SAR 2006-2007 Year-end Project Summary Report

Project Title: An Aerial Track Survey for Endangered Badgers in Southern Ontario

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Project Introduction & Objectives

To undertake late winter-early spring aerial surveys for sign (e.g., tracks, diggings, den excavations) of the American Badger (*Taxidea taxus jacksoni*) across the species' current known range in southwestern Ontario. The primary goals of this project were to develop and test the feasibility of aerial survey methods for identifying sites of badger activity, and to identify new records of American Badger occurrence where they exist for the purposes of population monitoring and recovery planning.

Project Description

Records of badger occurrence in southern Ontario are primarily obtained incidentally through reports from the general public (e.g., observations of roadkill or rural landowners discovering badger presence on their property) and field naturalists, as well as by MNR employees coming across sign while carrying out other field work activities. Due to the patchy and opportunistic nature of this type of information flow, a pilot study was initiated in winter 2006 to develop an aerial survey methodology that could be used to more efficiently and comprehensively locate and map areas of American Badger activity in southwestern Ontario. Resource constraints and the difficulties associated with private-land (which comprises the majority of badger habitat in Ontario) access preclude the application of comprehensive ground-level surveys for this species. In 2006, one survey flight over parts of Brant and Norfolk Counties was undertaken in a small-fixed wing aircraft. In 2007, two aerial surveys were conducted over parts of Norfolk County – one in late winter conditions using a helicopter, and one in early spring conditions using a small fixed-wing plane. By employing two different survey methodologies we were able to compare the relative advantages and disadvantages of each.

Based on similar surveys carried out by badger researchers in British Columbia (Weir and Packham, pers. comm.), the expectation in this project was that observers would be able to locate the presence of badgers by detecting tracks, setts or diggings, if not actual individuals. Surveys were planned to occur in either late winter conditions, when there was still sufficient snow cover for the detection of tracks but mild enough temperatures to encourage badger movement (as badgers have reduced activity levels in the coldest part of winter), or in early spring conditions after snow melt and ground thaw but prior to leaf-out (for enhanced visibility to the ground) and farmland cultivation.

Study Area

The 2007 surveys were restricted to an approximately 800 km^2 area of Norfolk County, and focussed on those areas known from recent or historic records to support the highest density of badgers as well as areas of seemingly suitable habitat. The surveys generally covered the area just north of Tilsonburg east to about the County border, south to the town of Simcoe and southwest to Walsingham, as well as in the vicinity of Long Point.

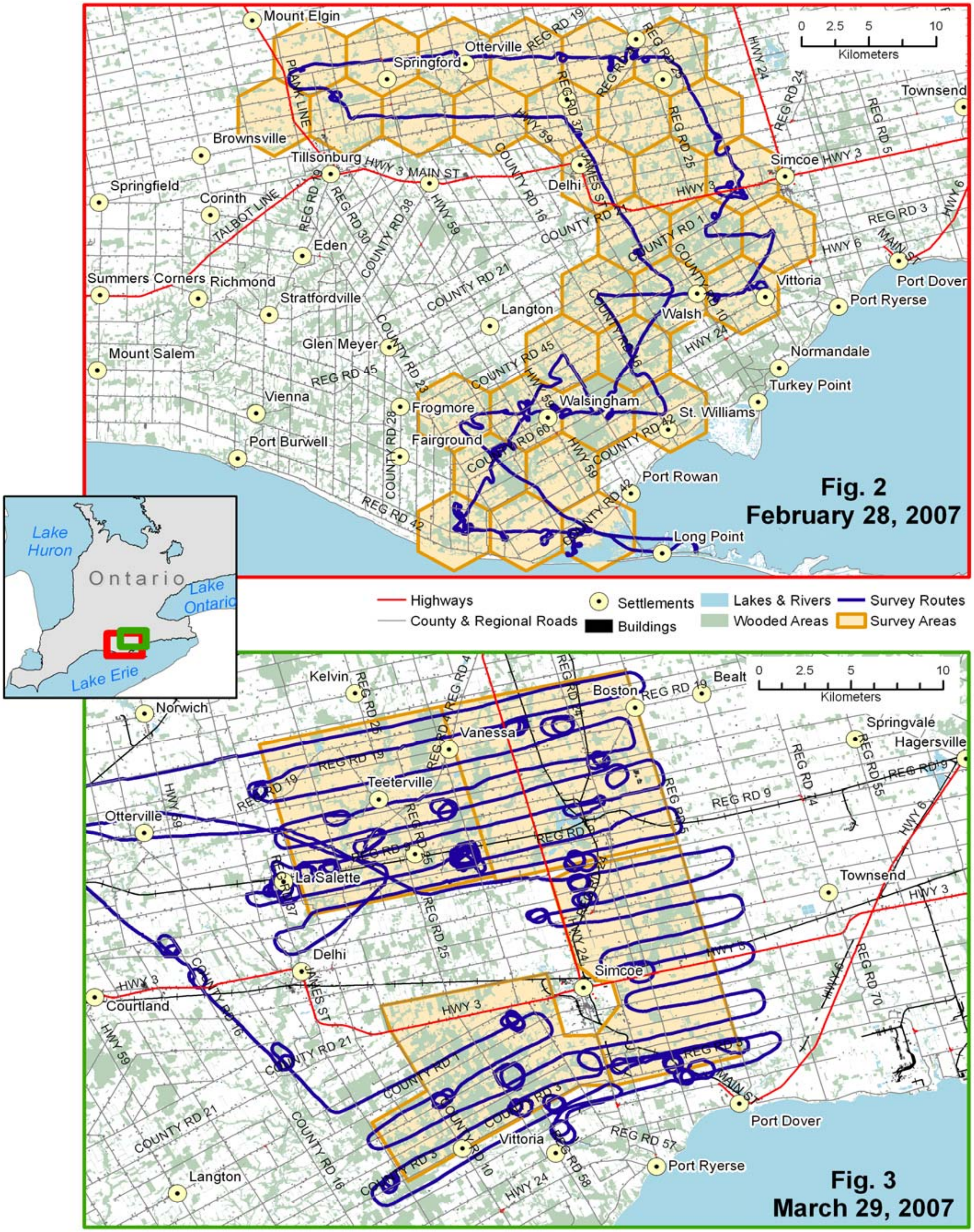
The general landscape surveyed was rural in nature (Fig. 1), with patches of relatively intensive row crop agriculture (primarily soybean, corn, rye, wheat, tobacco) on sand plains, occasional farmsteads and small communities, along with scattered woodlands and woody corridors along streams and hedgerows. Natural areas represent approximately 15% of the landscape and consist of remnant and/or restored native Carolinian forest-types, 2nd-growth managed woodlots, pine plantations, small patches of remnant and/or restored native tallgrass prairie, and various types of wetlands. The area also contains some orchards (primarily apple) and a few livestock farms. The core survey area was close to the shore of Lake Erie, and although it represents the best known habitat area for badgers in Ontario, it is heavily fragmented by human development. The extensive road network and traffic volumes in the area represent one of the major known causes of badger mortality.

Figure 1. Example of habitat of survey area, Norfolk County, February 2007

Methods and Survey Design

The 2006 pilot survey was conducted on April 6 in clear conditions, after snow-melt and before leaf-out, using a Cessna Skyhawk 172 – a single-engine fixed-wing plane that seats up to 3 people plus pilot. This aircraft was chosen based on its relative low cost ($195/hr), MNR safety approval and proven success for conducting low-level resource inventory work. Three and one-half 10x10 km blocks in areas of Norfolk County with the highest historical density of badger records were surveyed in 4 hours of flying, following fight transects spaced approximately 1 mile apart, enabling complete coverage of the landscape in that 350 km^2 area at an altitude of 500-1000 feet above-ground level and at air speeds of 60-70 knots. Three observers were on board the flight, permitting survey coverage out each side of the aircraft in addition to undertaking navigation, note-taking, and geo-referencing tasks. Flight routes were mapped out prior to the flight using Arcview and were plotted onto ortho-rectified aerial photos.

2007 Badger Surveys



The 2007 surveys tested out two different survey designs. The late winter survey, flown February 28 in mostly clear, >0°C conditions just after a light snowfall (with 10-25 cm of older snow accumulation still remaining on the ground), employed a hexagonal sampling design (Fig. 2) as used on the Boreal Wolverine Project's aerial track surveys in northern Ontario (Magoun et al. 2007). This survey was flown using a Bell Long-ranger helicopter (206L-1) cruising at a speed of about 40 knots and at an altitude of 250-300 feet above ground level. The 800 km^2 survey area was stratified into hexagonal sampling units 25 km^2 in size, based primarily on estimated average home range sizes for badgers in southern Ontario and reduced travel distances expected in late winter (Newhouse and Kinley 1999). A flight route was mapped using Arcview and Garmin Mapsource to pass through the centre of each chosen hexagon (entering from any of the six sides and exiting any other side), such that each sampling unit had a survey transect of approximately 5.4 km in length. However, rather than fly a direct line from centre to centre of each sampling unit, the aircraft could deviate short distances off the planned flight route to search for badger sign in areas judged by the crew to have a higher chance of finding sign (e.g., deciduous woodlots and woody edges, hedgerows, stream/creek valleys, ditch banks, etc.) so long as the original flight route was returned to. The planned flight route consisted of passing through 40 hexagons (31 unique sampling units, and 9 replicate sampling units flown through along a different flight path from the first pass) in the estimated 4 hours of survey time allotted. Hexagon choice was based on representing a variety of habitat types, but gave some preference to those plots with woody cover and/or previous badger records, within the limitations of an appropriate configuration (e.g., more clustered design = more robust analysis), survey time available, and a required re-fuelling stop. Flight cruising speed and altitude remained as consistent as possible throughout the flight. In some cases the pilot was required to fly a bit higher to avoid hazards and disturbance to communities or livestock, and in other cases the pilot dropped low to the ground to enable closer inspection of features of interest. Landing the aircraft was not possible due to the majority of sampling units comprising privately-owned lands that we did not have advance permission to access.

The early spring survey, flown March 29 in clear cool conditions after snow-melt and before leaf-out, was conducted using the block-grid survey design (Fig. 3) followed on our 2006 preliminary flight and was again flown using a Cessna Skyhawk 172. Average airspeed while surveying was about 70 knots, and altitude was maintained around 500 feet. Survey transects (flight lines) were laid out at a spacing of approximately 1 mile apart, resulting in 7-8 transects per block. The idea was to follow these transects systematically at the specified cruising height and speed (i.e., as low and slow as we were permitted to go), with observers looking out each side of the aircraft, and to circle back to investigate and mark observations of suspected badger activity at lower altitude. A map of each survey block containing the plotted transects, roads and ortho-rectified air photos was printed out for observers in the aircraft to assist with navigation and recording observations. Navigation and marking of observations, however, was primarily undertaken using GPS units. Block choice was based on representing a variety of habitat types, while giving some preference to those with woody cover and/or previous badger records, survey time available, and a required re-fuelling stop.

On all surveys, any observations of interest were noted and geo-referenced for further investigation on the ground, where possible and warranted.

Results

The surveys carried out under this project yielded no confirmed new badger records for southwestern Ontario. However, an abundance of sign from various wildlife species was observed and recorded, and follow-up ground-level investigations of many of these sites did provide some useful information on probable, as well as historic, badger activity.

In 2006 approximately 50 different sites of fossorial mammal activity (mostly diggings and holes) were observed, described and geo-referenced, but were not able to be positively identified to species from the air (due to height and speed of aircraft and perhaps inexperience of observers), although the characteristics of a few of the sites suggested they were created by a badger. Poor timing (i.e., farmers began working fields shortly after survey date, due to early spring), low landowner permission rates and low accuracy of geo-referencing prevented Aylmer District staff from being able to carry out an adequate post-survey ground-level investigation of the features of interest. However, one probable old badger foraging digging of a groundhog hole in a hedgerow between two large fields (with several other active groundhog dens nearby in the open fields) was located during follow-up visits. Generally, we felt from this initial flight that without ground-level confirmation (e.g., tracks, prey remains, hair, etc.) it is difficult to identify badger digging activity from the air using a fixed-wing plane, unless observers are able to ground-truth marked sites after the flight and gain a better understanding of how to positively identify known badger sign from the air, including how to distinguish it from activity signs of other similarly-sized or behaved species. We also found that detection of badger or any prey species sign in more closed, woody habitats from the air was difficult to impossible from altitudes $\geq$ 500 feet and speeds $\geq$ 50 knots.

In February 2007, on the late winter survey, again no definite Badger sign was found. Observers saw, investigated and marked numerous sites with other wildlife activity – such as Wild Turkey flocks, individual White-tailed Deer, Coyotes, a variety of animal tracks and some small, shallow diggings and scratchings – but found nothing suspected to be of Badger in origin (Table 1). Due in part to a timing constraint (4.5 hours of survey time was originally anticipated, but this was reduced to 3.5 as the helicopter encountered a weather delay on the morning of the scheduled survey on route from its base headquarters), only 34 of the 40 originally chosen sampling units were surveyed, 6 of these comprising replicates. In total, 298 km of ground was surveyed – 184 km of sampling unit transects plus an extra 114 km in deviations off the flight path into prospective areas thought to have more likelihood of yielding badger sign. Fig. 2 shows the flight track followed during the survey.

The subsequent early spring survey flown in March 2007 yielded more observations of potential interest. About 45 different sites with fossorial mammal activity were found and marked, with 17 of these flagged as having suspected badger association, in the 400 km of ground surveyed (Fig. 3) over 5.5 hours. District staff subsequently sought landowner permission to access as many of these sites as possible, and were able to visit 11 of the 17 sites for a more thorough ground-level investigation of the features of interest. This ground-truthing work revealed many of the open field sites to appear to be older canid (fox or coyote) diggings for small rodents, due to their linear trench-like shape as opposed to the deeper and broader excavations characteristic of badgers, but due to the age and weathered nature of most of these diggings it was difficult to be absolutely certain. Woodland edge and hedgerow diggings seemed to be a mix of active groundhog, coyote or fox dens. However, the ground visits did yield one site at the edge of a woodlot bordering a rye field with possible old badger activity and another site with probable, but again old/weathered, badger digging in a grassy patch in the middle of a corn field (Table 2). As well, through the new landowners contacts made, we obtained information on possible older sighting records in the area.

Discussion

It is difficult to say why no definitive badger sign was found during our aerial surveys. However, there are many possible explanations which may be broken down by the following factors:

<u>Badger Abundance</u>
Perhaps there are so few badgers present on the landscape now (the Ontario population estimate in 1999 was $\leq$ 200 individuals and there have been more records of badger mortalities than new live badger sightings since then) and at such low densities, that simply not enough ground was covered on our surveys to expect a high enough probability of detection. A longer, larger-scale survey might help to answer this question, but the costs associated with aerial survey methods are generally prohibitive.

<u>Location/Habitat</u>
It could be that the areas currently occupied by American Badgers in southern Ontario, or occupied in highest density, were not the areas targeted on our surveys. Many of the traditional “hot spots” of badger occurrence in Norfolk County were covered, but recent records have emerged from areas toward the edge of Norfolk County and into Brant and Oxford Counties that were not focused on during our flights due to time and budget limitations.

As well, based on reports in the literature and the findings of researchers in British Columbia, it was expected that badger activity at the time of year we surveyed would be found primarily in association with vegetated patches, riparian areas and other natural corridors. However, perhaps American Badgers in southern Ontario have different habitat preferences than badgers elsewhere (perhaps driven by prey availability), which could be suspected based on the number of badger records that seem to be closely associated with human activity – such as the den site found in 2006 under a residential workshop. Yet, while the February and March surveys did focus on habitats containing a high proportion of cover, many other habitat types – from open fields, to farmsteads, to residential areas – were flown over and explored as well. Based on the current uncertainty of badger habitat propensities in the study region, any future aerial surveys should include a representative sample of the wide diversity of habitat types that could support badger activity.

Timing/Weather

The results of our preliminary survey work have not yet clarified when the most fruitful time of year to survey for badger sign is. The date of the February 2007 survey was chosen to coincide with a time that represented "late winter" conditions in southern Ontario – i.e., when there was still widespread snow cover, but when temperatures had been mild for a long enough time period to expect increased badger activity levels over the preceding mid-winter period. Winter torpor has been demonstrated in badgers, but with a high degree of individual and inter-annual variation (Newhouse and Kinley 1999). Eurasian Badgers in central Poland (where the climate and habitat conditions are very similar to that of the American Badger's range in southern Ontario) were found to have significantly increased lengths of time spent outside their dens and significantly greater daily distances travelled in February-March over the preceding winter months, and this increase in activity was positively correlated with mean daily temperatures (Goszczynski et al. 2005). It was felt that surveying when there was still snow on the ground would allow for recent excavations (e.g., from diurnal resting burrows, foraging events, or preparation of natal dens) to be detected more easily, as the contrast of freshly dug soil against the snow would increase their visibility. Tracks would also be more detectible, which would allow for easier identification of species responsible for any observed diggings. The weather leading up to the February 28 survey had been relatively mild (daily highs were at or above the seasonal mean of about 0 degrees Celsius) for approximately 8 days. During this period there had been a couple light snowfalls, including patchy flurries and a light wet snowfall the day and night before the survey, but this resulted in minimal accumulation and did not obscure known tracks that were visible prior to the snowfall. Ideally, an aerial survey such as this would not take place less than 24 hours after a fresh snowfall with $\geq$ 2 cm accumulation. However, temperatures had been unseasonably low and there had been several significant snowfalls in the preceding month and a half. Perhaps it simply had not yet warmed up for long enough to encourage increased badger activity – and thus the laying down of fresh sign across the landscape – before the survey was undertaken. Little information seems to be known about how much (i.e., how long, or how warm) of a mild spell is required after a cold period before badgers increase their activity levels, or about other factors (such as prey activity) that influence their movements in late winter/early spring.

The early spring (late March-early April) surveys were likely ideal for finding areas of badger feeding activity that occur in open, cultivated fields, since the survey was conducted post-harvest, but pre-ploughing & planting. As such, sites had maximum visibility, and represented activity that may have occurred anywhere from late the previous fall to early in the spring, so a larger number of sites would theoretically be available to find. Once these fields are ploughed up and planted, most of the small diggings are destroyed or covered over. Thus it is critical for observers to get out on the ground to as many of the sites and as soon after the flight as possible to ground-truth. Obtaining landowner permission, however, often impedes this step. Surveying post-ploughing and during the early planting period would likely only reveal recent activity sites. As well, although observers did not find diggings, etc. in treed areas, it was still felt that it is better to survey pre-leaf-out, to maximize the chance of being able to observe sign in edge or cover habitat. Although surveying at this time of year eliminates the ability to detect diggings by the contrast of freshly dug earth against snow, the substrate is almost exclusively sand in the study area (the Norfolk Sand Plain represents area with greatest number of badger records), so diggings result in excavated piles of reddish-beige sand which contrasts well against typical ground covers of the area. Diggings can also be aged by the colour of the excavated sand such that older sand that has been exposed for a longer time period is lighter in colour, due to sun-bleaching and drying effects. We did not feel that weather played a significant role in influencing our observations on the spring 2007 flight as temperatures had been close to seasonal in the month leading up to the survey.

Generally, it seems there may be a short window of visible badger activity between their more sedentary winter habits and the start of agricultural tillage in the spring. Although many road-kills and other sightings occur very early in the season (March-May, indicative of hungry badgers on the move) the well-drained nature of dunes and other sand plain soils also means that spring cultivation can and does occur earlier compared to other areas in the region. As a result, it will always be somewhat of a race to undertake spring surveys over more open agricultural lands where spotting burrows and digging activity is easier.

Detectability

In planning our surveys we consulted with badger researchers in B.C. who have successfully carried out aerial inventories for badger sign. Based on photos we viewed of the badger diggings they observed, we expected that we would have no difficulty spotting and identifying badger excavations if they were present in our survey areas, yet we found nothing as distinctly badger-created as they did. It is possible that the detectability of badger sign was not as high as expected in southwestern Ontario, due to habitat/terrain differences, different badger densities, or characteristics of the aircraft we used.

All observations made from the Cessna surveys comprised sign left in open fields, or at the edge of fields, adjacent to hedgerows or forest patches. The relatively fast speed and cruising altitude of the fixed-wing aircraft prevented observers from being able to scan vegetated habitats as broadly & effectively as the open areas, thus limiting the search area and reducing the likelihood of actually spotting an activity site. As well, despite the absence of leaves, the tree cover was thick enough in places, particularly on some of the sand dunes where conifers were present, to obscure clear sight lines to the ground. It was felt that the signs we did observe were most likely one-time feeding excavations (particularly for small rodents such as mice and voles) in the middle of fields, and thus represented areas of possible short-term badger use, but not longer-term burrow sites which may have repeated use. It is thought that diurnal resting burrows and natal dens of the American Badger are more likely to occur in areas of cover, such as within hedgerows and woodlots, or along stream/creek banks, where there is much less disturbance from farming operations and other human activity.

Using the slower and lower-flying helicopter, despite increased visibility in areas of cover over the fixed-wing flights, most tracks and diggings were still observed in open areas (e.g. within open fields). Some tracks were observed at the edges of fields, adjacent to hedgerows or forested patches, or within but near the edge of wooded areas, and some individual animals (eg., turkeys, deer, coyotes) were observed within woodlot interiors, but for the most part very little sign was found in areas of cover. Although observers felt they had good visibility to the ground in these areas, it not clear whether the lack of observed sign was a direct reflection of a lack of (or comparably less) sign in these habitats, or a result of relatively poor detectability in these habitats. Yet, studies of the Eurasian Badger have shown that in winter months (through to March) badger movements are restricted to wooded areas, and that even in early spring badgers spend the majority of their time in woodlands, not moving into fields and orchards until June and through the summer months (Goszczynski et al. 2005). Observers made a strong effort to search habitat patches that had a high concentration of cover features, and although many promising-looking areas were surveyed, no suspected badger sign could be found.

We felt that the helicopter was a superior aircraft for enhanced visibility, as the craft and window design enabled a greater ground viewing area for all observers, and could be flown at approximately half the altitude and speed of the fixed-wing aircraft. It could be possible to fly even lower than the 250-300 feet flown in this survey and/or to fly slower than the average of 40 knots maintained, and this would maximize the ability to observe sign at any one location if sign was present; however, doing so would compromise the total search area, as less ground would obviously be covered travelling at slower speeds in the same length of survey time, and at decreased heights observers would have a decreased horizontal search range – thus the rate of encountering any sign available to be observed would be expectedly lower. It was estimated that, on the helicopter flight, observers could effectively scan up to 400 m out on each side of the aircraft.

The weather the day of the late winter helicopter survey was clear (i.e., no precipitation in the air) and dull-bright with low winds, so conditions for visibility were ideal. However, snow cover was patchy in some areas, particularly in wooded areas, and this variability of ground cover may have prevented any recent dirt excavations from standing out as much as anticipated. As well, there may be factors relating to badger behaviour, such as extent of burrow re-use (versus creation of new burrows), and microhabitat characteristics of burrow location (e.g. a burrow under a large shrub may not detectable from the air under any circumstances), and activity levels that further limited the detectability of badger sign using this method at this time of year.

Comparison of Methodologies

Aircraft

Fixed-wing: The cruising height and speed of the Cessna 172 used for our surveys was workable, but not ideal for the type of features we were searching for. Cruising altitudes of 500-1000 feet AGL and air speeds of 60-70 knots enabled observers to spot areas of fossorial mammal activity in open landscape patches, but precluded confirmation of the species responsible for the observed sign, and quite likely precluded the observation of badger sign in landscape patches with heavy tree cover. The speed of the aircraft did enable the survey crew to cover nearly 500 km of flight lines in approximately 3.5 hours (four 100 km^2 blocks), plus some additional sites were incidentally observed at higher cruising altitudes during ferrying legs of the flight. Thus a relatively large area of ground can be searched using this method in a small amount of time. However, the speed, in combination with the height, likely compromised the crew's ability to observe a high proportion of sign present on the landscape. This handicap likely could not be remedied for a future survey unless a different aircraft was selected, as a Cessna 172 cannot typically cruise at a slower speed, and flights below 500 feet are generally not permitted in inhabited areas nor approved by MNR in fixed-wing aircraft. Another drawback to using the particular type of fixed-wing aircraft employed for this study was the manoeuvrability. On average, circles to investigate particular diggings were 1 km in diameter, which is not tight enough to allow for close observation from different angles or to be able to accurately geo-reference sites, unless many different passes are made and an attempt is made to fly the aircraft directly over each specific observation.

Rotary-wing: As discussed previously, in virtually all respects a helicopter is superior to a fixed-wing plane for this type of survey work as it is more manoeuvrable, permits greater visibility, can fly lower and slower, and has the ability to land to investigate sites at ground-level (where landowner permission has been secured). The only significant disadvantage to selecting this type of aircraft is cost, which typically runs at least 4 times the hourly rate of a Cessna (e.g., we were charged $195/hr for the Cessna 172 plane and $860/hr for Bell Long-ranger helicopter). Generally the cost of a helicopter rental is too high for small-budget research projects, but we made the decision to sacrifice about half of our flying time budget in this project in favor of testing out helicopter survey techniques, allowing us to compare the difference in methods between the two types of aircraft.

Design

Block-Grid Survey: The grid-style spacing of our survey flight lines (at approximately 1 mile apart) in selected 10 x10 km survey blocks enabled complete coverage of the ground and seemed ideal at cruising altitudes of 500-1000 ft AGL and air speeds of 60-70 knots in the Cessna 172. Observers felt it permitted a reasonable width of search area (1/2 mile wide for each observer, on each side of aircraft) to scan effectively in the open landscape areas. Patches of more closed habitat would likely require more tightly spaced lines, and preferably at lower altitudes, since one could likely only be able to effectively search an area of ¼ mile in width on each side of plane. The lay-out of the survey transects in relation to the landscape features was also helpful. Lines were laid out to fly in a southwest-to-northeast (and vice versa) direction in between and, essentially parallel (in most cases) to, the east-west concessions roads which also occur at one mile intervals. This made navigation easier for the pilot and gave observers a simple, distinct boundary for each transect's search area. Using this method approximately 400 km^2 were surveyed in 5 hours with complete coverage of the survey area.

Hexagon Sampling:
This method can provide quantifiable information on a species' distribution and relative abundance across a landscape without the need to achieve complete survey coverage, by estimating detection probabilities based on the number of observations per length of search. Using this approach, about 750 km^2 were surveyed in 3.5 hours, but only provided complete coverage of about 300 km^2 of the area sampled. Because we did not identitify any definitive badger sign with either method, and the two methods were employed at different times of the year in different aircraft, it is not possible at this preliminary stage to state which sampling method is preferred.

Fig. 4. Seven holes dug along slope of forest edge, as seen from air on March 2007 survey, Norfolk County

Summary

Overall, based on our preliminary efforts we feel that, while aerial survey methods do hold promise for detecting areas of badger activity, and some value was derived from our initial efforts, given the variety of factors influencing the success of detection and the costs involved, aerial surveys may not be the most economically feasible method for American Badger inventory and monitoring efforts in southwestern Ontario. A more complete assessment of the different approaches to aerial surveys (e.g., considering different aircraft, sampling techniques, and different times of year) would require additional surveys.

Aerial surveys employing the cheaper fixed-wing aircraft option could, however, be employed as a cost-effective method for identifying sites of *potential* badger use over a large geographic area, via either prey species occurrence records or observations of actual badger sign, provided that such surveys are followed up with ground-truthing visits to clarify and confirm ambiguous sign detected from the air. With multiple survey flights over time, this should allow for the identification of general locations/patterns of consistent use, on a broad-scale, that could warrant extra protection measures be implemented in certain locations (e.g., through habitat mapping), and which could possibly be monitored on a regular basis to provide an index of population trends. The method presently described is likely not feasible as a means for finding and monitoring sites of natal dens and resting burrows; however, ground-searches of feeding excavations identified from the air may lead observers to areas where larger, more permanent den and burrow sites may be found. As such, aerial surveys may serve as an initial screening tool to quickly idenitify areas worthwhile to explore more exhaustively on the ground.

Although this project has not yet yielded any definitive new American Badger records for Ontario, an important benefit gained from our survey work – particularly via the direct contacts made in the ground-truthing phase – is an increased awareness among rural landowners in the survey area about badger presence and conservation concerns. Hopefully this will lead to word spreading among rural communities in badger range and result in increased reporting and stewardship measures that will help protect badger habitat over the long-term.

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Table 1. February 2007 Badger survey data

GPS ID	Feature	Species	N	Habitat	Comments
~ C1	nest	Bald Eagle	1	marsh edge - in stand of large trees	Didn't investigate further - known nest site regularly monitored from the ground
001	individuals	Sandhill Crane	3	marsh	
001	tracks	Coyote	many	marsh	
002	digging	American Crow	1	corn field	Crow tracks and shallow digging through snow into corn stubble/waste corn
003	tracks	Raccoon	1 line	corn field - edge	
004	tracks	Raccoon	many	stream valley - banks	
005	individuals	Wild Turkey	6	corn field	
006	individuals	Wild Turkey	2	corn field	
007	individuals	Wild Turkey	25	soy field - corn along edges	
008	individual	Bald Eagle	1	mixed conifer plantation, small	Perched in large tree
009	individuals	Wild Turkey	7	field (crop?) edge, with small sand extraction pits	
010	individuals	Wild Turkey	3	corn field	
011	individuals	Wild Turkey	4	corn field	
012	individual	Coyote	1	field (crop?)	Lone individual, crossing field
013	individuals	Wild Turkey	9	corn field	
014	individuals	Wild Turkey	50	field (soy?)	
014a	individuals	Wild Turkey	10	deciduous woods	At feeding piles
014b	individuals	Wild Turkey	8	field (crop?) - edge	
015	tracks	Human + others (unknown)	many	deciduous woods and fields	Tracks crossed fields & through woods
016	individuals	Wild Turkey	4	deciduous woods	
017	individual	Coyote	1	deciduous woods	
018	tracks	Fox, Dog, Hare, small mustelid (mink/weasel?)	many	field (crop?) edges	Wildlife activity hotspot - large variety and concentration of animal tracks.
019	individuals	White-tailed Deer	4	deciduous woods	
020	individuals	Wild Turkey	6	field (crop?)	
021	track + beds	White-tailed Deer	several	field (crop?)	Many craters (beds) in snow, along with tracks
022	individuals	Wild Turkey	7	field (crop?)	
023	individuals	Wild Turkey	15	field (crop?)	
024	individuals	Wild Turkey	20	field (crop?)	
025	individuals	Wild Turkey	15	field (crop?) - edge	Extensive tracks and scratching
026	individuals	Wild Turkey	5	field (crop?)	
027	individuals	White-tailed Deer	4	deciduous woods	
028	individuals	Wild Turkey	20	field (crop?)	
029	individuals	Wild Turkey	10	field (crop?)	
030	individuals	Wild Turkey	2	field (crop?)	
031	individual	Wild Turkey	1	field (crop?)	
032	individuals	Wild Turkey	5	field (crop?)	
033	individuals	Pileated Woodpecker	2	deciduous woods	
034	individuals	Wild Turkey	5	field (crop?)	
035	nests	Great Blue Heron	5	deciduous woods	Start of a new rookery
036	individuals	Wild Turkey	3	field (crop?)	
037	digging	Coyote	1	field (crop?)	Shallow digging through snow to dirt. Coyote and Crow tracks present.
037	individuals	White-tailed Deer	5	field (crop?) - edge	
038	individuals	Wild Turkey	3	field (crop?)	
039	individual	Pileated Woodpecker	1	deciduous woods	
Total Deer observed: 13 individuals, plus occasional other tracks (didn't mark)					
Total Wild Turkey observed: 245 individual birds at 25 different sites (marked), plus 5-10 other sites with WITU tracks and scratchings (not					
Diggings observed: Shallow Coyote digging, Crow and Wild Turkey scratchings					
Tracks observed: Coyote, Fox, domestic dog, small mustelid (mink/weasel?), Raccoon, Hare/Rabbit, Crow, Wild Turkey, Deer, Human					
Other birds observed: Bald Eagles (2), Pileated Woodpeckers (3), Sandhill Cranes (3), Red-tailed Hawks (several - not marked), Northern					
Nests observed: Bald Eagle (1), Great Blue Heron (5)					

Table 2. March 2007 Badger survey data

GPS ID	Feature	Species	N	Habitat	Comments	Ground Visit Priority	Groundtruthing Observations (April 10-12 2007)
53	Holes	Grdhog?	6	Corn & Soy Fields	Round holes, little soil excavated		
053b	Holes	Grdhog?	4	Field			
54	Individuals	WITU	10	Soy Field			
55	Den mound?	Coyote?	1	Treed pond margin in Soy Field		*High*	Not surveyed - no listed phone or street address
56	Hole	Grdhog?	1	Field			
57	Hole	Grdhog?	1	Field			
58	Hole	Grdhog?	1	Field			
59	Holes / Diggings	?	2+	Corn + other fields, near hedgerow & woodlot edge	2 largest holes have large sand spray out one side.	*High*	Not Surveyed - numbered co.
60	Individuals	WITU	7	Field			
60	Holes	Grdhog?	2	Field			
61	Holes	?	2	Field	Looked very old.		
62	Holes	?	2	Field	Looked very old.		
63	Holes / Diggings	?	4	Wheat Field	3 oval holes with large sand spray.	*High*	2 areas of fox or coyote diggings in deer mice colonies, many exposed mouse tunnels still visible
64	Individual + Holes	Fox	1+	Fields	Fox checking out holes in field. Lots of other small holes in general area - within couple hundred metres of rail line.		
65	Hole / Diggings	?	1	Soy Field		*High*	Weathered, sunken in groundhog hole with old but visible sand mound
66	Holes	Grdhog?	~15	Field	Large group of old small round holes.		
67	Hole	?	1	Field	Single old oval hole.		
68	Holes	?	5, 6	Soy Field	2 clusters (5 + 6) of round holes close together		
69	Hole or Blowout?	?	1	Field	Hard to tell if an old small animal hole or a drain blowout.		
70	Holes / Diggings	?	2	Field (wheat or rye)	2 large holes.	*High*	Not surveyed to date - left message
71	Den mound?	Canid?	2+	Grassy patch in Corn Field	2 large dug out mounds, plus several smaller holes/diggings	*High*	1 probable (but weathered) badger digging with large claw marks along sides of tunnel, some fist-sized cobble extruded from hole which appears to be previous groundhog den; 3 active coyote den entrance holes, 1 old weathered groundhog hole
72	Holes / Diggings	?	2	Soy Field	Large sand sprays	*High*	2 areas of dug up deer mice colonies with sand throws, too weathered to determine predator type, but large and open nature suggests canid species. Many exposed mouse tunnels still visible. European hare remains nearby.
73					Ignore this point		
74	Holes	Dog?	2	Field	Shallow; not a lot of earth thrown		
75	Holes	?	4, 5	Soy or Wheat Field	2 clusters (4 + 5) of holes	*High*	Not surveyed - no response to message
76	Holes	?	3+	Soy or Wheat Field	3 larger holes, several smaller holes	*High*	Not surveyed - no response to message
77	Holes	Grdhog?	2	Soy Field			
78	Holes	?	2, 2	Deciduous woodlot edge		*High*	2 active groundhog holes located north of creek on south-facing slope near bee hives. Other reported digging along creek and deciduous woodland edge not relocated.
79	Holes / Diggings	?	~11, 23	Berm next to wetland complex	Many very fresh-looking diggings, others older. ~ 11 holes on E side of berm, ~23 on W side, all along steep banks of berm. Large sand spray out bottom of many holes.	*High*	No definitive badger diggings found, but many burrows present of various ages and condition. 2 active coyote dens with tracks found in berm, 2 older and smaller canid burrows (perhaps fox) and 39 Grdhog?holes.
81	Holes	Grdhog?	5 grps	Soy and other fields	5 clusters/patches, each with 3-4 holes. Some appear dug-out.		
82	Hole	?	1	Soy Field	Hole dugout		
83	Holes	?	2	Soy Field	Holes dugout		
84	Holes	Grdhog?	> 12	Old Christmas Tree farm	Small holes		
85	Holes	?	1+	Field	Single large hole with smaller on top, and 3 smaller holes around it.	*High*	2 weathered fox/coyote diggings in area of deer mice colony. Some exposed mouse tunnels still visible.
88	Individual	WITU	1				
89	Holes	?	2	Soy Field			
90	Holes	Grdhog?	2	Soy Field	Small, old.		
91	Holes	Grdhog?	many	Soy Field	Several clusters of holes, appear dug-out by something	*High*	1 cluster of fox/coyote diggings in area of deer mice tunnels
93	Holes or Blowouts?	?		Field	Small, old.		
94	Holes	Grdhog?	3	Field	Small, old.		
95	Hole/Digging	Grdhog?	2	Edge of small sand pit in field	Appear to be dug out (i.e. by predator)		
96	Holes / Diggings	?	5+	Soy Field	4 freshly dug holes in a line, + 1 extra, + other smaller ones in vicinity	*High*	Location of 4 diggings in a row could not be relocated on foot. One small open digging found in field, appeared to be older fox digging for field mice.
97	Holes / Diggings	?	1+	Soy Field - Pine Plantation edge	1 larger digging in Soy Field, near edge of plantation, plus several smaller diggings in dune (edge of plantation)		
98	Nests	GBHEs	~30	Birch trees in Buttonbush swamp	Herons flying around nests; Mary might have spotted 1 Great Egret as well.		
99	Holes / Diggings	?	2	Field (very sandy)	2 adjacent holes. Small dry sand spray. Near sand diggings marked on 2006 flight.		
101	Holes / Diggings	?	7+	Mixed forest edge, bordering Rye fields	7 large holes dug out, with large sand spray, on W-facing slope at forest edge (dune base). Additional smaller holes in vicinity. Close to diggings marked last year.	*High*	6 large holes found along edge of woodland, all appear to be recently active. Rainy weather prevented positive identification of tracks, but size and shape of holes seem to indicate one fox burrow and some large groundhog holes. Badger activity possible
102	Holes / Diggings	?	4?	Soy Field	Larger holes, with sand spray. Mary suggested talking to Allen Arthur (DFO?) for access.	*High*	Not surveyed - no answer to mulitiple calls, no voicemail option
104	Individuals	WITU	4	Field			
105	Individuals	WITU	9	Field			
106	Holes	Grdhog?	50-100	Fields			
107	Holes / Diggings	?	4+	Hedgerow in field	3-4 large holes with large sand spray on raised edge of hedgerow, plus several smaller holes (feeding excavations) in vicinity.	*High*	Active groundhog burrow with multiple holes in fencerow. 1 large and 3 smaller entrances found, all with recent tracks and small groundhog scratch marks.