A Possible Method for Estimating River Otter, *Lutra canadensis*, Populations Using Snow Tracks

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A possible method for estimating the size of a River Otter, *Lutra canadensis*, population is described. The various potential sampling errors which might result from misinterpretation of snow tracks and other survey characteristics are described. The relative advantages and disadvantages of the proposed technique are compared with those of other population estimation techniques for River Otters which use sign surveys, scent attractant with track boards, or radioactive labelling of individual otters. The use of snow tracks as a population estimation technique would be the least expensive but still requires substantial manpower to achieve population estimates with reasonable precision.

Key Words: River Otter, *Lutra canadensis*, population density, snow tracks, Alberta.

Techniques for estimating population size of free-ranging furbearers are difficult to derive and implement. Historically, managers have relied on trends in fur-harvest data from commercial trappers or on species-specific indices, such as active Beaver, *Castor canadensis*, lodges in autumn (Hay 1958) or visits to scent stations by Coyotes, *Canis latrans* (Linhart and Knowlton 1975).

River Otters, *Lutra canadensis*, are harvested annually in many parts of North America, but their semi-aquatic habits and relatively low densities in many habitats make a direct census impractical. Researchers have addressed the need to produce a reliable and rigorous estimation technique by using sign left by otters. Knaus et al. (1983) found that radioactive ^{65}Zn could be detected in labelled scats of captive otters for up to 215 days, and proposed applying the technique to a wild population. Humphrey and Zinn (1982) proposed the use of line transects of chalk-dusted trackboards, each with a scent attractant, to record tracks of otters attracted to the scent. In testing this technique in Florida, Robson (1982) and Robson and Humphrey (1985) concluded that the technique was insufficiently sensitive because otters became habituated to the scents offered or were reluctant to step on trackboards.

Surveys of otter sign (scats and scent mounds) along stream and lake shores can provide relative estimates of otter abundance (MacDonald and Mason 1985; Jenkins and Burrows 1980), but have not yet been developed with statistical rigour. Robson (1982) concluded that a statistically rigorous technique for measuring relative abundance, contingent on understanding the effects of age, sex, density, and season on defecation and scent-marking behaviours, could be developed from sign surveys.

Over much of their range in Canada, River Otters live in a seasonal climate with winter snow in which they leave distinctive tracks. Otters are harvested in nearly all jurisdictions, but estimates of abundance are still based on fur-harvest data (Boyd 1977) with their inherent biases. Researchers have not indexed population size using snow tracks, yet snow tracks appear to offer some advantages over other sign. Any otter, no matter what sex or age, will produce tracks when moving above ground in winter, whereas the incidence of scats and scent mounds may vary with sex or age-class in different seasons. Snow tracks are a continuous type of sign of measurable dimensions, such that independence of otter activity at different locations can be discerned by following tracks and identifying individual animals within groups by their unique sign.

This paper outlines the development and initial field testing of a technique for estimating the population density of otters by using tracks left in snow. This experimental research took place as part of a long-term study of River Otter ecology in northeastern Alberta.

Study Area

The study area, surrounding Winefred Lake (55°30′N, 110°30′W), was chosen for its relatively high density of River Otters (Boyd 1977). The physiography is characterized by low relief and no outcropping bedrock, and the area has a surficial geology of outwash and lacustrine glacial deposits. Drainage channels vary from indistinct muskeg channels (subsurface drainage) to the Winefred River (10–15 m wide). Lakes vary from shallow, eutrophic bog ponds, often without surficial drainage, to large eutrophic (Winefred Lake) and oligotrophic (Grist Lake) lakes.

The terrestrial surface area of catchments through which surveyed streams flowed was 345 km^2. The surface area of lakes falling inside these catchments was 121 km^2, including 96 km^2 on Winefred Lake alone. Streams of different orders (Strahler 1969: 483) were found in the following total lengths: first order — 66.0 km, second order — 19.5 km, third order — 8.5 km, and fourth order — 32.0 km, giving a total of 126.0 km. Total shoreline length of lakes was 124.0 km, of which 41.0 km were on Winefred Lake, 12.5 km on Grist Lake, and 70.5 km on a combination of many much smaller and generally eutrophic lakes and ponds.

The climate and vegetation are typical of the boreal mixed-wood forest (Rowe 1972; Strong and Leggat 1981). Winters are dry (1170 mm snow from October to April) and cold (mean temperature from December to February of -15.5° C). Summers are moist (320 mm rain) and warm (mean temperature from May to September of 12° C). Snow cover is continuous for an average of 150 days and accumulates to a mean maximum thickness of 50 cm. Mean maximum and minimum daily temperatures between 1 and 6 December 1983 were -11.0° C and -19.0° C, respectively. Daily temperatures were not recorded in 1984.

The study area supports a wide variety of boreal animals. Of special importance to otters are populations of cyprinid, gasterosteid, esocid, catastomid and salmonid fishes (Paetz and Nelson 1970; Gilbert and Nancekivell 1982). The density of Beavers is similar to that in other southern boreal areas (Reid 1984). Two other semi-aquatic mammals, Mink, *Mustela vison*, and Muskrat, *Ondatra zibethicus*, are not common (Boyd 1977).

This area includes no year-round public road access or permanent human settlements except for two natural gas processing plants and two tourist fishing lodges. Commercial fur trapping took place on three of five registered traplines during the study.

Materials and Methods

Development of the Technique

General observations of otter sign and evidence from radio-telemetry (Reid 1984) revealed patterns which were important in designing a survey technique. Otters may forage underwater hundreds of metres from shore, but with ice cover, they must return to shore to breathe and to move above ground. All winter dens were located on shorelines within 10 m of water. When travelling in terrestrial habitats between water bodies, otters generally took straight-line routes to destination shorelines where water access was assured. Otter habitat was therefore considered to be linear and composed of shorelines.

A shoreline segment length of 500 m was chosen as the unit for sampling the expected, clumped distribution. It was a length which, judging by our observations over previous winters, incorporated most of the daily activity of an individual or group of otters, with very little chance of encountering another independent group of otters in the same segment on the same day. In addition, 500 m was a convenient length when confronted with the problem of surveying a sufficient number of segments in as short a time as possible.

To use snow tracks as a direct measure of the number of otters on a shoreline segment, two conditions must be met: (i) that there be sufficient snow of good quality to record the passage of otters, and (ii) that all otters resident in a segment move above ground at some time during the day (i.e., temperatures are not so cold as to preclude movement or defecation above ground). Ideally, all water bodies should be ice-covered, thereby increasing the snow-covered area on which otters can make tracks to indicate presence and group size.

These conditions can only be met in our study area during a relatively short period of time in early witner, usually the last week in November and the first ten days of December. This is the period between the first substantial snowfall and the onset of very cold weather. Sampling cannot proceed without snow, but a test of whether the second condition can be met at this time of year was made by following radio-instrumented otters. Otters were live-captured, instrumented and telemetered for other study objectives as described by Reid (1984). In December 1983, all 11 radio-instrumented otters moved above ground during the sampling period.

Otters may be found individually or in small groups of variable composition at any time of year (Melquist and Hornocker 1983). The number of otters on a sample segment can be determined from snow tracks. However, the presence of otters is a relatively rare phenomenon, so that many sample segments can be expected to have no otter tracks present, and very few will have tracks of more than two otters present. These results suggest that presence of otters on the segments may be described by a Poisson distribution. The population estimate is the mean number of animals, determined from observed tracks in the sampled segments, extrapolated across all segments in the study area.

TABLE 1. Frequency and mean number of otter tracks in 0.5-km intervals, and approximate 95% confidence limits for true population (Nθ) of otters in 250 km of otter habitat in northeastern Alberta.

Year	Total segments N	Sample size n	Frequency of tracks 0	1	2	Sample mean θ	Estimated population Nθ	Approximate confidence limits (95%)
1983	500	60	56	2	2	0.100	50	$18 < N\theta < 109$
1984	500	55	51	4	0	0.073	36	$9 < N\theta < 93$
Both Years	500	115	107	6	2	0.087	44	$20 < N\theta < 80$

Application of the Technique

The shorelines of all lakes and water courses shown on 1:50 000 N.T.S. mapsheets were divided into numbered, 500-m-long segments. Numbering was initiated at creek or river mouths and proceeded upstream along the main channel. Segments were then numbered progressively upstream on each tributary and its tributaries. Shoreline segments on lakes were numbered counter-clockwise from the overflow if the entire lake fell within the study area, and in both directions from a major river mouth if part of the shoreline fell outside the area. Excess shoreline segments less than 500 m long, whether at the head of tributaries or on lakes, were amalgamated into 500-m lengths and jointly numbered. Both banks of a stream or river were included in the segment if the water course was less than 20 m wide. Wider water courses, though very rare in the study area, were sampled with separate segments along each bank.

A total of 500 segments representing 250 km of shoreline were numbered. Two random samples (independent and with replacement) of numbered segments were selected for survey over seven-day periods in each of two winters, with 60 segments surveyed 1-6 December 1983 and 55 segments surveyed 5-11 December 1984. Each segment was searched on foot for otter sign, which was estimated to be either less than or more than 24 hours old, judging by snow and hoar frost in the tracks and whether or not the scats had frozen. Only otter sign believed to be less than 24 hours old at the time of the survey was tallied. Characteristics of all observed sign, including estimated age of tracks and size and composition of otter groups, were also recorded. The longer the survey period, the greater the chance that otter sign on separate segments would not be independent. This eventuality was frequently checked by following tracks through adjacent, non-sampled segments to ensure that they were not tallied twice, and by comparing furrow widths of otter tracks on closely spaced segments.

In addition to conventional statistical methods, we used the Kolmogorov-Smirnov two-sample test (Siegel 1956) to test for agreement between the two samples. The distribution of the combined sample values was tested for agreement with a theoretical Poisson distribution with mean equal to the combined sample mean using the Kolmogorov-Smirnov one-sample test (Siegel 1956). Confidence intervals for estimating the true population mean were calculated using upper and lower limit factors for the Poisson distribution given by N. Mantel, reproduced in Johnson and Kotz (1969: 97, Table 1).

We calculated sample sizes necessary for estimating the density of otters to within ±20% and ±10% of the true density with 95% confidence using the formula for the normal approximation to the Poisson distribution given by Johnson and Kotz (1969: 96, formula 30). The upper limit factors calculated using this formula had close correspondence to the upper limit factors in Johnson and Kotz (1969: 97, Table 1) for infinite populations. Therefore, we used the upper interval only in calculating sample sizes. To reduce the size of samples required to obtain the desired levels of precision of estimation, we assumed sampling without replacement and corrected the formula for finite population (Snedecor and Cochran 1980: 439).

Results

Most segments contained no otter tracks, and none contained tracks of more than two otters. The sample means (θ) for 1983 and 1984 were 0.100 and 0.073 otters per segment, respectively, and the combined mean was 0.087 otters per segment, with a total population estimate of 44 otters (Table 1). The Kolmogorov-Smirnov two-sample test showed no difference ($P > 0.05$) between the two annual samples, and the Kolmogorov-Smirnov one-sample test showed no difference ($P > 0.05$) between the combined sample distribution and the theoretical Poisson distribution with mean 0.087. The approximate 95% confidence limits for each of the annual samples and the combined sample are shown in Table 1. The sample sizes and sampling intensity required to achieve the specified precision of estimation are shown in Table 2.

TABLE 2. Sample sizes and sampling intensity required for interval estimation (95%) of true population density (Θ) of otters in 250 km of otter habitat in northeastern Alberta.

Precision of estimation	Sample size (500-m segments)	Sampling intensity
Θ ± 20%	364	72.8%
Θ ± 10%	454	90.8%

Discussion

Our population estimate of 44 otters has a very wide confidence interval, even for the relatively high sampling intensity (23% for the combined sample). This illustrates the central problem in estimating populations with low densities: estimates with reasonable precision can only be achieved with very intensive sampling. We were unable to verify this population estimate directly, but from observation of otter sign and radio-instrumented otters over four years of study, we believe the estimate to be reasonable and within the calculated confidence interval.

Because sampling must take place on the ground and often in terrain of difficult access, and because it should take place within a short period of time (approximately one week), the proposed technique is labour-intensive. In this study area two observers sampled an average of five segments each per day, giving a sampling intensity of 10 to 15%. With more intensive sampling, sample segments would be less dispersed and travel time per sampling unit reduced, thereby allowing more efficient sampling.

The reliability of the population estimate is subject to several potential sampling errors. Misinterpretation of tracks could result in underestimation or overestimation. For example, an observer may not be able to assess the number of otters using a short stretch of repeatedly-used trail from den entrance to latrine. A search for other tracks coming to points of water access either within the same segment or in adjacent segments will be necessary. Otters may tavel in a line, making a single furrow, or may travel in different directions along the same route. To avoid error, an observer must carefully scrutinize and follow tracks beyond the limits of the segment and identify individual otters by measuring furrow widths where possible.

The second potential sampling error is built into the maximum allowable lag (24 hours) between tracks being made and observed. If the otter(s) have moved off the segment and the sign is tallied, an overestimate will result.

The third potential sampling error occurs when otters are present without leaving above-ground sign because they have reached a den site on the segment by travelling through open water or under the ice. An underestimate will result. This potential error may vary with ambient temperature and can be minimized by ensuring that the survey takes place in early winter before temperatures become excessively cold, and before water draw-down in beaver ponds creates air cavities under the ice (Reid 1984). In general, the second and third potential errors will work to counteract each other, but sampling errors, when considered together, are most likely to produce an underestimate of the population density.

A potential statistical error is the possibility that sample segments may not be independent. When sign found on one segment is similar in type (furrow width and group size) and age to that on a nearby segment, observers must check that the sign was not made by the same otters. They may have to survey intervening segments even though these were not chosen as sample segments.

The technique of using snow tracks can give an absolute estimate of population size. Other techniques, which rely on scats or visits to scent stations, require considerable refinement to determine the effect of age, sex and season on the observed sign before they can produce relative or absolute population estimates (Robson 1982). Each technique has advantages or disadvantages in terms of other criteria (Table 3). Snow tracks provide a relatively cheap technique because little equipment is required and observers need visit the study area only once. However, this technique can only be used in northern portions of otter range. The exact timing of its application will vary with latitude, depending on the onset of winter.

The estimated density can be expressed in terms of individuals per linear length of shoreline, or of individuals per unit area of land surface falling within the catchment area of the drainages sampled. We suggest recording both statistics, and also providing measures of the length of different shoreline types (e.g., first-, second- and third-order streams, lakes, ponds etc.) found in a study area. These statistics are important in comparing population estimates from different study areas which may vary considerably in their aquatic community composition.

This technique has given an estimate of total numbers along unstratified lengths of stream and lake shores. However, it is likely that otters show seasonal preferences for certain water bodies or shoreline types in response to changing food availability and ice cover (Melquist and Hornocker 1983). When this study was initiated, such preferences were unclear for the boreal ecosystem, but are expected to be clarified through analysis of the radio-telemetry data (Reid 1984). This

TABLE 3. Comparison of the utility of various population estimation techniques.

	Criteria			
Technique	Handling animals	Equipment*	Field effort	Application across range
Snow tracks	Not required	Insignificant	Extensive labour — one visit	Limited to northern distribution
Scent and track boards	Not required	Elaborate (chalkboards and scent)	Extensive labour — multiple visits	Possible
Radio isotope	Required	Elaborate (scintillation counter)	Extensive labour — multiple visits	Possible

*Equipment normally not available within the area.

estimation technique will likely benefit both in accuracy and in reduction of sampling effort by stratified sampling of shoreline types.

Acknowledgments

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The shorelines of all lakes and water courses shown on 1:50 000 N.T.S. mapsheets were divided into numbered, 500-m-long segments. Numbering was initiated at creek or river mouths and proceeded upstream along the main channel. Segments were then numbered progressively upstream on each tributary and its tributaries. Shoreline segments on lakes were numbered counter-clockwise from the overflow if the entire lake fell within the study area, and in both directions from a major river mouth if part of the shoreline fell outside the area. Excess shoreline segments less than 500 m long, whether at the head of tributaries or on lakes, were amalgamated into 500-m lengths and jointly numbered. Both banks of a stream or river were included in the segment if the water course was less than 20 m wide. Wider water courses, though very rare in the study area, were sampled with separate segments along each bank.

A total of 500 segments representing 250 km of shorehne were numbered. Two random samples (independent and with replacement) of numbered segments were selected for survey over seven-day periods in each of two winters, with 60 segments surveyed 1-6 December 1983 and 55 segments surveyed 5-11 December 1984. Each segment was searched on foot for otter sign, which was estimated to be either less than or more than 24 hours old, judging by snow and hoar frost in the tracks and whether or not the scats had frozen. Only otter sign believed to be less than 24 hours old at the time of the survey was tallied. Characteristics of all observed sign, including estimated age of tracks and size and composition of otter groups, were also recorded. The longer the survey period, the greater the chance that otter sign on separate segments would not be independent. This eventuality was frequently checked by following tracks through adjacent, non-sampled segments to ensure that they were not tallied twice, and by comparing furrow widths of otter tracks on closely spaced segments.

In addition to conventional statistical methods, we used the Kolmogorov-Smirnov two-sample test (Siegel 1956) to test for agreement between the two samples. The distribution of the combined sample values was tested for agreement with a theoretical Poisson distribution with mean equal to the combined sample mean using the Kolmogorov-Smirnov one-sample test (Siegel 1956). Confidence intervals for estimating the true population mean were calculated using upper and lower limit factors for the Poisson distribution given by N. Mantel, reproduced in Johnson and Kotz (1969: 97, Table 1).

We calculated sample sizes necessary for estimating the density of otters to within ±20% and + 1 0% of the true density with 95% confidence using the formula for the normal approximation to the Poisson distribution given by Johnson and Kotz (1969: 96, formula 30). The upper limit factors calculated using this formula had close correspondence to the upper limit factors in Johnson and Kotz (1969: 97, Table 1) for infinite populations. Therefore, we used the upper interval only in calculating sample sizes. To reduce the size of samples required to obtain the desired levels of precision of estimation, we assumed sampling without replacement and corrected the formula for finite population (Snedecor and Cochran 1980: 439).

Results

Most segments contained no otter tracks, and none contained tracks of more than two otters. The sample means (6) for 1983 and 1984 were 0.100 and 0.073 otters per segment, respectively, and the combined mean was 0.087 otters per segment, with a total population estimate of 44 otters (Table 1). The Kolmogorov-Smirnov two-sample test showed no difference ($P > 0.05$) between the two annual samples, and the Kolmogorov-Smirnov one-sample test showed no difference ($P > 0.05$) between the combined sample distribution and the theoretical Poisson distribution with mean 0.087. The approximate 95% confidence limits for each of the annual samples and the combined sample are shown in Table 1. The sample sizes and sampling intensity required to achieve the specified precision of estimation are shown in Table 2.

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Table 2. Sample sizes and sampling intensity required for interval estimation (95%) of true population density (0) of otters in 250 km of otter habitat in northeastern Alberta.

Precision of
estimation

Sample size
(500-m segments)

Sampling
intensity

+ 20%
± 10%

364

454

72.8%

90.8%

Discussion

Our population estimate of 44 otters has a very wide confidence interval, even for the relatively high sampling intensity (23% for the combined sample). This illustrates the central problem in estimating populations with low densities: estimates with reasonable precision can only be achieved with very intensive sampling. We were unable to verify this population estimate directly, but from observation of otter sign and radio-instrumented otters over four years of study, we believe the estimate to be reasonable and within the calculated confidence interval.

Because sampling must take place on the ground and often in terrain of difficult access, and because it should take place within a short period of time (approximately one week), the proposed technique is labour-intensive. In this study area two observers sampled an average of five segments each per day, giving a sampling intensity of 10 to 15%. With more intensive sampling, sample segments would be less dispersed and travel time per sampling unit reduced, thereby allowing more efficient sampling.

The reliability of the population estimate is subject to several potential sampling errors. Misinterpretation of tracks could result in underestimation or overestimation. For example, an observer may not be able to assess the number of otters using a short stretch of repeatedly-used trail from den entrance to latrine. A search for other tracks coming to points of water access either within the same segment or in adjacent segments will be necessary. Otters may tavel in a line, making a single furrow, or may travel in different directions along the same route. To avoid error, an observer must carefully scrutinize and follow tracks beyond the limits of the segment and identify individual otters by measuring furrow widths where possible.

The second potential sampling error is built into the maximum allowable lag (24 hours) between tracks being made and observed. If the otter(s) have moved off the segment and the sign is tallied, an overestimate will result.

The third potential sampling error occurs when otters are present without leaving above-ground sign

because they have reached a den site on the segment by travelling through open water or under the ice. An underestimate will result. This potential error may vary with ambient temperature and can be minimized by ensuring that the survey takes place in early winter before temperatures become excessively cold, and before water draw-down in beaver ponds creates air cavities under the ice (Reid 1984). In general, the second and third potential errors will work to counteract each other, but sampling errors, when considered together, are most likely to produce an underestimate of the population density.

A potential statistical error is the possibility that sample segments may not be independent. When sign found on one segment is similar in type (furrow width and group size) and age to that on a nearby segment, observers must check that the sign was not made by the same otters. They may have to survey intervening segments even though these were not chosen as sample segments.

The technique of using snow tracks can give an absolute estimate of population size. Other techniques, which rely on scats or visits to scent stations, require considerable refinement to determine the effect of age, sex and season on the observed sign before they can produce relative or absolute population estimates (Robson 1982). Each technique has advantages or disadvantages in terms of other criteria (Table 3). Snow tracks provide a relatively cheap technique because little equipment is required and observers need visit the study area only once. However, this technique can only be used in northern portions of otter range. The exact timing of its application will vary with latitude, depending on the onset of winter.

The estimated density can be expressed in terms of individuals per linear length of shoreline, or of individuals per unit area of land surface falling within the catchment area of the drainages sampled. We suggest recording both statistics, and also providing measures of the length of different shoreline types (e.g., first-, second- and third-order streams, lakes, ponds etc.) found in a study area. These statistics are important in comparing population estimates from different study areas which may vary considerably in their aquatic community composition.

This technique has given an estimate of total numbers along unstratified lengths of stream and lake shores. However, it is likely that otters show seasonal preferences for certain water bodies or shoreline types in response to changing food availability and ice cover (Melquist and Hornocker 1983). When this study was initiated, such preferences were unclear for the boreal ecosystem, but are expected to be clarified through analysis of the radio-telemetry data (Reid 1984). This

[Begin Page: Page 580]

Table 3. Comparison of the utility of various population estimation techniques.

Technique

Handling
animals

Criteria

Equipment*

Field
effort

Application
across range

Snow
tracks

Scent and

track

boards

Radio
isotope

Limited to

northern

distribution

Possible

Possible

*Equipment normally not available within the area.

estimation technique will likely benefit both in accuracy and in reduction of sampling effort by stratified sampling of shoreline types.

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