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NON INTRUSIVE POPULATION ESTIMATOR for SWIFT FOX USING VOICE PRINTING

by

COCHRANE ECOLOGICAL INSTITUTE
COCHRANE WILDLIFE RESERVE
P.O. Box 484
Cochrane, AB, T0L 0W0

Executive Summary

A two year study was conducted on the use of voice printing as a means of estimating population numbers of Swift fox in the wild. The Swift fox is an extremely vocal species. Part of its repertoire is a distinctive lubricious bay during the breeding season (February - March). The methodology developed during the study was based on:

1. the voice printing of the lubricious bay
2. the development of a play back system which will solicit responses from the Swift fox in the wild
3. the voice printing of the responses to identify the number of individuals, and
4. the estimate of population levels using the voice prints as a mark/recapture procedure.

In 1995 and 1996 820 individual lubricious bays from Swift fox were recorded at the captive breeding colony, Cochrane Ecological Institute. A sub-sample off these calls were digitized using a Sound Blaster AWE32 Sound Card, and analyzed using Sound Phrase Comparison Package v1.8 obtained from Dr. M. Evans, Sterling University, Scotland. The resulting data was clustered using squared euclidean distance as a measure of dissimilarity and the Ward method of clustering. This procedure clustered the lubricious analyzed into groups with similar properties. The method of voice printing developed identified the individual Swift fox but was not 100% accurate.

At Cochrane Ecological Institute the Swift fox captive colony was found to call most actively between 17:30 to 06:45. The calling was found to be effected by vehicle noise but not by temperature. Wind did not appear to affect the calling at night but the start of a light breeze may elicit calling during the day.

Tests on five playback tapes were performed to find the one that solicited the optimum response. The optimum tape was composed of the lubricious bays of 4 individuals alternating every 20 seconds and followed by a single call at 40 seconds. This combination was repeated for 15 minutes.

Responses from the breeding colony were solicited after the breeding colony by the use of the playback tape.

During field studies in 1994, it was found that the Swift fox begins to occupy the natal dens during the mating season and that the location of the natal dens was a likely place to find animals in February to March. Two primary activities were used to locate study areas for the field testing of the methodology. A natal den survey was conducted in the summer of 1995, in the Border Area and Grasslands National Park; a post release

survey was conducted of the captive bred Swift fox release sites in November, 1995. Cooperative efforts to obtain data from research being conducted in the Border area was not successful.

Field tests of the methodology were conducted from March 8 to 30, 1996. Over that period 130 indvidual play back sessions were conducted in the area of Grasslands National Park, West Block and the Border Area. During these sessions 24 responses were solicited, seven of which were recorded for voice printing.

Twenty-three of the recorded calls were digitized and analyzed , using the method outlined above. The quality of the recordings made in the field were of poor quality which resulted in the need for considerable digital manipulation before analysis. The methodology used to voice print lubricious bays from the captive colony was not successful on these manipulated calls.

During the field testing access to much of the area was prevented by snow and weather conditions. This prevented the testing of the mark/recapture aspect of the methodology.

In summary the study showed that the Swift fox lubricious bays could be voice printed but the accuracy of the voice printing was not 100% with the technology and software used. The Swift fox was shown to respond to a play back tape both in the captive breeding colony and in the field. The problems encountered with the voice printing could be remedied by the use of Digital Audio Tape (DAT) equipment (both the tape recorder and the microphone) and the use of a parabolic microphone dish. Because of the difficult weather conditions and resulting access problems field work must be performed from an All Terrain Vehicle (ATV).

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1 Introduction

1.1 Background

The Swift fox (*Vulpes velox, V.v.hebes*) is a species unique to the Great Plains of North America. The Great Plains are one of the most rapidly and radically altered biomes in the world. The Swift fox is a species which was declared extirpated in Canada (extinct in its range) by C.O.S.E.W.I.C. in 1978. Since 1971, Swift fox have been bred for re-introduction and release by the Cochrane Ecological Institute / Cochrane Wildlife Reserve (C.E.I.).

The release of Swift fox to their original range began in 1983 in Alberta and 1985 in Saskatchewan. Since then 640 captive born Swift fox have been released. Little is known of their home range requirements and population numbers in the release sites. To date, trapping has been the major tool used by the Alberta Fish & Wildlife Branch as method of estimating Swift fox population levels. Trapping for this purpose has proven to be intrusive and unsatisfactory. (***"Subcommitteee members are still concerned about the intrusiveness of the proposed live-trapping and tattooing methods to determine population estimates."*** (May 4th,1994 letter from Gary Blundell**,** Chairman RENEW Recovery Plans Subcommittee, rejecting the 2nd submission of the "National Recovery Plan for the Swift Fox"))

The management of mammalian species and in particular reintroduction of endangered species is often hampered by the availability of effective and non-intrusive methods for estimating population size. When dealing with extremely small numbers of individuals in the wild, which is usually the case with an endangered species, this problem is compounded by the necessity of not disturbing the limited natural population with intrusive sampling methods.

Traditional methods of estimating population size, mark recapture, trapping, hunting and trapping records, are either not available to a reintroduction program or are disruptive to small populations. The advent of animal rights groups and an increasing anti-trapping feeling amongst the general public further complicates the science of population dynamics. Without a knowledge of population numbers of wildlife it is impossible to gauge their requirements, nor protect suitable habitat.

The reintroduction of the Swift fox to the Canadian prairies has been plagued with these problems. Attempts have been made to monitor by the use of radio collars, but this has only been done for a limited number of Swift fox, was expensive, time consuming, and held the possibility that the radio collars themselves could have an effect on the behavior and survival of the collared fox. In addition radio collaring experiments do not lead to population estimates but to a better knowledge of animal movements.

Individually distinct vocalizations, or vocal signatures, have been identified in many mammals (Brady, 1981; Harrington, 1987; Leger, et al, 1980). Vocal recognition through vocal signatures has been documented in coyotes (McCarley, 1973), red wolves(McCarley, 1978; Harrington, 1989), bottlenose dolphin (Fretag and Tyak, 1993), bush dog, crab eating fox and the maned wolf (Brady, 1981), tree shrew (Zimmerman, 1989), grey wolf (Tooze, et al, 1973), northern pikas (Nikolskii and Serbrodolskaya, 1989) and humpbacked whale (Levenson and Leapley, 1978). Sound has also been used as a method of locating animals and estimating changes in pack numbers in wolves (Fuler and Sampson, 1987; Harrington, 1989; and Dekker, 1985).
As yet, no work has been done on the recognition of individuals through vocal signatures in Swift fox.

The concept of using voice printing as a method of estimating population numbers has received limited attention in the scientific literature. Schemnitz (1980) noted the use of vocalization in wildlife studies and grouped it with the true census methods (not estimates). The combination of using vocalization to census animals (such as using bird calls) combined with voice printing (the identification of individuals in a population) was the subject of this study.

1.2 Swift Fox Vocalization

The Swift fox is an extremely vocal species. Its vocal range can be described as; infant whine, infant grunt, extended whine, repetitive whine, pulsed vocalization, short scream, warning bark, chitter, growl, and lubricious bay.

Of the 10 sounds which make up the extensive vocabulary of the Swift fox, only the lubricious bay is seasonal. Swift fox of both sexes emit the lubricious bay from late January to late March, this sound is distinctive and was believed to have a vocal signature which could be used to distinguish individuals animals using only the human ear. Preliminary work (Dennington, 1994, Harris, 1994, Michie, 1994) has shown that the lubricious bay can be heard for over 1/2 a Km in the release sites; Swift fox, in the release sites, will respond to recorded calls of the lubricious bay; and ground truthing of the area where lubricious bays were heard in the field in February resulted in the discovery of natal dens.

The objectives of the present research were to develop a method of voice printing the lubricious bay of the Swift fox using off-the-shelf technology; and to use the voice printing of lubricious bays recorded in the wild to develop a population estimation method for the species.

2 Methods

The research was divided into three components 1) collection of data on the captive colony relating to voice printing, responses to a played tape and the impact of distance and weather on the response to the tape; 2) locating field testing areas; and 3) field testing of the population estimation method.

2.1 Captive Colony Research

During the 1995 and 1996 Swift fox breeding season (February to April) the following research was conducted at the Swift fox captive breeding colony at CEI:

1. recording of individual lubricious bays from Swift fox for the development of a voice printing methodology. (the number of recorded calls obtained from each individual fox did not reflect the frequency of lubricious bays uttered by that fox).
2. determination of Swift fox calling patterns and natural call rates
3. development of a play back tape that elicited an optimum response
4. examination of the impact of weather, distance from the animals, and other noise on response to the play back tape
5. examination of the time period that the captive colony would respond to the play back tape.

2.1.1 Recording of Lubricious Bays and Voice Printing Methodology Development

Lubricious bays from individual Swift fox in the captive breeding colony were recorded using a *SONY WM-D6C* Professional Walkman and a *SONY ECM-Z157 (1995)* Electret Condenser Microphone*.* The recordings were made from as close to the fox as possible to enhance the quality of the recording, and to ensure that the fox which was calling could be correctly identified. Most of the recordings were made from a distance of 10 m. The name of the individual Swift fox was also recorded at the time of taping. Where possible, foxes were recorded without the use of a playback tape in order to reduce background calling.

During the 1995 breeding season 400 lubricious bays were recorded from 13 Swift fox. During the analysis of the calls from 1995 it was discovered that several of the Swift fox names had been associated with the wrong bays. In 1996 an additional 420 lubricious bays were recorded from 19 Swift fox. During the recording in 1996 additional care was taken to insure that animals were identified correctly. In addition in 1996 the recordings were made using a *Sony ECM-727P* Electret Condensing Microphone designed specifically for digital recording.

Recorded calls were transferred to a DOS based 486 computer using *Creative Wave Studio v.2* for *Windows*, in conjunction with the *CREATIVE SoundBlaster AWE32* sound card.

The software package, Sound Phase Comparison Package v1.8 (SPCP) was obtained from Dr. Matthew Evans, Sterling University, Sterling, Scotland. A description of the software can be found in Evans and Evans (1994). The lubricious bays were prepared for analysis by cropping the digital sound wave to exclude dead time at the beginning and end of the sound, placing a short (less than 1/10 second) period of silence between the phrases of the sound wave, and by saving the sound wave in a raw data format. This was done using the program COOL Edit v 1.52 from Syntrillium Software Corporation.

SPCP was a series of three software packages that worked interactively to analyse the sound waves. First the sound waves were prepared for analysis using TRANS.EXE. This program converted the raw data files to stripped data (*.ASC) and modulated (*.MOD) data files for analysis. The phrases in the transformed files were compared to a data base of phrases using the COMPHRA.EXE program. The third program PRTGRPH.EXE was used to examine the individual sound waves and the phrase library, as well as modifying the phrase library.

The program COMPHRA.EXE compares each of the sound wave phrases to the phrase library, if the phrase being examined was with in a specified correlation coefficient of a phrase in the library the number of that phrase is noted, if no matching phrase is found the phrase is added to the library. In this way a library is built up as the sounds waves are analysed. The output of COMPHRA.EXE is a text file indicating the name of the sound wave analysed and the identification number of the phrases found in the sound wave.

A random set of 30 lubricious bays (from the 400 recorded in 1995 were used to determine the most appropriate correlation coefficient to use in the voice printing. The 30 sound waves were analysed using a correlation coefficient of 0.50, 0.65, 0.80 and 0.90. The results of four tests were compared to determine the correlation coefficient that would give the highest level of information when identifying individual animals.

The results of the SCPC analysis was a list of the phrase numbers for each of the phrases for each individual call. To analyse the similarity between the individual calls the phrase combinations were compared using the principles of Mathematical Ecology and Numerical Taxonomy. To compare communities in an ecological system Peilou (1977) suggests the use of Euclidean distance or its square as a measure of dissimilarity. This can be done in *s* -space with *s* species. Applying this to the analysis of the similarity between the lubricious bays the phrases that compose the individual calls were equated to the species in a ecological community and the Euclidean distance were calculated using the following formula:

$$d_{ij}^2 = \sum_{v=1}^{s} \left(x_{iv} - x_{jv} \right)^2$$

The Euclidean distance between each lubricious bay and every other lubricious bay was calculated as a measure of dissimilarity between the bays. To graphically present the comparison the Ward method of cluster analysis was used (Sneath and Sokal, 1973). This method used a hierarchical grouping method which first calculated the means of the variables within each cluster. Then for each cluster it calculated the squared Euclidean distance to the cluster means. These distances were summed for all of the cases. At each step the two clusters that merged were those that resulted in the smallest increase in the overall sum of the squared within cluster distance. The results were plotted in a dendrogram format to show the dissimilarity (similarity) between the individual lubricious bays. The statistical analysis was conducted using SPSS v7.0 for Windows

2.1.2 Swift fox Calling Patterns and Natural Call Rates

Three 24 hour monitoring sessions were used to examine Swift fox calling rates throughout the day. For the first of these, calls were counted from an open window with no listening device; for the second and third period, listening was done using a condenser microphone which amplified the sound and allowed for a wider audible range. Weather observations were made during the three periods using a Davis Instruments, Weather Monitor II weather station.

2.1.3 Development of a Play Back Tape to Elicit Optimum Response

An assessment of the natural calling patterns observed in the captive colony was made for frequency of calls. Based on this assessment a series of five play back tapes were prepared with the call rates shown in Table 1. To evaluate the response of the captive colony to these calling patterns, call rates were noted over 5 minute intervals for 30 minutes before the tape was played. The tape of pre-recorded calls was then played for 30 minutes from at a distance of approximately 40m from the nearest foxes. During the playback, call rates from the colony were noted for each 5 minute interval. After the playback, call rates were noted over each 5 minute interval for a further 60 minutes.

A total of 16 play back sessions were conducted at a varying times of day using the five tapes.

To assess whether the call rate noted before, during and after the play back varied, the average rates of calling in the three periods were compared using a Student T test (EXCEL v5 software).

2.1.4 Impact of Distance from Swift fox, Weather and Vehicular Noise on Responses

To examine the impact of distance on the response of the Swift fox in the breeding colony to the play back tape 11 trials were conducted as summarised in Table 2. Tape 5 (Table 1) was used for all of the trials. In all the trials the responses were noted using the *SONY ECM-Z157* Electret condenser microphone.

To examine the impact of weather on the calling rate for the Swift fox in the captive colony, the call rates observed over 24 hour periods were compared to weather observations for observations periods.

Table 1: The call composition of the play back tapes tested.

Tape No.	No. of Swift fox per Tape	Call Interval
1	1	1 per minute
2	1	2 per minute
3	1	4 per minute
4	1	12 per minute
5	4 (alternating, each call)	4 calls in 20 seconds followed by 1 in 40 seconds

Two vehicles were used to examine the impact of foreign noise on the response rate. One vehicle was a CEI truck always present at the Institute, and the other was foreign to the Institute. Call rates were monitored for 30 minutes, following which the vehicle was run for 15 minutes; calls were monitored during the time that the vehicle was running and for 30 minutes after the vehicle was turned off. Three trials were conducted, two with the foreign vehicle and one with the CEI vehicle.

The average call rates before during and after the running of the vehicles were compared for significant differences using a Student T test.

2.1.5 End of Mating Season Response to the Play Back Tape

The captive breeding Swift fox colony stopped calling toward the end of the first week of April. From April 9 to 14th the play back tape (Tape 5) was played each night. On the first night the tape was played from a distance of 400 m. south east of the nearest foxes and on the following five nights from approximately 40 m. east of the nearest fox. Calling rates were monitored for 15 minutes prior to, during, and 15 minutes following the tape.

2.2 Selection of Field Testing Areas

Based on the theory that Swift fox are a creature of habit and tend to use the same dens for successive breeding seasons (Pruss, 1994), and that the location of the Swift fox in the early winter will indicate natal den sites three groups of data were collected to help select study areas for field testing of the program.

2.2.1 Summer Den Site Survey

Locations of den sites were obtained from the literature, the Canadian Wildlife Service Swift fox data base, and file records in Grasslands National Park. Records for 21 den sites were found. All sites found were recorded on topographical maps (1:50,000 scale) and visited during July and August 1995.

Access to within one km. of the den site area was by vehicle. The final search was done on foot. Holes encountered on the survey were identified as A) occupied, B) sign of fox in area, or C) vacant, no sign of fox in area. If a den site was occupied by Swift fox at the time of the survey, it was observed for 12 hours (dusk) to determine whether it was a natal den and/or the number of Swift fox present at the site.

At all den sites that were occupied or had sign of Swift fox in the area a biophysical survey was conducted. The survey included:
1) Soil type - core samples were taken from each den site using a hand held auger; the samples were placed into bags for analysis, i.e. loam, clay-loam, sandy-clay-loam, clay, etc.

2) Vegetation analysis - frequency of occurrence was estimated along two 30 m line transects located at either side of the den site.

3) Old grass - mean height of grass (± 1 cm) from previous years (i.e. prior to 1995) based on five replicate samples taken within three metres of a den hole.

4) New grass - mean height of grass (± 1 cm) for current year, based on five replicate samples taken within three metres of a den hole.

5) Proximity to water - distance in metres from den site to nearest permanent body of water was measured on topography maps and verified in the field.

6) Proximity to road, trails, or fences - distance in metres from den site to nearest road/trail/fence was measured on a topographic map and verified in the field.

7) Approximate slope - the angle of the slope on which the site was located was measured with a clinometre.

8) Slope position or level - the position of a den on the slop of the hill was noted as b = bottom, m = middle, t = top.

9) Number of holes - number of holes (den entrance holes) occurring at each site was noted.

10) Dimensions of den entrances - width and height of entrances were measured in cm.

11) Aspect - directional orientation of each den entrance, was measured by placing a metre stick into each den hole entrance and taking the compass reading along the meter stick.

12) Agricultural land use adjacent to den site - adjacent use of land next to sites was noted as C = crop land, G = grazing, comments = other agricultural uses, or N = no agricultural land use.

13) Small mammal activity in vicinity - small mammals visible, or evidence of their existence, such as a gopher colony, or scat, was noted as P (present) or a NP (not present).

14) Raptor/predator activity in vicinity - visible identification of predators was noted as P (present) or a NP (not present); feathers, scat, castings, and other physical evidence was collected for later analysis.

Notes on the condition of the den and Swift fox sign were taken at all sites visited.

Table 2: Playbacks trials conducted to examine responses at different distances (Tape 5)

Trial	Date	Time	Direction	Approximate Distance to nearest foxes (m)	Intervening terrain
1	15.3.95	21:30	ENE	1020	Densely wooded
2	15.3.95	22:45	ENE	1020	Densely wooded
3	16.3.95	00:00	ENE	730	Densely wooded
4	16.3.95	01:15	ENE	550	Densely wooded
5	16.3.95	02:30	ENE	360	Densely wooded
6	16.3.95	14:50	SE	400	Sparsely wooded
7	16.3.95	16:05	SE	400	Sparsely wooded
8	17.3.95	00:25	SE	400	Sparsely wooded
9	17.3.95	01:40	SE	400	Sparsely wooded
10	17.3.95	13:00	SE	400	Sparsely wooded
11	17.3.95	14:15	E	50	Clear

2.2.2 November Survey of the 1995 Release Sites

From November 27 to December 8 of 1995 the 1995 captive bred Swift fox release sites were monitored for sign of Swift fox activity. The locations of the release sites are found in Table 4.

The post release monitoring was conducted in two phases. First each of the release sites was visited and checks for sign of Swift fox activity (i.e. scat, tracks, and use of the existing dens). Second, a 1 mile by 1 mile grid around the release site was systematically walked in search of Swift Fox sign. The grid was divided up into 1/4 mile sections and each section was walked by an observer. If tracks were found, they were followed and observations made on the activity along the routes. While following the tracks, all Swift fox activity was documented for type and location. This included scat, kill sites, direction of travel, holes or dens, etc. Photographs were taken of tracks, scat and den site. The scat was collected and placed in plastic bag and archived for future analysis. Air temperature and the wind speed were recorded on each day of the survey.

2.2.3 Swift fox Location Data from Border Area

During 1995 and 1996 an intensive study of Swift fox movements has taken place in the 'border area' and south eastern Alberta. Arrangements were made to use this data in the selection of field test sites and in the evaluation of the effectiveness of the methodology.

2.3 Field Testing Voice Printing Methodology

A standard play back tape based on tape 5 (Table 2) was prepared for the field testing. The sequence of lubricious bays outlined for tape 5 were repeated for a 15 minute period.

The locations for the field testing were selected as the border area, and the West Block of Grasslands National Park. Both areas had known populations of Swift fox. In the Border Area the population numbers were better known because of the research that has been conducted in the area.

The field testing methodology was based on the results of the research on the captive breeding colony. The methodology involved the playing of the tape on a one km. grid pattern over the study areas. While the tape was playing and for 30 minutes after the tape ended, recordings were made of all Swift fox responses. The tape was played through a Samsung portable stereo. The recordings were made using a *SONY WM-D6C* Professional Walkman and a *SONY ECM-727P d*igital microphone.

The field testing in the West Block of Grasslands National Park was conducted during

March 8 to 21, 1996 and in the border area during March 24 to 30, 1996.

Table 3: The locations of the 1995 captive bred Swift fox releases.

Release Site	UTM	Swift Fox Released
CHANDLER'S PROPERTY - SITE 1	307900E, 5440400N	Foxfire (male) S-495 Falernan (male) S-496 Fiddledeedee (female) S-499 Five-oh (male) S-500
MASEFIELD PASTURE - SITE 2	304300E, 5437300N	Frank (male) S-488 Ferocious (male) S-489 Firdella (female) S-484 Fred (male) S-485
WEST BLOCK - SITE 3	316000E 5444200N	Fargy (male) S-503 Foster (male) S-504 Farceur (female) S-505 Foxglove (female) S-508 Didsbury (male) S-404 Delors (female) S-398 Dandelion (female) S-421 Dreyfuss (male) S-423
EAST BLOCK - SITE 4	344600E, 5433300N	Fame (female) S-506 Fammulus (male) S-509
EAST BLOCK- SITE 5	349900E, 5431200N	Fizz (male) VZ 27 Faust (male) VZ 24 Fierabras (male) VZ 25 Frilly (female) VZ 23 Fabulous (female) VZ 26
EAST BLOCK - SITE 6	350100E, 5439300N	Finnegan (male) S-478 Foudroyant (male) S-479 Fleet (male) S-480 Factum (male) S-481 Fellow (male) S-482

The recorded sounds were digitised and analysed using the method outlined in Section 2.1.1 above. The lubricious bays recorded were identified as FOX1 … FOXi. Following the voice printing analysis the number of calls recorded on each day, their locations and the number of calls that were also recorded on the previous day were tabulated.

The assumption was made that lubricious bays recorded on the first night of the survey of an area were “Marked” animal, because the call recorded from that animal on a successive night can be identified. The recordings from successive nights in the same sample area were assumed to be “Recaptured” or “Unmarked” animals. This provided for the analysis of the data using the statistics applied to Mark-Recapture methods.

Because of the short time frame over which the data was collected (two to three nights), it was assumed that the population was “closed”.(no recruitment, or deaths). The sampling method does not involve handling of the animals so the assumption was made that the model did not have to involve a factor for “Catchability”. The methodology could be used on several successive capture dates (K>2) but it was concluded that for the development of the methodology only two "captures" would be used.

Based on the above assumptions the simple Lincoln-Peterson model was used to estimate the population size (Bookout, 1994). The formula used in the population estimates were:

$$\hat{N}_c = \left[\frac{(n_1+1)(n_2+1)}{(m_2+1)}\right]-1$$

$$\text{var}(N_c) = \frac{(n_1+1)(n_2+1)(n_1-m_2)(n_2-m_2)}{(m_2+1)^2(m_2+2)}$$

$$CI_{95\%} = N_c \pm 1.965\sqrt{\text{var}(N_c)}$$

where: N_c = estimate of population size
var(N_c) = variance in population estimate
CI 95% = 95% confidence in population estimate
n_1 = animals recorded and voice printed on the first night
n_2 = number of animals recorded and voice printed on the second night
m_2 = number of animals voice printed on night 2 which were also voice printed on night 1 (recaptures)

3 Results and Discussion

3.1 Captive Colony Research

3.1.1 Recording of Lubricious Bays and Voice Printing Methodology Development

Table 4 presents the lubricious bays that were recorded at the captive breeding colony during the study. Recording the calls and the exact identification of the Swift fox emitting the call was hampered by the close proximity of the single pair breeding pens. This became apparent with the calls recorded in 1995, and resulted in another series of lubricious bays being recorded at the captive breeding colony in 1996.

Table 4: Swift fox lubricious bays recorded for the development of a voice printing methodology in 1995 and 1996.

Fox Name	Number of Calls Processed 1995 (1996)
Caesar	4
Cheops	55 (6)
Chomper	66 (14)
Condor	15 (2)
Dotstoysky	(78)
Dakota	(3)
Elegant/ Escapade	38
Elusive	1
Endemic	6 (13)
Esperato	(4)
Evangaline	(2)
Evasive	18
Fortunatus	(5)
Pepe	57 (12)
Rhinehart	(1)
Sinbad	55 (24)
Steve	46 (6)
Thule	(16)
Tonto	4 (153)
Tryal	(39)
Tuffy	35 (37)
Valkyr	(5)

Figure 1 presents a sample of the voice print of the lubricious bay. The SPCP software compared each of the phrases to a library of existing phrases, If the phrase was found in the library then the number of the phrase in the library was attached to the case record. If the phrase was not found in the library , the phrase being examined was attached to the library and the new number was attached to the case record. The results were a list of numbers corresponding to the phrases that were identified in the case being examined. As the number of calls in the library increased each comparison took more time. In the case of the 1995 analysis where there were 159 phrases in the library the analysis of one voice print took approximately five minutes.

The only variable that can be changed in the analysis is the correlation coefficient for the comparison of the phrases with the phrase library. If the coefficient was set to 0.80, then the phrases had to 80% similar to be considered to be the same. As the correlation coefficient approached one the number of phrases that were unique and were stored in the library increased. The question of what was the appropriate correlation coefficient to provide enough information to differentiate between the individual lubricious bays, but not too much information to slow down the analysis was addressed.

This question was examined by analysing a similar subset of lubricious bays from 1995 at R = 0.50 (Appendix 1, 0.80 (Appendix 2) and 0.90 (Appendix 3). The analysis is presented in the appendices as dendrograms of the squared Euclidean distances for the individual calls. It was assumed that if the Rescaled distance of the clusters was under 5 then the cases could be considered to belong to one group. The three tests were run using lubricious bays from five individual animals. At r = 0.50 , 17 phrases were recognised from the six animals and only one cluster represented one individual (Tuffy). At r = .80, 24 phrases were recognised from the six animals and two individuals were recognised by the clusters (Tuffy and El_esc). At r = 0.90, 68 phrases were recognised and four of the six individuals were clustered (Tuffy, El_esc, Chomper, and Cheops). The other two individuals were not consistent in any of the clusters and it was assumed that these animals may have been misidentified during the recording of the lubricious bays.

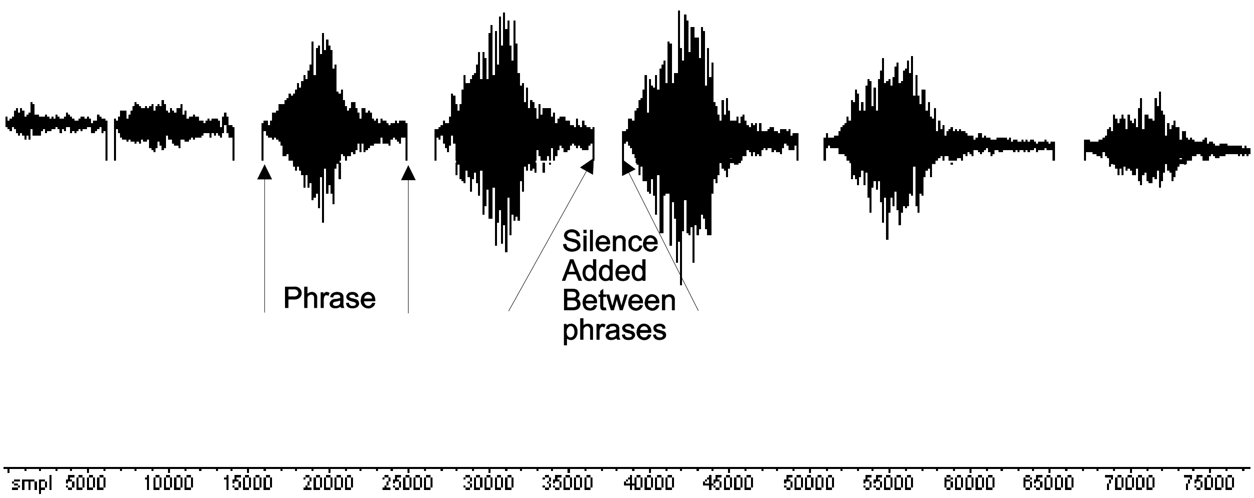


Figure 1: The voice print for Sinbad, showing the seven phrases and the periods of silence placed between the phrases before analysis.

From the above results using the 1995 data, 120 of the highest quality recordings of lubricious bays were analysed using an r = 0.90. This resulted in the identification of 157 individual phrases, from 13 animals. The cluster from this analysis can be found in Appendix 4.

A summary of the individual swift fox represented by each cluster is found in Table 5. The results show that using a clustering distance of 5 there would be 10 individuals identified. The next question was the accuracy of the identification of individuals. Two of the clusters were composed of single individuals. One cluster was not dominated by any individual Swift fox but contained varying numbers of lubricious bays from six individuals. Three individual Swift fox were not dominant in any of the ten clusters. Table 5 also provides a summary of the number of False identifications in each cluster.

Table 5: Summary of the cluster contents for the 1995 analysis.

Cluster	Swift Fox in Cluster	No.of Calls In Cluster	Dominant Swift Fox	Number of False ID's
1	El_esc Pepe Endemic Chomper Sinbad Condor	19 10 1 1 1 1	El_esc	14
2	Evasive Chomper Endemic	4 2 1	Evasive	3
3	Cheops	3	Cheops	0
4	Condor Sinbad Pepe Chomper	7 4 1 1	Condor	6
5	Elusive Endemic Evasive Cheops	1 1 1 1		4
6	Steve Sinbad	4 1	Steve	1
7	Tuffy Chomper Endemic Sinbad	3 2 1 1	Tuffy	4
8	Chomper Endemic Evasive	14 1 4	Chomper	5
9	Sinbad	10		0
10	Evasive Pepe Condor Sinbad Steve Endemic	5 4 3 2 1 1		16

Several factors may have contributed to the results of the 1995 analysis:

1. The recordings were made at night when the accurate identification of the calling Swift fox was difficult.

2. The quality of the recordings may have been affected by the microphone used.

3. Many of the 1996 recordings were made from a second story window near the breeding pens, it was assumed that the location was a significant factor in the misidentification of the calling Swift fox.

The recordings made in 1996 attempted to remedy the perceived problems with the following procedures:

1. More recordings were made at dusk and dawn when there was some light for the identification of calling Swift fox.
2. Recordings were made with a higher quality microphone (Sony ECM 727P)

which was designed for digital sound.

3. All recordings were made from within 20 meters of the calling Swift fox, and in most cases from ground level.

The analysis of the lubricious bays recorded in 1996 was done at r = 0.90 and r = 0.80 (Appendix 5). An examination of the first analysis (r = 0.90) showed that the level of information (197 phrases from 83 calls) produced almost indecipherable results. In comparison the dendrogram resulting from the analysis at r = 0.80 showed the identification of six clusters at a combined distance of 5 (Table 6).

Four of the seven Swift fox used in the 1996 analysis dominated clusters in the analysis. The clusters that contain the three individuals Sinbad, Tryal and Dotosk may provide an insight into the problem of the proper identification of the calling Swift fox. These three Swift fox were in adjoining single pair breeding pens and were separated by a maximum distance of 15 meters. It was possible that some of the calls from these individuals were misidentified in the recording process.

Table 6: Summary of the cluster analysis for the lubricious bays analysed from the 1996 recordings.

Cluster	Swift Fox in Cluster	No. of Calls in Cluster	Dominant Swift Fox	No. of False ID's
1	Tryal Sinbad	10 1	Tryal	1
2	Sinbad Dotosk Tryal	11 2 3	Sinbad	5
3	Dotosk Sinbad Tryal	9 4 1	Dotosk	5
4	Chomper Endemic Tryal Fortun Sinbad	4 3 2 2 1		12
5	Chomper Fortun Cheops Endemic Tryal	3 3 2 2 1		11
6	Tonto Chomper	21 1	Tonto	1

The analysis of the lubricious bays recorded in 1995 and 1996 provided an insight into both the problems and strengths of the methodology. The results indicated that Swift fox can be identified by voice printing their lubricious bays, although the identification, using the present method, was not 100% accurate. The accuracy was affected by:

1. Quality of the recording equipment. It appeared that the use of a microphone with higher sensitivity in 1996 allowed for more accurate identification of some individuals at a lower correlation coefficient (0.80).
2. The ability to accurately

identify the calling Swift fox. The highest period of calling activity occurs at night, which makes the identification of the individual more difficult. This is less of a problem in the application of the method in field studies where the number of responses are more important.

3. Test recording in a large captive colony where there was usually more than one Swift fox calling.

Items 2 and 3 above were less significant when applying the methodology to the field because of the lower density of Swift fox.

The tape recorder used in the 1995 and 1996 work was analogue equipment. It was postulated that the use of digital recording equipment may improve on the quality of the recordings and therefore the ability to analyse the voice prints. This was supported by an apparent improvement in the analytical process when recordings were made with a higher quality microphone in 1996.

3.1.3 Swift fox Calling Patterns and Natural Call Rates

The call patterns for the lubricious bays from the captive breeding colony are shown in Figure 2. Table 7 summarises the rates of calling for the entire day and for various periods of the day. The calling rates began to increase at sunset and continued at elevated rates until dawn. Although there were several peaks during this period there was not enough data collected to relate these peaks to external conditions. From this analysis it was concluded that in the application of voice printing to population estimates of the Swift fox, playback and recording should be concentrated in the period from sunset to dawn.

3.1.3 Development of a Play Back Tape to Elicit Optimum Response

In 13 of the 16 trials resulted in higher numbers of calls during the half-hour of playback than in the half-hour preceding playback; in 12 of these trials, the number of calls during playback was also higher than the number of calls in the half-hour following playback.

Table 7: Summary of the call rates for lubricious bays for the Swift fox captive breeding colony.

Date	Average Call Rate (Calls per 15 minutes)± SD			Maximum Call Rate	
	Over 24 hours	*07:00 to 17:15*	*17:30 to 06:45*	*Calls/15 mins*	*Time*
2-3/3/95	13.79±19.43	0.50±1.60	24.13±20.63	78	03:30
4-5/3/95	13.14±19.80	0.38±1.13	23.06±21.74	110	06:15
5-6/3/95	16.28±22.17	3.50±8.47	26.22±24.39	112	00:00

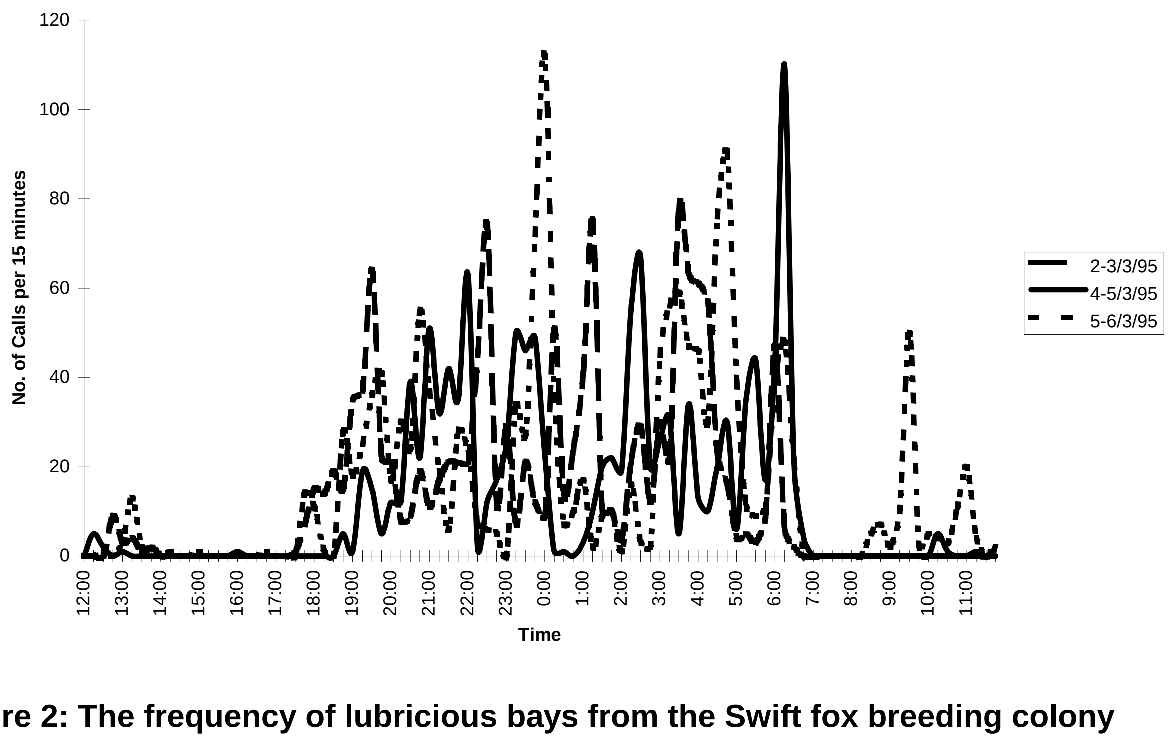


Figure 2: The frequency of lubricious bays from the Swift fox breeding colony over three 24 hr. periods.

The significance of these observations evaluated at p = 0.05 were:

7 tests show significantly **higher** rates of calling **during** playback **than prior to** playback;
7 tests show significantly **higher** rates of calling **during** playback **than after** playback;
1 test shows significantly **higher** rates of calling **prior to** playback **than after** playback; and
2 tests show significantly **higher** rates of calling **after** playback **than prior to** playback

Tape 5 was the only tape that produced significant differences in call rates before, during and after the calling sessions. Although all tapes solicited a response during some of the tests.

Based on the above results the master tape for the field tests was prepared in the same form as Tape 5 with a total of four individual Swift fox lubricious bays, spaced at varying intervals.

3.1.4 Impact of Distance from Swift fox, Weather and Vehicular Noise on Responses

The response rates for the 11 tests of responses over different distances were in conclusive (Appendix 6). Using the student T test three (Test 1, 3 and 9) of the tests showed significant differences between the average response rates before and during the test and during and after the test. During one of these tests (Test 3) the response during the playback was significantly lower than before the playback. In two tests the responses after the playback tape were significantly higher than before the tape. Six of the tests showed no significant response to the tapes.

Significant responses were recorded at distances of 1,000 meters and 400 meters from the nearest Swift fox. The variability of the results led to the conclusion that more work was necessary to determine at what distance the Swift fox would respond to the play back tape. One of the difficulties in these tests was that the breeding colony is located in the transitional grasslands and the single pair pens were, in many cases surrounded by trees. The impact of this on the response was not determined but during the field testing of the methodology it was noted that on a windless night the play back could beheard by the human ear as far as 2 km. from the tape player.

The results of the three vehicle-running tests are shown in Table 9. Using the T-Test to examine the differences in the calling rates before, during and after the running of the vehicle shows that for the two unfamiliar vehicles the call rates before and during vehicular operation were the same but when the unfamiliar vehicle was shut off the call rate dropped significantly. When the familiar vehicle was operated there was no significant change in the call rate.

Continuous weather observations were made during the study at Cochrane Ecological Institute. No relationship could be found between the temperature and calling rates. There may be a relationship between calling rate and wind speed.

During most of the observations on calling rates the wind was light at night, with little

Table 8: Comparison of the Swift fox responses to five playback tapes.

Date:	7.3.95	8.3.95	9.3.95	11.3.95	7.3.95	9.3.95	12.3.95	13.3.95
Time at start:	19:00	3:00	16:40	23:55	23:00	14:40	1:55	11:45
Playback tape:	1	1	1	2	2	2	3	3
Before/During	0.056	0.213	0.017	0.376	0.066	0.138	0.371	0.637
Before/After	0.041	0.088	0.040	0.417	0.012	0.175	0.133	0.857
During/After	0.009	0.055	0.155	0.186	0.090	0.170	0.023	0.630

Date:	7.3.95	8.3.95	9.3.95	13.3.95	8.3.95	9.3.95	11.3.95	13.3.95
Time at start:	21:00	5:00	10:40	15:45	1:00	12:40	21:55	13:45
Playback tape:	3	3	3	4	4	4	5	5
Before/During	0.001	0.012	0.802	0.007	0.005	0.020	0.093	0.000
Before/After	0.218	0.106	0.258	N/A	0.072	0.203	0.276	0.756
During/After	0.001	0.656	0.567	0.007	0.140	0.017	0.031	0.000

(shaded box) Significantly different at p = 0.05

fluctuation. During these nights the calling rates showed great fluctuations. During the day, when calling rates were low, a few instances point towards a possible correlation between light winds and calling (Figure 3). On March 2, 1995 at approximately 13:00 hrs. a light breeze mirrored an increase in calling rate. A similar increase was observed on March 6, 1995 at approximately 10:00 hrs and on March 4, 1995 at approximately 12:30 hrs.

Swift fox actively scent before the breeding season and before they begin to call. It is hypothesised that the dispersion of this scent throughout the colony may prompt calling. Dispersion of the scent by light breezes during the day was believed to prompt the calling that was noted above. If winds were heavy the scent would be more diffuse and the foxes would be less likely to smell it as they would be avoiding the wind in their dens. The behaviour of the Swift fox in relation to courting rituals, the function of scent and the function of calling are poorly understood and require further study.

Table 9: The influence of vehicular activity on Swift fox calling rates.

Date:		14.3.95	15.3.95	15.3.95
Start of monitoring:		23:00	0:15	1:30
Vehicle type:		Unfamiliar car	Unfamiliar car	Familiar truck
	Time From Start	5 Minute Average Call Rate		
	0:00	22	45	8
	0:05	15	22	9
	0:10	16	50	14
	0:15	11	38	19
	0:20	11	46	28
	0:25	6	27	37
Vehicle:	0:30	8	38	42
Running	0:35	23	46	31
	0:40	2	27	20
	0:45	35	30	11
	0:50	38	47	28
	0:55	32	15	14
	1:00	24	10	11
	1:05	17	17	15
	1:10	19	6	9
T-Test	before /during	0.74	0.89	0.20
	during /after	0.10	0.10	0.11
	before /after	0.01	0.05	0.43

(shaded) p>0.05 (not from same population)

3.1.5 End of Mating Season Response to the Play Back Tape

Table 10 summarises the responses to the playback tape when played after the breeding season. Responses were obtained in four of the six tests. In some cases, the responses were believed to be from only one Swift fox. The results indicated that it was possible to elicit a response after the end of the natural calling period.

3.2 Selection of Field Sites

3.2.1 Den Site Survey

Observations on the 21 den sites visited during the summer of 1995 are found in Appendix 7. The location of the sites can be found in Figure 4, and Figure 5. The results of the survey were used for two purposes. The prime purpose was to locate suitable sites for the field testing of the of the voice printing methodology in the winter of 1996. It is known that natal dens were used by Swift fox year after year, even if they were not occupied on a continuous basis over the year (Pruss, 1994). The location of dens that have been active will lead to the probable location of breeding pairs during February and March when the Swift fox will be calling.

The second purpose of the den site survey was to contribute to the selection of release sites for the 1995 captive bred Swift fox releases. This was also related to the voice printing study as the 1995 release sites were prime candidates for the field testing. The release sites are shown on Figure 4.

Table 10: Summary of the responses to the play back tape after the breeding season.

Date:	9.4.95	10.4.95	11.4.95	12.4.95	13.4.95	14.4.95
Time:	10:50 PM	2:15 AM	1:30 AM	3:00 AM	1:30 AM	12:15 AM
Location of Playback (relative to nearest fox):	400m SE	40m E	40m E	40m E	40m E	40m E
Conditions:	Still, clear, cool	Still, cloudy, mild	Still, clear cool	Light breeze, cloudy, cool	Still, light cloud, mild	Still, clear, cool
Time from Start: 0:00	0	0	0	0	0	0
0:05	0	0	0	0	0	0
0:10	0	0	0	0	0	0
Playback 0:15	0	43	0	0	0	0
0:20	0	0	0	0	4	0
0:25	1	0	0	8	6	0
0:30	3	0	0	1	0	0
0:35	0	0	0	0	0	0
0:40	0	0	0	0	0	0
No. of Foxes heard:	Up to 3	3	0	2	2	0

3.2.2 Post Release Monitoring

In November 1995 a survey was conducted of the 1995 captive bred Swift fox release sites. The objective of the survey was to evaluate the success of the captive bred swift fox releases in 1995 (Table 3) and to find locations in the area of Grasslands where the field testing of the voiceprint methodology could be done in the winter of 1996.

The observations made on the initial visit to each of the release sites were:

Site 1: Chandlers, November 30, 1995
The holes at the release site were not being used, with the entrances covered in snow. Tracks were found near the release area as was a den site. Evidence of small rodent kills were present.

Site 2: Masefield PFRA Pasture, November 29, 1995

The holes at the release site were not being used. Tracks and scat were found near by. The swift fox appeared to be using two holes. Scat was found at various spots. Evidence of the fox eating small rodent was also observed.

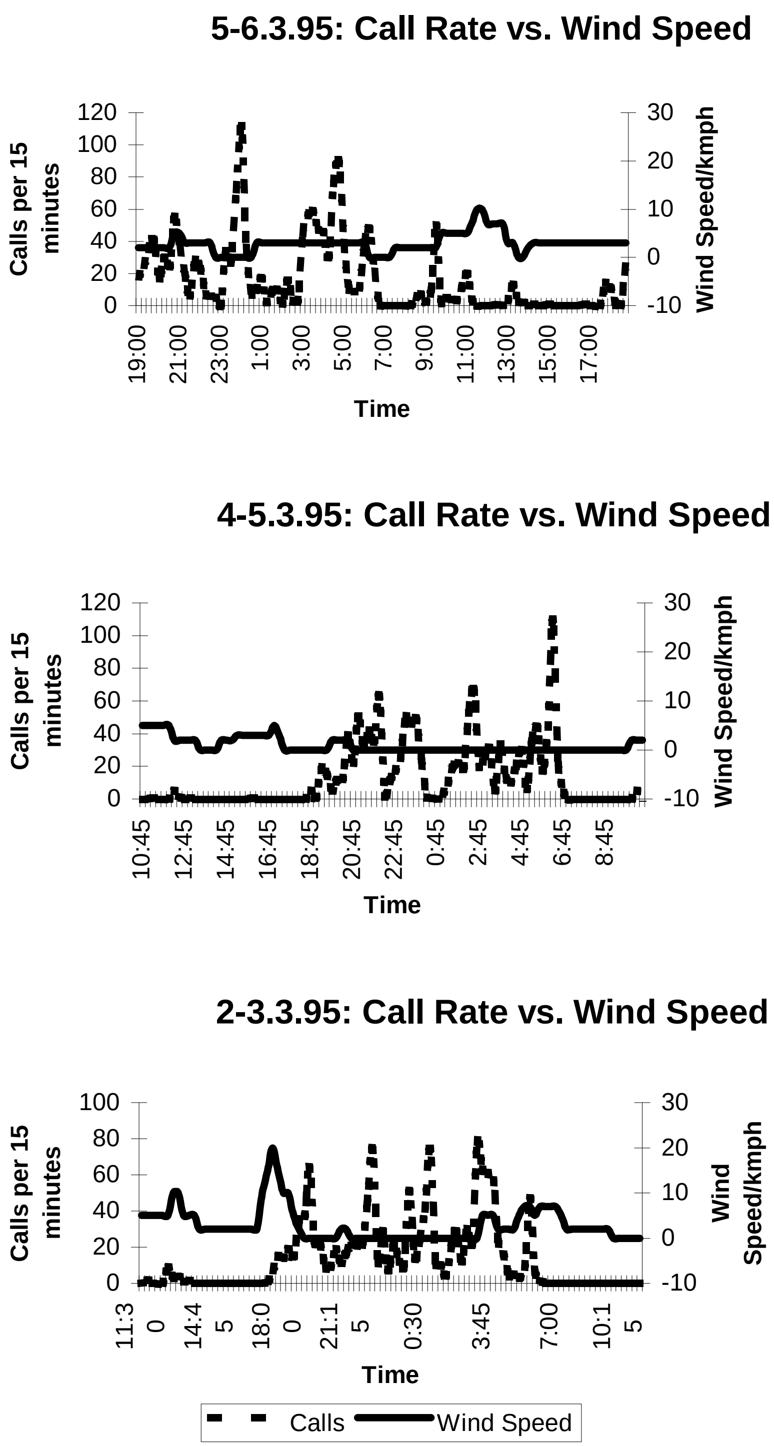


Figure 3: The relationship between the Swift fox calling rate and wind speed.

Site 3: West Block Grasslands National Park, November 28, 1995
The holes at the release site were being used by a rabbit. There was no evidence of swift foxes found in the grid area. Swift foxes have been spotted by park wardens (see below).

Site 4: OK Ranch, December 6, 1995
No holes were found at the release area and no evidence of a swift fox living in the vicinity. A number of coyote scats were found a long the fire lane beside the release area. Badger scat was also found on the fire lane.

Site 5: McLeod Property, December 5, 1995
There was one hole at the release site. The site was near a slough. There was no evidence found of a swift fox living in the vicinity of release area.

Site 6: Lowen Property, December 5,995
The release holes were still being used by the swift fox. Scat was found. A great deal of digging was occurring at two of the holes with the dirt going back in a straight line.

Positive sign of Swift fox activity were found at three of the six release sites in 1995. Because there were no positive sightings of Swift fox an estimate of survival from the 1995 releases could not be made. The grid surveys of the six release areas found numerous signs of Swift fox which are summarised in Table 11. Although no Swift fox were seen during the November monitoring between the time of the present study and the release the staff at Grasslands National Park had observed Swift fox on several occasions (Table 12). The locations on Tables 11 and 12 are also shown on Figure 4. The total number of Swift fox observed by the staff was not known but the wide spacing of the observations indicated that more than one Swift fox was observed.

The post-release monitoring survey during 1995 provided an opportunity to examine the daily activity patterns of Swift fox at two release sites. It also indicated that Swift fox from the fall release had survived to November, although the survival rate could not be estimated. The success of the monitoring was related to the light snow falls during the monitoring period and further confirms that the best time for Swift fox ground searches may be the winter months.

Table 11: Summary of the locations of Swift fox sign found during the monitoring program, November/December, 1995.

Site	SCAT	SMALL RODENT KILL	SPOTS URINATED	DEN SITE
Site 2	E304400 N5437200 E306050 N5436900 E306000 N5460000 E305200 N5437200 E303600 N5437300	E306050 N5436900 E306000 N5460000	E306000 N5436100	E304500 N5437000 E306200 N5435300
Site 1	E308600 N5440600 E308500 N5439000 E307400 N5439000 E307400 N5439000	E308600 N5440600	E308600 N5440600 E309850 N540700	E310100 N5440500 E307700 N5439400
Site 6	E350500 N5439400			

Table 12: Locations and dates of Swift fox sightings by park wardens.

No. of SWIFT Fox	LOCATION (UTM)	Date	TIME
1	E301800 N5451010	10/22/95	7:OOP.M
1	E317100 N5446600	10/22/95	8:00P.M.
1	E321800 N5442000	10/22/95	8:30P.M.
1	E309600 N5443400	11/10/95	8;00P.M.

3.2.3 Data From the Border Area

Although requests were made to obtain data from research being conducted in the border area by a graduate student and other researchers, little cooperation was received. The field testing in this area was therefore based on the 1995 den site survey, the research of by Pruss (1994) and past knowledge of Swift fox distribution.

Pruss(1994) conducted research on the dening behavior of Swift fox in the area located on Figure 5. The location of the most intensive observations was at the junction of Alberta Hwy. 501 and Hwy 48. The exact location of natal den sites were not given in the thesis so the Swift fox activity in 1995-’96 at the locations could not be checked.

3.2.4 Site Selection for 1996 Recall Survey

Although the data that was available on the Swift fox activity in the Alberta-Saskatchewan Border area was not complete, it was known that there was an active Swift fox population in the area bounded by Saskatchewan Hwy 13 and Alberta Hwy 501 to the north, Saskatchewan Hwy 21 to the east, Alberta Hwy 48 to the west and the US border to the south (Figure 5). The border area survey was therefore concentrated in this area.

The data collected from the area of Grasslands National Park indicated extensive Swift fox activity in the southern portion of the West Block and in the north eastern portion of Masefield, PFRA Community Pasture. The survey in the area was therefore concentrated in the West Block of Grasslands National Park and Masefield pasture (Figure 6).

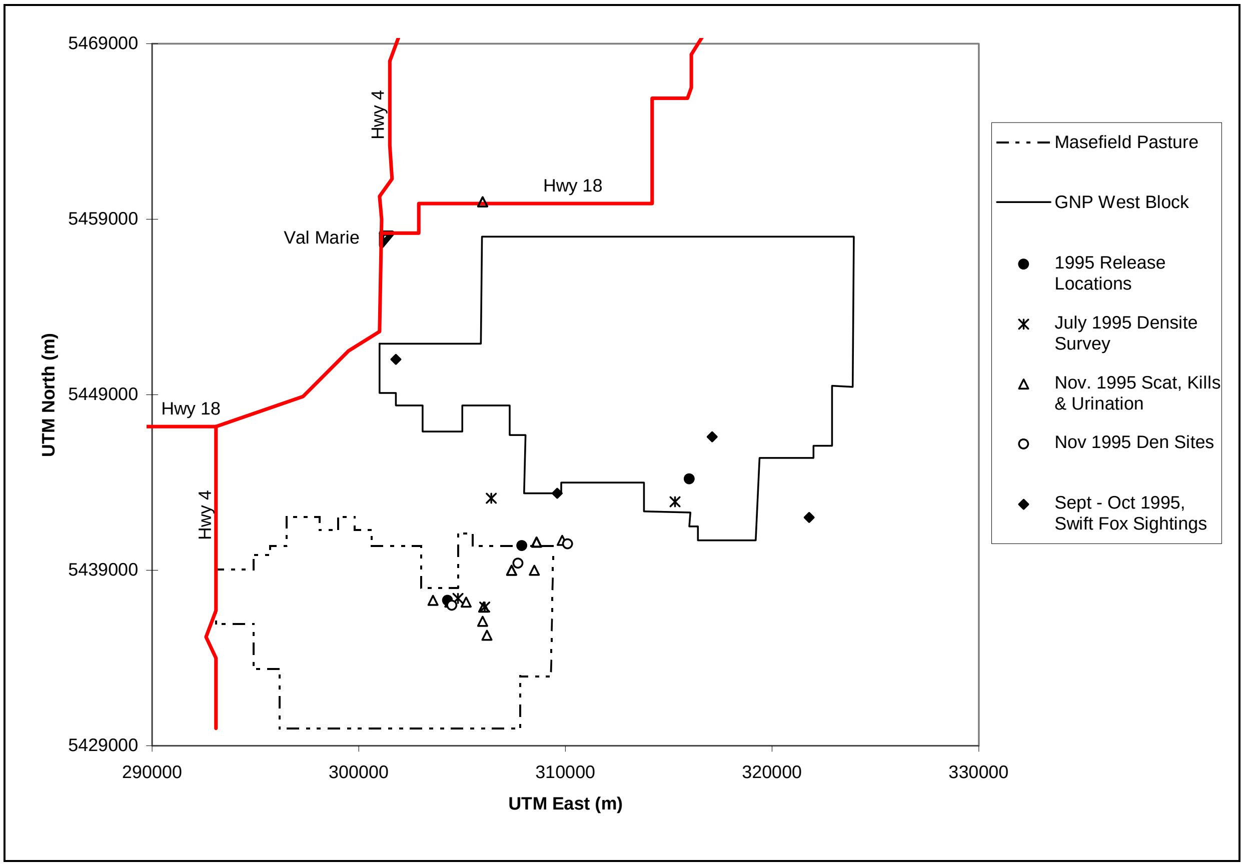
3.3 Field Testing of Methodology

3.3.1 Location of Play Back Responses

The detailed results of the field testing of the methodology are found in Appendix 8 and are summarized in Figure 5 and 6.

During the period of March 8, 1996 to March 31, 1996, 130 individual playback sessions were conducted (92 in Grasslands National Park Area, and 38 in Border Area). Twenty-four positive responses were obtained form the play back sessions (18 in Grasslands National Park Area, and 7 in Border Area). Seven recordings were made of the 24 responses received.

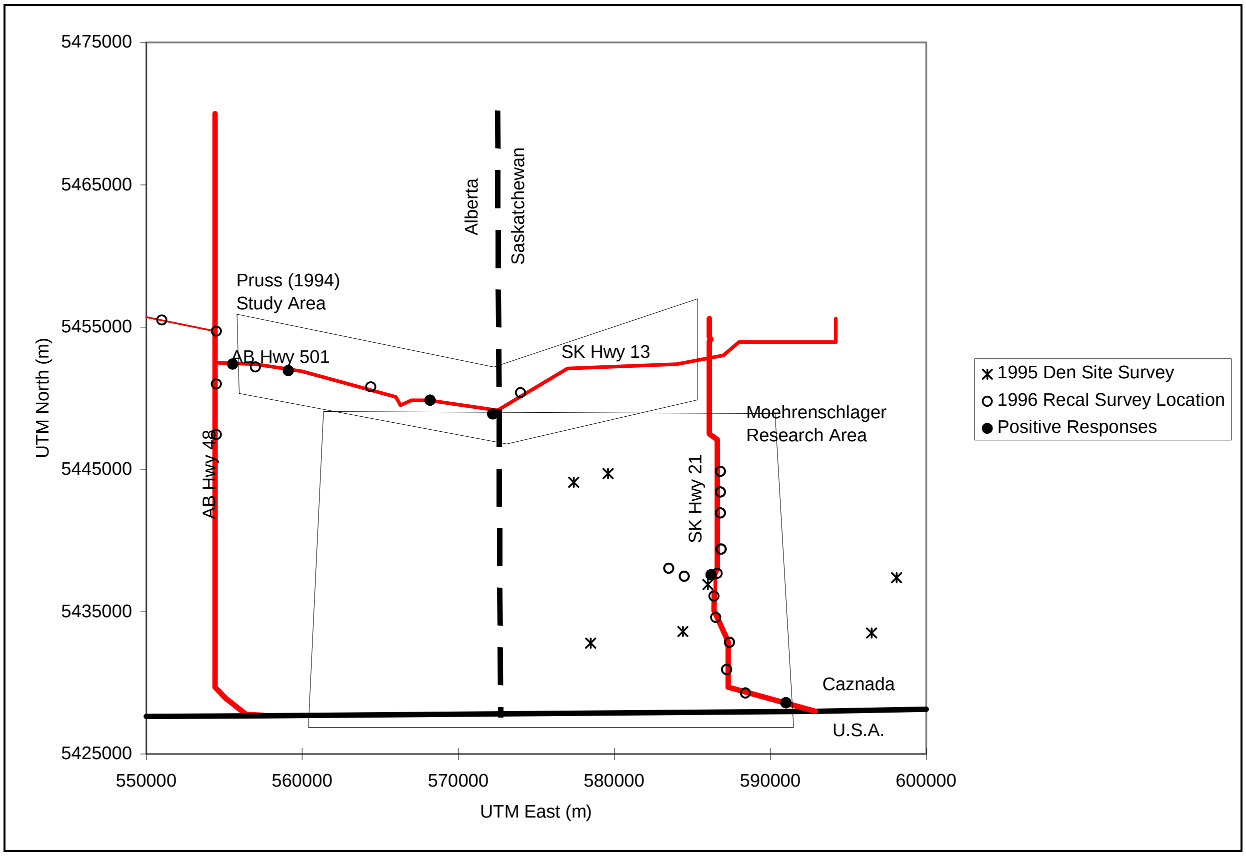
Figure 4: Location of data collection during the site selection for field testing in the Grasslands National Park Area, Saskatchewan.



A comparison of the location of the responses in the Grasslands National Park (Figure 6) area with the site selection data (Figure 4) two of the areas where responses were obtained closely match the den site examined in the summer and fall of 1995. The third set of responses, near the eastern boundary of GNP West Block, was near the location of a Swift fox sighting in the fall of 1995.

The majority of the responses in the border area were concentrated along Alberta Hwy 501 and in the study area of Pruss (1994). One of the other responses was near a den site surveyed in the summer of 1995 near Saskatchewan Hwy 21.

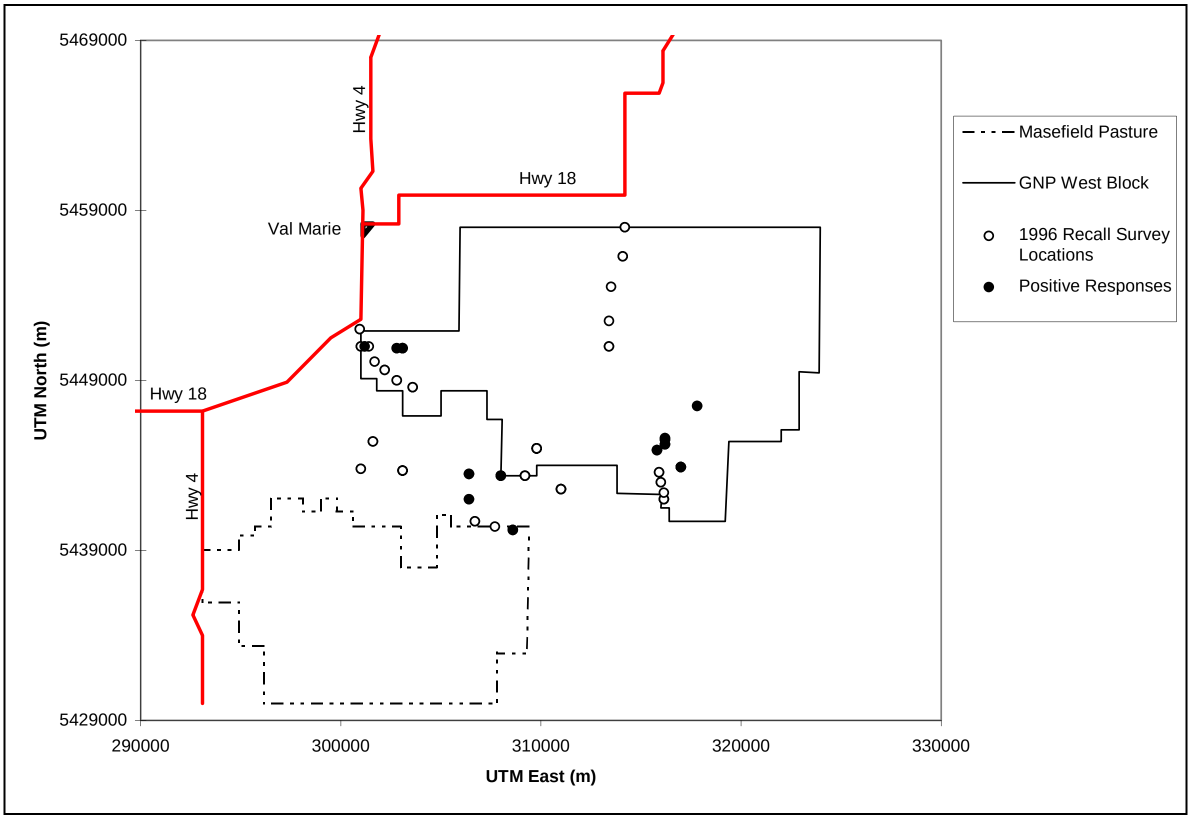
Figure 5: Summary of the den site survey locations and the recall survey results in the Saskatchewan-Alberta border area.



Based on the field results the concept of soliciting responses from Swift fox in the wild to a played tape of lubricious calls was successful. There was no time during the survey that a Swift fox was seen that did not respond to the playback tape.
The methodology outlined called for the solicitation of responses on a systematic 1 km by 1 km grid throughout the two areas. This was not possible for because of the weather and the lack of an All Terrain Vehicle (ATV). When the field work began (March 8, 1996) the weather was cold and many of the access roads to the Masefield Pasture and Grasslands National Park were blocked with snow drifts. The snow prevented access by 4 wheel drive vehicles which were being used. On March 10, 1996 a chinook caused the temperature to raise to well above freezing during the day. This caused a significant snow melt and turned the access roads to melt. At this point the pasture manager for Masefield PFRA Community Pasture, closed the access roads to vehicles, preventing any further work in the area. Similarly the access roads to the GNP West Block became to muddy for travel. From March 10 to 21, the survey in the

GNP West Block area was limited to secondary roads in the area, preventing a complete test of the methodology.

Figure 6: Summary of the Recall survey results in the Grasslands National Park area, 1996.



When the survey moved to the Border Area (March 24, 1996) the temperatures were cold and continued cold throughout the survey in that area. The access to conduct the play back survey on a systematic grid in this area was blocked by heavy snow and snow drifts.

The limited area covered in both study areas was disappointing and means that a full test of the methodology was not possible. The responses obtained in both areas were direct evidence that the methodology works and suggests that if it were done on a systematic grid, population estimates would be possible.

3.3.2 Voice Printing the Field Responses

From the seven sites where recordings of the Swift fox responses were made, 23 individual calls were digitized for analysis. In all cases the recordings were of very poor quality because of wind noise and the distance from the animal which was responding. In an attempt to over come the poor quality of the recording digital amplification and noise reduction were used. Although the lubricious bays recorded were enhanced by these procedures, the calls were distorted.

The analytical procedure described in Section 2.1.1 was used to analyze these calls. The analysis was performed with a correlation coefficient of 0.90 and 0.80. At r = 0.90 all the phrases in the 23 calls were unique and clustering of the calls resulted in 23 clusters of one call each. Similar results were obtained at r = 0.80.

The inability to procure good quality recordings in the field was related to the type of recording equipment used. As noted the use of Digital Audio Tape (DAT) tape recorders would improve quality as would, the use of parabolic microphones. The DAT recorders would reduce background noise and tape “hiss”, the use of the parabolic microphone would allow for better sound concentration and reduce the need for manipulation of the waves before they were analyzed. One of the major problems with recording in the field was wind noise. Methods of reducing the impact of wind noise on the recordings have to be investigated, but it is anticipated that that at wind speeds above approximately 15 km/hr will make the recording of good quality recordings unlikely.

3.3.3 Population Estimates

The reduced access to the study areas prevented the collection of data on a systematic grid and therefore did not permit the application of population estimation techniques to the data.

4 Methodology Evaluation and Future Refinements

The use of voice printing as a non-intrusive population estimator for the Swift fox was extensively studied over a two year period. The progress made in the development of the methodology indicated that the concept has merit and can contribute to the evaluation of the Swift fox populations and other vocal species. The following is a summary of the progress made in the development of the methodology:

1. It was shown that Swift fox lubricious bays could be voice printed but the accuracy of the voice printing was not 100% with the technology and software used.
2. Calling was found to be concentrated from dusk to dawn.
3. Calling was found to be affected by vehicle noise.
4. The Swift fox was shown to respond to a play back tape both in the captive breeding colony and in the field.

The methodology needed further refinements. Some of the refinements were highlighted in the present study, and were:

1. All recordings should be made using Digital Audio Tape (DAT) equipment. This includes both the tape recorder and the microphone.
2. All recordings should be made using a parabolic microphone dish.
3. Field Access must be via All Terrain Vehicle (ATV).

Further study is required on the method of comparing the individual voice prints. Although the SCPC software performs the analysis it is cumbersome to use, takes a long time and requires a fast computer to perform the analysis.

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APPENDIX 1: Dendrogram for Test analysis of 1995 lubricious bays with r = 0.50

* * * * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * * * Dendrogram using Ward Method

```
                          Rescaled Distance Cluster Combine

  C A S E   0         5         10        15        20        25
  Label     +---------+---------+---------+---------+---------+

  sinbad03  -+-----+
  sinbad03  -+     +---+
  el_esc01  ---+---+   I
  el_esc04  ---+       +-----+
  el_esc02  -+-----+   I     I
  el_esc03  -+     +---+     +---+
  el_esc05  ---+---+         I   I
  sinbad05  ---+             I   +-----+
  sinbad02  -----------------+   I     I
  tuffy01   -+---+               I     I
  tuffy03   -+   +---------------+     I
  tuffy04   -----+                     +---------------------+
  cheops03  ---+---+                   I                     I
  sinbad01  ---+   I                   I                     I
  condor01  ---+   +-------+           I                     I
  condor04  ---+-+ I       I           I                     I
  condor02  ---+ +-+       +-----------+                     I
  sinbad04  -----+         I                                 I
  condor03  ---------------+                                 I
  cheops04  ---+---------+                                   I
  chomper2  ---+         I                                   I
  cheops01  -+-+         +-----------------------------------+
  chomper3  -+ +-+       I
  cheops02  ---+ +-------+
  chomper5  -----+       I
  cheops05  -+-----+     I
  chomper1  -+     +-----+
  condor05  -----+-+
  chomper4  -----+
```

APPENDIX 2: Dendrogram for Test analysis of 1995 lubricious bays with r = 0.80

* * * * * * H I E R A R C H I C A L C L U S T E R A N A L Y S I S * * * * * Dendrogram using Ward Method

```
                          Rescaled Distance Cluster Combine
C A S E     0         5        10        15        20        25
  Label     +---------+---------+---------+---------+---------+

  el_esc02  -+
  el_esc03  -+-------+
  el_esc05  -+       +---------------+
  el_esc01  ---+-----+               I
  el_esc04  ---+                     +-----------------+
  cheops01  -+-+                     I                 I
  cheops02  -+ +-----+               I                 I
  chomper5  ---+     +---------------+                 I
  chomper3  ---------+                                 I
  condor01  ---+-+                                     I
  condor02  ---+ +-------+                             +-----+
  chomper1  -----+       I                             I     I
  condor05  ---+---+     +-------------------------+   I     I
  sinbad01  ---+   +---+ I                         I   I     I
  cheops03  -------+   +-+                         I   I     I
  condor03  -----------+                           I   I     I
  sinbad04  -----+                                 +---+     I
  sinbad05  -----+-----+                           I         I
  condor04  -----+     +---------------+           I         I
  chomper4  -----------+               I           I         I
  tuffy01   ---+---+                   +-----------+         I
  tuffy03   ---+   +---------------+   I                     I
  tuffy04   -------+               +---+                     I
  sinbad02  -------+---------------+                         I
  sinbad03  -------+                                         I
  cheops05  ---+-----+                                       I
  chomper2  ---+     +---------------------------------------+
  cheops04  ---------+
```

APPENDIX 3: Dendrogram for Test analysis of 1995 lubricious bays with r = 0.90

* * * * * * H I E R A R C H I C A L C L U S T E R A N A L Y S I S * * * * * Dendrogram using Ward Method

```
                         Rescaled Distance Cluster Combine

C A S E      0         5        10        15        20        25
  Label      +---------+---------+---------+---------+---------+

  condor01   -+---+
  condor02   -+   +-----------+
  sinbad04   -----+           I
  el_esc03   -+---+           I
  el_esc04   -+   +-+         +-----+
  el_esc01   ---+ I I         I     I
  el_esc05   ---+-+ +---+     I     I
  el_esc02   ---+   I   I     I     I
  sinbad03   -------+   +-----+     +-+
  condor04   -----------+           I I
  condor05   -----------+           I I
  cheops01   -+                     I +-+
  cheops03   -+---------------------+ I I
  cheops02   -+                       I I
  cheops04   -----------+-------------+ +-+
  cheops05   -----------+               I I
  sinbad01   -+-----+                   I I
  sinbad05   -+     +---+               I +-------------------+
  condor03   -------+   +---------------+ I                   I
  sinbad02   -----------+                 I                   I
  tuffy03    -+                           I                   I
  tuffy04    -+---------------------------+                   I
  tuffy01    -+                                               I
  chomper1   -+-+                                             I
  chomper5   -+ +-+                                           I
  chomper3   ---+ +---+                                       I
  chomper4   -----+   +---------------------------------------+
  chomper2   ---------+
```

APPENDIX 4: Dendrogram for Call analysis in 1995 @ r = 0.90

```
******HIERARCHICAL CLUSTER ANALYSIS*****
 Dendrogram using Ward Method

                         Rescaled Distance Cluster Combine

     C A S E      0         5        10        15        20        25
  Label      Num  +---------+---------+---------+---------+---------+

  el_esc13.   48   -+
  el_esc14.   49   -+---+
  el_esc21.   54   -+   +---+
  el_esc15.   50   -+   I   I
  el_esc22.   55   -+---+   I
  el_esc10.   46   -+       I
  el_esc16.   51   -+       I
  pepe0006.   82   ---+-+   I
  pepe0008.   84   ---+ I   +-+
  pepe0005.   81   -----+---+ I
  pepe0015.   91   -----+   I I
  pepe0001.   77   -+-+     I I
  pepe0003.   79   -+ +---+ I I
  pepe0002.   78   ---+   I I I
  pepe0009.   85   ---+-+ I I I
  pepe0010.   86   ---+ I I I I
  el_esc06.   42   -+   I I I I
  el_esc08.   44   -+---+ I I I
  el_esc03.   39   -+   I I I I
  el_esc04.   40   -+   I +-+ I
  el_esc02.   38   -+-+ I I   I
  endemic4.   60   -+ I I I   I
  chompr20.   25   -+-+ I I   +-+
  el_esc07.   43   -+ I I I   I I
  el_esc01.   37   -+ I I I   I I
  el_esc09.   45   -+-+ I I   I I
  el_esc05.   41   -+ I +-+   I I
  el_esc12.   47   ---+-+     I I
  pepe0007.   83   ---+ I     I I
  sinbad06.   97   ---+ I     I I
  el_esc17.   52   -+---+     I I
  el_esc18.   53   -+   I     I I
  sinbad03.   94   -----+     I I
  condor05.   30   -----+     I I
  cheops05.    5   ---+-------+ I
  evasiv13.   73   ---+       I I
  chompr17.   22   -+-+       I I
  endemic2.   58   -+ +-----+ I I
  chomper9.   14   ---+     +-+ I
  evasiv01.   63   -+-+     I   I
  evasiv10.   71   -+ +-----+   +-+
  evasiv04.   66   ---+         I I
  cheops01.    1   -+           I I
  cheops03.    3   -+-----------+ I
  cheops02.    2   -+           I I
  condor01.   26   -+---+       I I
  condor02.   27   -+   +-----+ I I
  sinbad04.   95   ---+-+     I I I
  sinbad07.   98   ---+ I     I I I
  pepe0004.   80   -----+     +-+ I
  condor04.   29   ---+---+   I   +-+
  condor11.   36   ---+   I   I   I I
  condor06.   31   ---+   +---+   I I
  condor08.   33   ---+---+       I I
  chomper2.    7   ---+   I       I I
  sinbad01.   92   ---+-+ I       I I
  sinbad05.   96   ---+ +-+       I I
  condor03.   28   -----+         I +---+
```

```
elusive1.   56   -+-+           I I   I
endemic3.   59   -+ +-+         I I   I
evasiv03.   65   ---+ +---------+ I   I
cheops04.    4   -----+           I   I
steve004.  114   ---+             I   I
steve005.  115   ---+-------+     I   I
steve007.  116   ---+       +-----+   +-----------------+
sinbad20.  111   ---+---+   I         I                 I
steve008.  117   ---+   +---+         I                 I
steve002.  112   -------+             I                 I
tuffy003.  119   -+                   I                 I
tuffy004.  120   -+-----+             I                 I
tuffy001.  118   -+     +-----+       I                 I
chompr10.   15   -+-+   I     I       I                 I
chompr13.   18   -+ +---+     +-------+                 I
endemic6.   62   ---+         I                         +---------+
sinbad02.   93   -------------+                         I         I
chomper5.   10   -+                                     I         I
chomper7.   12   -+-+                                   I         I
chomper1.    6   -+ +-------+                           I         I
chomper3.    8   ---+       I                           I         I
chomper4.    9   ---+       I                           I         I
chomper8.   13   -+         I                           I         I
endemic1.   57   -+         I                           I         I
chompr16.   21   -+-+       I                           I         I
chompr12.   17   -+ +-+     +---------------------------+         I
chompr14.   20   -+-+ I     I                                     I
chompr18.   23   -+   I     I                                     I
chompr19.   24   -+   +-+   I                                     I
evasiv09.   70   -+-+ I I   I                                     I
chomper6.   11   -+ I I I   I                                     I
chomor15.   19   -+ +-+ +---+                                     I
evasiv12.   72   -+-+   I                                         I
evasiv18.   76   -+ I   I                                         I
chompr11.   16   ---+   I                                         I
evasiv02.   64   -------+                                         I
sinbad09.   99   -+-+                                             I
sinbad16.  106   -+ +-----+                                       I
sinbad10.  101   ---+     I                                       I
sinbad08.  100   -+-+     I                                       I
sinbad13.  104   -+ I     +-------------+                         I
sinbad11.  102   -+ I     I             I                         I
sinbad14.  105   -+-+---+ I             I                         I
sinbad15.  107   -+ I   +-+             I                         I
sinbad19.  110   ---+   I               I                         I
sinbad12.  103   -------+               I                         I
evasiv05.   67   -+-+                   +-------------------------+
sinbad17.  108   -+ +---+               I
condor07.   32   -+-+   I               I
evasiv06.   68   -+     +-------+       I
evasiv07.   69   ---+---+       I       I
pepe0011.   87   ---+   I       I       I
sinbad18.  109   -+     I       I       I
steve003.  113   -+     I       +-------+
endemic5.   61   -+-+   I       I
evasiv15.   75   -+ +---+       I
evasiv14.   74   ---+           I
condor09.   34   -+-----------+ I
condor10.   35   -+           +-+
pepe0012.   88   -+-+         I
pepe0014.   90   -+ +---------+
pepe0013.   89   ---+
```

APPENDIX 5: Dendrogram for Call analysis in 1996 @ r = 0.80

Rescaled Distance Cluster Combine

```
  C A S E                0         5        10        15        20        25
  Label                  +---------+---------+---------+---------+---------+
  tryal012               -+
  tryal012               -+
  tryal006               -+
  sinbad04               -+-+
  tryal010               -+ I
  tryal010               -+ +-+
  tryal011               -+ I I
  tryal011               -+-+ +---------------------+
  tryal008               -+   I                     I
  tryal002               -+---+                     I
  tryal005               -+                         I
  sinbad07               -+-+                       +-----+
  sinbad18               -+ +-+                     I     I
  dotosk05               -+ I I                     I     I
  sinbad06               -+-+ I                     I     I
  sinbad11               -+   +---------------------+     I
  dotosk07               -+   I                           I
  sinbad10               -+---+                           I
  sinbad05               -+   I                           I
  sinbad16               -+-+ I                           I
  tryal003               -+ I I                           I
  sinbad09               -+ +-+                           I
  sinbad12               -+ I                             I
  sinabd03               -+-+                             I
  sinbad02               -+                               I
  tryal004               -+                               +---------------+
  sinbad08               -+-+                             I               I
  sinbad17               -+ +-------+                     I               I
  sinbad13               ---+       I                     I               I
  dotosk03               -+---+     +-----------+         I               I
  dotosk04               -+   I     I           I         I               I
  dotosk02               -+-+ +-----+           I         I               I
  dotosk11               -+ I I                 I         I               I
  dotosk12               -+-+-+                 I         I               I
  sinbad14               -+ I                   I         I               I
  dotosk01               -+ I                   I         I               I
  dotosk09               -+ I                   I         I               I
  dotosk10               -+-+                   I         I               I
  dotosk08               -+                     I         I               I
  endem002               -+---------+           +---------+               I
  endem003               -+         I           I                         I
  chompr05               -+-+       I           I                         I
  endem05                -+ +-+     I           I                         I
  chompr01               -+-+ I     +---+       I                         I
  chompr04               -+   I     I   I       I                         I
  sinbad01               -+   I     I   I       I                         I
  tryal007               -+-+ I     I   I       I                         I
  fortun04               -+ +-+-----+   I       I                         I
  chompr07               ---+ I         I       I                         I
  tryal001               ---+ I         I       I                         I
  fortun06               -----+         +-------+                         I
  chompr03               -+-----+       I                                 I
  fortun03               -+     I       I                                 I
  cheops02               -+     I       I                                 I
  tryal009               -+-+   +---+   I                                 I
  fortun05               -+ I   I   I   I                                 I
  chompr02               ---+   I   I   I                                 I
  cheops01               ---+---+   +---+                                 I
  fortun02               ---+       I                                     I
  chompr06               -+-----+   I                                     I
  endem004               -+     +---+                                     I
  endem001               -----+-+                                         I
  fortun01               -----+                                           I
  tonto013               -+                                               I
  tonto015               -+---+                                           I
  tonto009               -+   I                                           I
  tonto019               -+   I                                           I
  tonto021               -+   +-----+                                     I
  tonto002               -+-+ I     I                                     I
  tonto016               -+ I I     I                                     I
  tonto005               -+ +-+     I                                     I
  tonto010               -+-+       I                                     I
  tonto020               -+ I       I                                     I
  tonto001               -+-+       +-------------------------------------+
  tonto006               -+ I       I
  tonto008               ---+       I
  tonto011               -+         I
  tonto018               -+-+       I
  tonto014               -+ +---+   I
  tonto017               ---+   I   I
  tonto003               -+     +---+
  tonto022               -+     I
  tonto004               -+---+ I
  tonto007               -+   +-+
  chompr08               -----+
```

APPENDIX 6: The responses of Swift fox to a playback tape from various distances.

Trial #		1	2	3	4	5	6	7	8	9	10	11
Time from												
Start:	0:00	9	21	21	26	17	0	1	0	18	0	1
	0:05	5	13	17	26	11	0	0	0	23	0	0
	0:10	8	7	15	23	2	0	0	2	26	1	0
	0:15	13	12	12	30	6	0	0	6	14	0	0
	0:20	7	15	6	41	8	0	0	12	9	0	0
	0:25	20	16	11	45	9	0	0	39	22	0	0
Playback:	0:30	21	32	4	33	9	3	0	83	32	0	1
	0:35	16	25	5	19	7	11	0	39	38	1	1
	0:40	15	17	6	25	8	3	2	46	32	2	0
	0:45	13	8	6	21	16	6	0	45	36	0	0
	0:50	9	23	5	35	14	0	0	23	23	0	0
	0:55	9	31	29	18	13	0	0	26	21	0	0
	1:00	5	46	37	10	21	0	1	39	8	0	0
	1:05	11	30	42	2	26	1	0	15	19	1	2
	1:10	15	9	21	9	27	0	0	13	5	0	0
	Befor/During	0.05	0.12	0.01	0.31	0.71	0.17	0.53	0.06	0.00	0.28	0.27
T Test	Before/After	1.00	0.14	0.20	0.02	0.01	0.29	1.00	0.06	1.00	1.00	0.67
	During/After	0.03	0.69	0.03	0.17	0.01	0.18	0.56	0.13	0.00	0.30	0.63

Appendix 7: Field Notes from Den Site Survey

Den 1, UTM 586000 5449000
This den site is located on Buchanan property. No Swift fox evidence was observed There were a large number of badger holes in the area. Ground squirrel were also present in the area.

Den 2, UTM 598100 5460200
This den site was located between Rhino pastures and the Wagner property. Mrs Wagner indicated that they have not observed swift foxes in the area for a several years. The Rhino pasture area was walked. There were very few holes and no gopher population present in this particular area.

Den 3, UTM 578500 5443800
The den location was found between Joe Saville property and the Willow Creek property. No evidence of swift fox was found. Both properties had a number of holes and a high ground squirrel population. Insects were abundant.

Den 4, Utm 596500 5435500
When approaching the den site in Govenlock pasture, a coyote was spotted laying in the area. The coyote moved away as we approached the site. The holes in the area had large entrance with measurement being 30cm to 50cm. There were numerous coyote scat in the area. Other holes were also present and the area had a good ground squirrel population. No swift fox sign were spotted.

Den 5, 584400 5470300
This den site was found on the Pridmore property. No swift fox sign was found and the den site had been cultivated.

Den 6, 577400 5436300
The den site was located on the Buchanan property. The den had five entrance. The entrance were filled in by rocks or animal debris such skulls. No swift fox sign was observed. This particular area was observed to have few other animal signs with few holes.

Den 7, UTM 579600 5466700
This den site was located on Beierback's property. There was evidence of fresh badger digging in the area and numerous ground squirrel. There was no sign of swift foxes living in the area.

Den 8, UTM 506300 5443100
This den site was located in the Nashlyn Pasture. Various holes were found in the area but no signs of swift foxes being presented. The gophers were very strong in the area.

Den 9, UTM 370500 5432000
Den 9 is located in the East Block of Grasslands National Park. The den had vegetation in the entrance, with spider webs across the entrance. There was no scat found at the den.

Den 10, UTM 367700 5442500
Various holes found in the area which also had a high ground squirrel population. No evidence for swift foxes found in the area.

Den 11, UTM 350300 5439500
Holes were in abundant in this area, but no signs of swift fox were found.

Den 12, UTM 370000 5432000
Den 12 is also located in the East Block of Grasslands National Park. The entrance had spider webs. No scat found in the area of the den.

Den 13, UTM 306400 5443100
Very few holes located in this area. No visible signs of a swift fox living in the area.

Den 14, UTM 315300 5442900

This den is located in the West Block of Grasslands National Park. There was no fox scat located at this den. Porcupine scat was found at one of the den entrance along with coyote scat. Four coyotes were spotted on the south hillside of the coulee in which this den is located at. Two coyotes came down to the den area and they proceeded to dig at one of the den entrance way. Swift foxes were not seen to live in these holes. A den survey was completed, because evidence of swift fox was found near this area. Scat was found along the an old cart trail UTM 316200 5444800 and 316200 5444700. Five swift foxes were seen night lighting on August 11, 1995 at11:15p.m. (UTM 316100 5443400).

Den 15, UTM 306100 5436900
This den is located in Masefield Pasture. No scat was found at the den entrance or along the cart trail. The den survey was completed, because scat was found in this area in May of 1995, March of 1995 and November of 1994. No visual siting of a swift fox occurred during the den survey.

Den Site 16, UTM 304800 5437400

Den 16 was located in Masefield Pasture. No swift fox ign was found in the general area of the den site, but scat was found 1.5 km away along a fence line. A den survey was conducted at this site because scat was found there in May 1995, March 1995 and November 1994. No Swift fox were spotted in the area during the survey.

Den 17, UTM 369500 5432800
Den 17 is located In the East Block. No scat was found at the den site, but swift fox scat was located across the cart trail from this den location.

Den 18, UTM 370100 5433500
The den had a black widow spider at the entrance. No scat found at the den site.

Den 19, UTM 370400 5433600
This den site was located in the East Block. Swift fox scats were found at the entrance. The scat was not fresh. During the 4 day stay in the East Block no swift fox approached this site. Because of the scat, the den survey was completed. Also on the third night of spot lighting a swift fox was picked up running along the cart trail that runs north and south (approximate 11:30p.m. UTM 768700 5431200).

Den 20, UTM 374600 5444100
Various holes were found in this areas, but no visible evidence of swift fox.

Den 21, UTM 375100 5444700
Various holes were found in this areas, but no visible evidence of swift fox.

Appendix 8: Summary of data from the Recall Survey Conducted in 1996

DATE	UTM East	UTM North	TIME	No. Seen	RESPONSE	TAPE Reference	Tape ID	WIND (km/hrk	TEMP.
8/3/96	316150	5442000	5:45		N			0	-25
	316150	5442000	6:15		N			0	-25
	315990	5443000	6:45		N			0	-25
	315900	5443600	7:45		N			0	-25
	315800	5444900	8:45		Y-2	TO FAR AWAY		0	-25
	316200	5445600	9:15		N			0	-20
9/3/96	316150	5442000	6:45		N			4	-20
	316150	5442000	7:15		N			4	-20
	316150	5442400	8:15		N			4	-20
	315990	5443000	8:45		N			4	-20
	315900	5443600	9:30		N			4	-20
	315800	5444900	10:00		Y-2	NO		4	-20
	316200	5445600	10:20		N			4	-5
10/3/96	317000	5443900	7:00					0	-5
	317000	5443900	7:20	2	Y-27+8	29-129	1A	0	-5
	316200	5445250	8:30	1	Y-37	178-453	1A	0	-5
	316200	5445500	9:00	SAME 8:30	3	NO		0	-5
	317800	5447500	9:45	SAME 8:30	Y-10	NO		0	-2
11/3/96	303100	5450900	7:15		Y-2	NO		0	-2
	303100	5450900	7:30					0	-2
	303100	5450900	7:50					0	-2
	302800	5450900	8:15					0	-2
	301200	5451000	8:45					0	-2
	301400	5451000	9:30		N			0	-2
	301000	5451000	10:00		N			0	-2
	301000	5451000	10:20		N			0	-2
12/3/96	303600	5448600	7:00		N			0	-2
	303600	5448600	7:30		N			0	-2
	303600	5448600	7:50		N			0	-2
	302800	5449000	8:20		N			0	-2
	302800	5449000	8:40		N			0	-2
	302200	5449600	9:20		N			0	-2
	302200	5449600	9:40		N			0	-2
	301700	5450100	10:10		N			0	-2
13/03/96	317000	5443900	7:30		Y-3	553	2B	0	-2

	317000	5443900	8:00		N			0	-2
	317000	5443900	8:20		N			0	-2
	316200	5445250	9:00		N			0	-2
14/03/96	313400	5451000	7:00		N			2	-2
	313400	5451000	7:25		N			2	-2
	313400	5452500	8:50		N			2	-2
	313500	5454500	9:20		N			2	-2
	314100	5456300	9:40		N			2	-2
	314100	5456300	10:10		N			2	-2
	314200	5458000	10:40		N			2	-2
	314200	5458000	11:00		N			2	-2
16/03/96	309800	5445000	5:20		N			7	-2
	309800	5445000	5:40		N			7	-2
	309800	5445000	6:05		N			7	-2
	309200	5443400	7:50		N			7	-2
	309200	5443400	8:10		N			7	-2
	311000	5442600	8:30		N			7	-2
	311000	5442600	8:55		N			7	-2
	308000	5443400	9:30		N			7	-2
	308000	5443400	9:50		N			7	-4
17/03/96	309800	5445000	5:20		N			6	-4
	309800	5445000	5:40		N			6	-4
	309800	5445000	6:05		N			6	-4
	309200	5443400	7:50		N			6	-4
	309200	5443400	8:10		N			6	-4
	311000	5442600	8:30		N			6	-4
	311000	5442600	8:55		N			6	-4
	308000	5443400	9:30		N			6	-4
	308000	5443400	9:50		N			6	-10
18/03/96	309800	5445000	7:30		N			6.5	-10
	309800	5445000	7:50		N			6.5	-10
	309800	5445000	8:10		N			6.5	-10
	309200	5443400	8:50		N			6.5	-10
	309200	5443400	9:15		N			6.5	-10
	311000	5442600	10:00		N			6.5	-10
	311000	5442600	10:20		N			6.5	-10
	308000	5443400	10:50	2	Y-23	434-453	3A	6.5	-10
	303100	5443700	11:30		N			6.5	-10
	303100	5443700	11:50		N			6.5	-10
	300950	5452000	12:15	1	N			6.5	-5
20/03/96	306400	5443500	8:30	1	Y-5	57-94	3B	0	-5
	303100	5443700	9:15		N			0	-5
	303100	5443700	9:40		N			0	-5
	301000	5443800	10:10		N			0	-5

	301000	5443800	10:30		N			0	-5
	301600	5445400	11:15	1	N			6	-5
21/03/96	308600	5440200	8:30		N			2	-5
	308600	5440200	9:50		Y-2	TO FAR AWAY TO PICK-UP		2	-5
	307700	5440400	10:40		N			2	-5
	306700	5440700	11:30		N			2	-5
	306700	5440700	11:50		N			2	-5
	306400	5442000	12:30	2	WARNING			2	-5
	306400	5443500	1:00		N			2	-5
	303100	5443700	1:30		N			2	-5
	303100	5443700	1:50		N			2	-5
	301600	5445400	2:25		N			2	-5
	300950	5452000	3:05		N			4	-25
24/03/96	591000	5428600	7:30		Y-2	NO		8	-25
	588400	5429300	8:00		N			8	-25
	587200	5430950	8:30		N			8	-25
	587400	5432850	9:00		N			8	-25
25/03/96	591000	5428600	7:30		Y-2	NO		6	-25
	588400	5429300	8:00		N			6	-25
	587200	5430950	8:30		N			6	-25
	587400	5432850	9:00		N			6	-25
	586500	5434600	9:30		N			6	-25
	586400	5436100	10:00		N			6	-25
	586600	5437700	10:30		N			6	-25
	586850	5439400	11:00		N			6	-17
26/03/96	583500	5438050	7:30		N			4	-17
	584500	5437500	8:00		N			4	-17
	586200	5437600	8:30	NONE	2	TAPE DAMAGED		4	-17
	586850	5439400	9:00		N			4	-17
	586800	5441950	9:30		N			4	-17
	586800	5443400	10:00		N			4	-17
	586800	5444850	10:30		N			4	-15
27/03/96	583500	5438050	7:30		N			4	-15
	584500	5437500	8:00		N			4	-15
	586200	5437600	8:30		N			4	-15
	586850	5439400	9:00		N			4	-15
	586800	5441950	9:30		N			4	-15
	586800	5443400	10:00		N			4	-15
	586800	5444850	10:30		N			4	-8
29/03/96	555550	5452400	8:00	2	Y23+2	04-166	7B	0	-8
	557000	5452200	9:00		N			0	-8
	559100	5451950	9:30	1	Y-2	507-511	7B	0	-8
	564400	5450800	10:00		N			0	-8

	568200	5449850	10:30		N			0	-15
30/03/96	554500	5447450	8:00		N			12	-15
	554500	5451000	9:00		N			12	-15
	554500	5454700	9:30		N			12	-15
	551000	5455500	10:00		N			12	-16
31/03/96	568200	5449850	8:00	1	Y-TO WINDY FOR MICROPHONE to Pick Up			20	-16
	572200	5448900	8:40	1-RADIO Collar	Y-TO WINDY FOR MICROPHONE to Pick Up			20	-16
	574000	5450400	9:30		N			20	