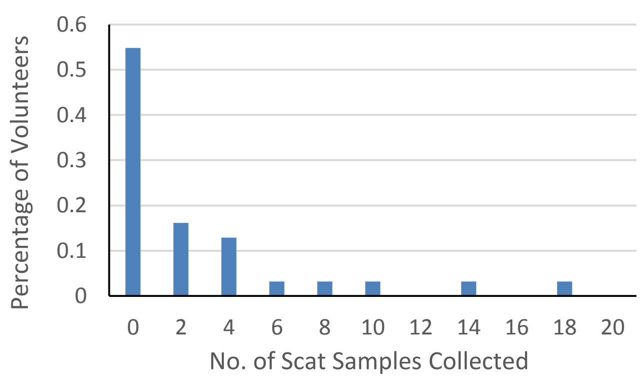

Figure 5. Number of scat samples collected per volunteer.

Volunteer Task Performance

The goal was to accurately record sampling effort, in addition to obtaining an adequate number of bear identifications for calculating a population estimate and eventually a survival rate (if the program was conducted for more than one year). It soon became apparent however that in addition to the app not performing as hoped (see above), the app was not being used properly by the volunteers. Monitoring of the routes and locations as they came in revealed that a lot of people were turning off the app after obtaining a sample and not recording the remainder of their hike. We reminded the volunteers of the problem, but this issue was never fully resolved. The combination of poor app performance, combined with improper route recording by the volunteers resulted in poor quantification of effort.

Rate of Sample Collection

As noted above, we couldn't adequately record effort, but we used the information we did have to roughly estimate number of kilometres hiked, to compare against the number of samples collected. The most common hike length for volunteers was 5km or less, and most hikes (almost 90%) were 15km or less (Figure 6). On average, volunteers hiked 8km between scat samples. This metric only counts distance hiked where sampling was possible – if the hike was an out and back on the same trail, it was only counted once.

Rate of sample collection for staff volunteers was similar – 10.2 km between scat samples.

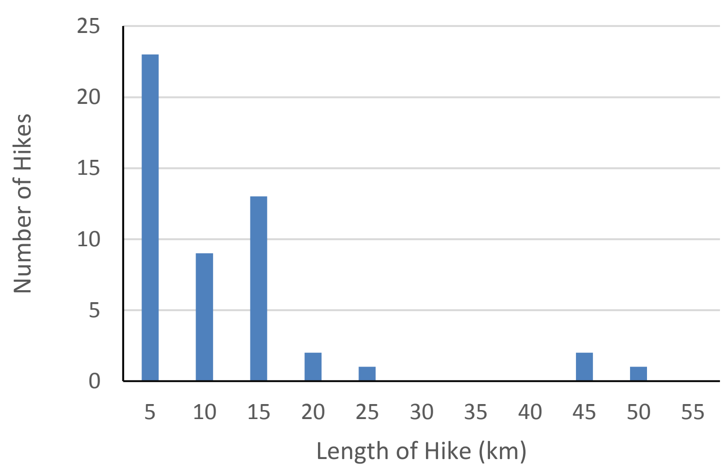

Figure 6. Histogram of hike lengths by volunteers.

Genotyping

Of the 134 samples sent out for genotyping, 53 yielded no information of any kind – the sample was likely too old and the DNA degraded. Eighty one samples yielded species identification (37 black bears, 44 grizzly bears). 62 samples yielded gender determination (31 males, 31 females) and 58 samples could be identified to individual. Success rate of genotyping to individual was therefore 58/134 or 43%.

Of the 26 successful black bear genotypes, 13 were unique individuals. Five bears were captured 2 or more times, while 8 bears were captured once (Figure 7).

Of the 32 successful grizzly bear genotypes, 17 were unique individuals. Five bears were captured 2 or more times, while 12 bears were captured once (Figure 7).

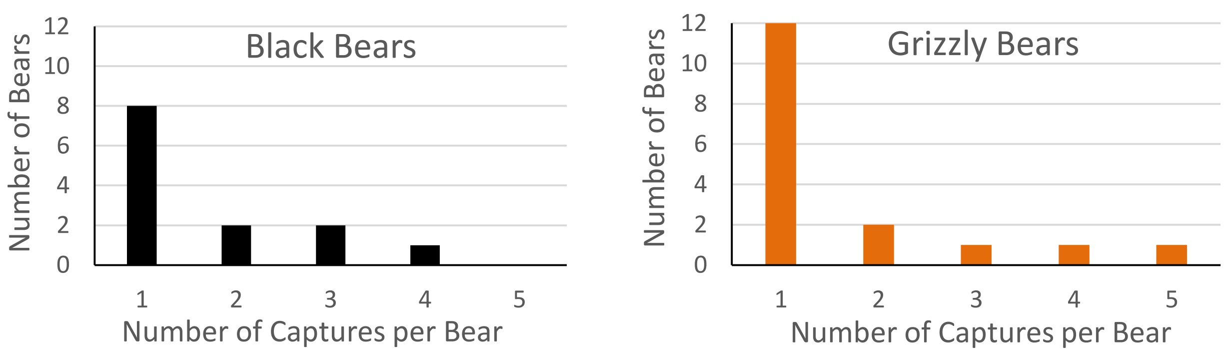

Figure 7. Number of captures per individual for black bears (left) and grizzly bears (right).

Only 3 black bears were identified 3 or more times, so only 3 minimum convex polygons (MCP) could be calculated (Figure 8). The largest MCP was 104 km^2. Even the largest MCP is an underestimate of an actual black bear MCP. Two other bears were identified twice.

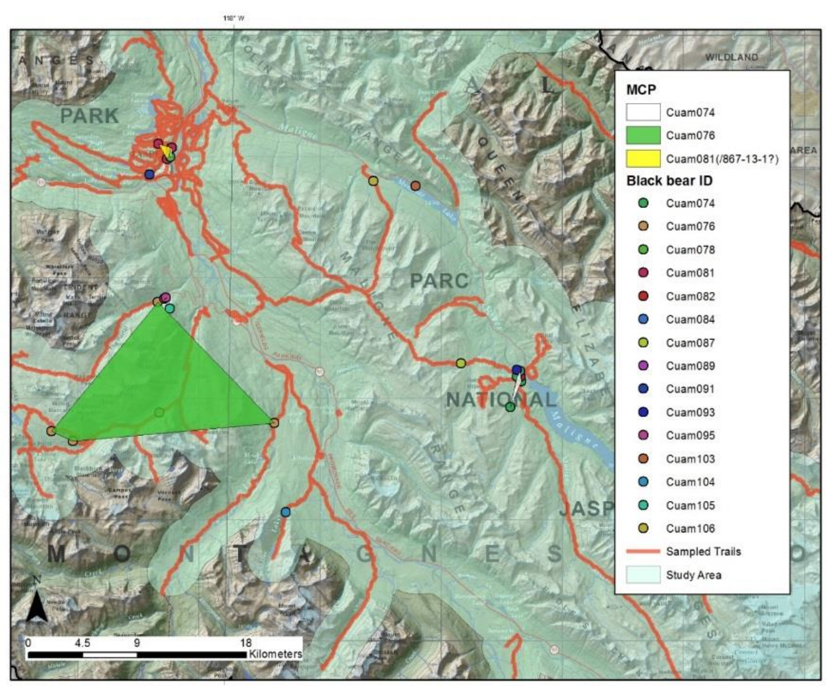

Figure 8. Individual locations, with minimum convex polygons (MCP) for black bears with three or more locations.

Only 3 grizzly bears were identified 3 or more times, so only 3 MCPs could be determined (Figure 9). The largest MCP was 27 km^2, an underestimate of an actual grizzly bear MCP. Two other bears were identified twice.

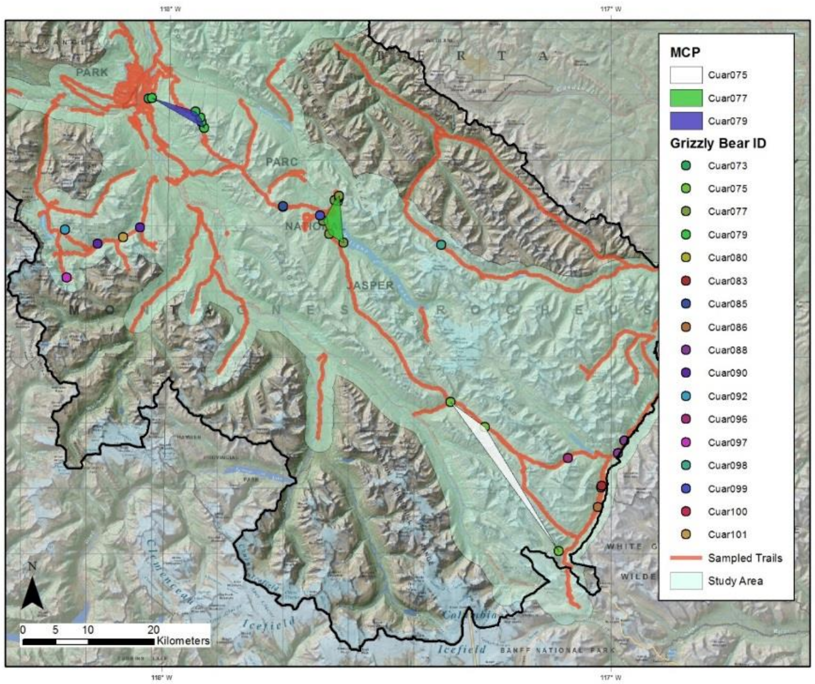

Figure 9. Individual locations and minimum convex polygons (MCP) for grizzly bears with three or more locations..

The SECR technique uses multiple captures of the same individuals to calculate home ranges (MCR is a type of home range) – the home range centres are used to estimate density. To calculate a valid population estimate, you should have at least 10 instances of multiple captures of the same individuals, but it is better to have 20 (Efford et al. 2004). In our study, only 5 bears (of each species, both sexes) were caught more than once, so viable population estimates could not be calculated.

Sampling per Month

We concentrated on August and September as our sampling months, so not it's not surprising that that's when almost all of our samples were collected (Figure 10). More black bear samples were collected in August, while more grizzly bear samples were collected in September (Figure 10).

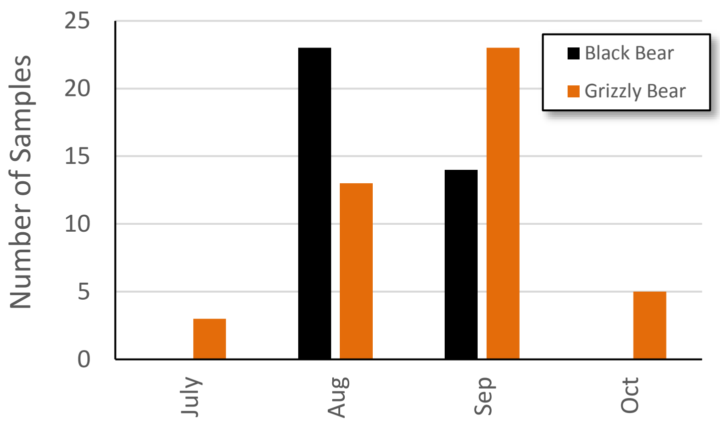

Figure 10. Collection date of samples, by species.

Cost Comparison: Hair vs. Scat Collections

We had a budget of $15,000 for this project. The genotyping contract for this project was for $14,000, or just over $100 per sample. The remaining $1,000 was spent on communications efforts. We had no staff dedicated to this project, but the wildlife biologist spent approximately 200 hours on study design, database design, GIS work and report writing. The volunteer coordinator likewise spent about 120 hours of his time on advertising the project and coordinating the volunteers. This amounts to about $10,000 in staff time. In total, the project cost about $25,000. Costs not included include Scat App development, sampling vials (donated by fRI), and GPS units (also donated by fRI).

The 2014 JNP DNA hair based population estimate for grizzly bears (Boulanger et al. 2016) cost about $140,000, plus another $8,000 for the black bear population estimate (based on black bear hair collected during the grizzly bear study(Boulanger et al. 2016)). If we estimate fRI and JNP staff costs for both of the 2014 studies, then the total cost for both bear species was approximately $170,000.

Since the current scat project did not result in a usable population estimate, it may be helpful to estimate the cost of a scat collection project that would have a better chance of being successful. For a theoretical enhanced scat project we propose that field staff would be hired to augment the sampling efforts of the volunteers, a GIS technician would devote 2 months of time to data cleaning and input into a database. A volunteer coordinator would devote 4 months of time (to increase the number of volunteers). GPS units and miscellaneous equipment would have to be purchased. Vehicles would have to be rented. The field season would be increased to 4 months instead of the current 2. We estimate the cost for an enhanced scat collection project to be about $158,750 (Table 1).

Table 1. Estimated costs for enhanced scat collection project.

Item	Description	Cost
Field Staff	4 for 16 weeks	$55,000
GIS Tech	8 weeks	$12,000
Volunteer coordinate/PR	16 weeks	$24,000
Project Lead	16 weeks	$26,000
Trucks	2 trucks for 16 weeks	$10,000
Public Engagement	Travel and promotion	$4,000
Field Equipment		$2,000
GPS	IGotU for Volunteers	$5,000
Sampling equipment, supplies	Sample Vials, bags, sticks	$2,000
Genotyping	250 samples	$18,750
	Total	**$158,750**

Discussion

Volunteers and Citizen Science

We recruited many enthusiastic people as volunteers for our project (55 people, including fRI and JNP staff). We gained a lot of publicity when an inadvertent comment by a JNP spokesperson was picked up by both traditional and social media. We feel that the project was a success in terms of promoting awareness of bear ecology and field techniques. Because we did not end up collecting enough samples to calculate a population estimate however, it is clear that to a completely successful project would require a lot more volunteers.

A small number of volunteers accounted for a large number of samples – 3 of our volunteers collected over half of the samples (not counting those collected by staff). These 'super' volunteers put in a lot of hours hiking. They didn't just hike for us – we were told this was their normal routine.

We had decided at the outset to not direct volunteers to specific trails or times, in an effort to maximize participation – and we feel that high participation was achieved. The high number of volunteers however came at the cost of efficient sampling of the study area. Much of the effort was spent on popular trails close to town, and many of our samples came from these trails. Another problem with volunteer workers is that they did not always operate the equipment (Scat App or GPS units) properly, or properly record effort. For all these reasons, it soon became apparent that we were not going to get a proper estimate of sampling effort, and thus calculating a valid population estimate would not be possible. A more viable strategy for using volunteers may be to put more effort into finding volunteers that would accept more instruction and supervision, and had the available free time to do field work at appropriate intervals, rather than when it was convenient for them. Volunteers would likely have to be paired with staff to be effective.

We had hoped to get samples from volunteers biking, and incidental samples from staff driving, but neither strategy worked. We think that the searching efficiency is likely lower when in a fast moving vehicle. Also, personal incentive to stop and collect scat is probably lower for a biker or driver.

Genotyping Success, Sampling Rate and Seasonality

About 43% of JNP samples submitted to the lab resulted in identification to individual. This actually compares favourably to the approximately 20% success rate for the concurrent project that was run in adjacent Alberta (Sorensen et al. 2017) or for European brown bears in Italy (De Barba et al. 2010) but is considerably less than the approximately 70% success rate reported by Swedish brown bear studies (Kindberg et al. 2011). Reasons for the discrepancy in success rates are unclear, but differences in bear diet have been linked to genotyping success (Murphy et al. 2003). Also, genotyping success is likely to be affected by the interaction of scat deposition rate and sampling rate – i.e. how often scat is deposited, and how often it is picked up. DNA has been shown to degrade with time due to temperature, humidity and UV exposure (Murphy et al. 2007, Stenglein et al. 2010, Lonsinger et al. 2015). Seasonal variation in genotyping success has also been reported for other species (Piggott 2005, Vynne et al. 2012).

Seasonal differences in success rates are why we timed our sampling for the last half of the summer (i.e. closer to fall). By doing so however, we eliminated May through July, a period where the co-occurrence of bears and people on the trails of JNP is probably maximal. In spring, bears forage in the valley bottoms for new vegetation and ungulate calves. After ungulate calves are mobile and vegetation green-up rises in elevation, the bears generally forage at higher elevations (unpublished JNP data). So our late summer sampling strategy likely increased the time between deposition and sampling, and may have contributed to our suboptimal sampling and genotyping.

So, in JNP we are faced with a difficult choice: collect samples in spring when genotyping success is low but sample collection is efficient, or collect samples in fall, when genotyping success is usually high, but sample collection is inefficient. It could be that a scat collecting project in JNP will not be practical until genotyping success of spring or summer bear scats improves.

Sweden obtains valid population estimates from volunteer surveys conducted by moose hunters recruited to collect bear scat (Bellemain et al. 2005). Their volunteers are able to provide approximately 6,000 scat samples per year, compared to our 134 samples. One reason for their success is a high number of volunteers – they typically recruit between 70 and 80% of an available 30,000 hunters. A second reason is a higher density of grizzly bears – about 30 grizzly bears per thousand km^2 (Kindberg et al. 2011), as opposed to 13 grizzly bears per thousand km^2 in our study area (Boulanger et al. 2016) (Sweden however, does not have black bears, which occur at 30 bears per thousand km^2 in our study area (Boulanger et al. 2016)). Lastly, there is a dense, regularly spaced network of roads in Sweden (0.7 roads per km^2 with an unreported density of trails (Kindberg et al. 2011) which enables their volunteers to access a high proportion of the land base. JNP for comparison has about 0.28 km of trail/km^2 that are concentrated mostly in the valleys.

Recommendations

Sweden represents an ideal situation for scat collecting: high densities of both volunteers and bears interacting during the ideal season for genotyping, coupled with easy and regularly spaced access. JNP is unlikely to ever enjoy any of these advantages, so using volunteers to gather scat in JNP may never result in valid population estimates. Even if implemented, an enhanced program at over five times the cost of the 2015 project (Table 1) may not end up producing a valid population estimate – it's only an assumption that the extra effort of the enhanced project would actually yield enough samples. Also, despite the estimated cost of an enhanced project being almost the same as the hair snag cost, a hair snag project would probably still yield more samples, because the snagging stations include a lure (rotten blood) that attracts bears to sampling locations, and hair is a more reliable source of DNA (Sorensen et al. 2017). So there seems to be little point in persisting with a scat based population estimate project for the JNP situation. Scat may however prove to be useful when used in combination with other data sources – the combination of hair from snag stations and hair from rub trees has been shown to improve the precision of estimates, even though hair from rub trees is not sufficient on its own to provide an estimate (Boulanger et al. 2008).

The use of scat as a source of DNA was shown to be possible however (if not particularly efficient), so collecting scat may be a useful technique for purposes other than population estimation. We could for example use DNA from opportunistically gathered scat to augment studies of genetic variability, relatedness to other bear populations, or genetic lineages of problem bears.

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