
Inventory Methods for Bats

Standards for Components of British Columbia's Biodiversity No. 20

Prepared by
Ministry of Environment, Lands and Parks
Resources Inventory Branch
for the Terrestrial Ecosystems Task Force
Resources Inventory Committee

March 13, 1998

Version 2.0

© The Province of British Columbia
Published by the
Resources Inventory Committee

Canadian Cataloguing in Publication Data

Main entry under title:

Inventory methods for bats [computer file]

(Standards for components of British Columbia's biodiversity; no. 20)

Previously issued as: Standardized inventory methodologies for components of British Columbia's biodiversity. Bats / P.F.J. Garcia, 1997.

Available through the Internet.

Issued also in printed format on demand.

Includes bibliographical references: p.

ISBN 0-7726-3471-8

1. Bats - British Columbia - Inventories - Handbooks, manuals, etc. 2. Ecological surveys - British Columbia - Handbooks, manuals, etc. I. Garcia, P. F. J. Standardized inventory methodologies for components of British Columbia's biodiversity. Bats. II. BC Environment. Resources Inventory Branch. III. Resources Inventory Committee (Canada). Terrestrial Ecosystems Task Force. IV. Series.

QL737.C5I58 1998

599.47'09711

C98-960037-8

Additional Copies of this publication can be purchased from:

Superior Repro

#200 - 1112 West Pender Street

Vancouver, BC V6E 2S1

Tel: (604) 683-2181

Fax: (604) 683-2189

Digital Copies are available on the Internet at:

<http://www.for.gov.bc.ca/ric>

Preface

This manual presents standard methods for inventory of Bats in British Columbia at three levels of inventory intensity: presence/not detected (possible), relative abundance, and absolute abundance. The manual was compiled by the Elements Working Group of the Terrestrial Ecosystems Task Force, under the auspices of the Resources Inventory Committee (RIC). The objectives of the working group are to develop inventory methods that will lead to the collection of comparable, defensible, and useful inventory and monitoring data for the species component of biodiversity.

This manual is one of the Standards for Components of British Columbia's Biodiversity (CBCB) series which present standard protocols designed specifically for group of species with similar inventory requirements. The series includes an introductory manual (Species Inventory Fundamentals No. 1) which describes the history and objectives of RIC, and outlines the general process of conducting a wildlife inventory according to RIC standards, including selection of inventory intensity, sampling design, sampling techniques, and statistical analysis. The Species Inventory Fundamentals manual provides important background information and should be thoroughly reviewed before commencing with a RIC wildlife inventory. RIC standards are also available for vertebrate taxonomy (No. 2), animal capture and handling (No. 3), and radio-telemetry (No. 5). Field personnel should be thoroughly familiar with these standards before engaging in inventories which involve either of these activities.

Standard data forms are required for all RIC wildlife inventory. Survey-specific data forms accompany most manuals while general wildlife inventory forms are available in the Species Inventory Fundamentals No. 1 [Forms] (previously referred to as the Dataform Appendix). This is important to ensure compatibility with provincial data systems, as all information must eventually be included in the Species Inventory Datasystem (SPI). For more information about SPI and data forms, visit the Species Inventory Homepage at: http://www.env.gov.bc.ca/wld/spi/ric_manuals/

It is recognized that development of standard methods is necessarily an ongoing process. The CBCB manuals are expected to evolve and improve very quickly over their initial years of use. Field testing is a vital component of this process and feedback is essential. Comments and suggestions can be forwarded to the Elements Working Group by contacting:

Species Inventory Unit
Wildlife Inventory Section, Resource Inventory Branch
Ministry of Environment, Lands & Parks
P.O. Box 9344, Station Prov Govt
Victoria, BC V8W 9M1
Tel: (250) 387 9765

Acknowledgments

Funding of the Resources Inventory Committee work, including the preparation of this document, is provided by the Corporate Resource Inventory Initiative (CRII) and by Forest Renewal BC (FRBC). Preliminary work of the Resources Inventory Committee was funded by the Canada-British Columbia Partnership Agreement of Forest Resource Development FRDA II.

The Resources Inventory Committee consists of representatives from various ministries and agencies of the Canadian and the British Columbia governments as well as from First Nations peoples. RIC objectives are to develop a common set of standards and procedures for the provincial resources inventories, as recommended by the Forest Resources Commission in its report "The Future of our Forests".

For further information about the Resources Inventory Committee and its various Task Forces, please contact:

The Executive Secretariat
Resources Inventory Committee

840 Cormorant Street

Victoria, BC V8W 1R1

Tel: (250) 920-0661

Fax: (250) 384-1841

<http://www.for.gov.bc.ca/ric>

Terrestrial Ecosystems Task Force

All decisions regarding protocols are the responsibility of the Resources Inventory Committee. Background information and protocols presented in this version are based on substantial contributions from Scott Grindal. In addition, Patrick F.J. Garcia and Robert M. R. Barclay contributed to an earlier unpublished draft, *Preliminary Inventory Manual for Sampling British Columbia's Bats* with editorial assistance from Tom Ethier and Ann Eriksson. Mark Brigham, Susan Holroyd, and Don Thomas were also involved in valuable discussions regarding this draft manual.

The Standards for Components of British Columbia's Biodiversity series is currently edited by James Quayle with data form development by Leah Westereng.

Table of Contents

Preface.....	iii
Acknowledgments.....	v
1. INTRODUCTION.....	1
2. INVENTORY GROUP.....	3
3. Protocol (General).....	5
3.2 Survey Standards	7
3.2.1 Time of Year	7
3.2.2 Time of Day	7
3.2.3 Environmental Conditions	7
3.2.4 Morphometric Measurements, Sex, Age, & Reproductive Assessment.....	8
3.2.5 Habitat Standards	10
3.2.6 Survey Design Hierarchy	10
3.2.7 Combining Techniques to Survey Bats.....	12
4. Presence/Not detected & Relative Abundance	15
4.1 Capture.....	15
4.1.1 Mist Nets.....	15
4.1.2 Harp Traps	17
4.2 Detection.....	19
4.2.1 Visual Detection	19
4.2.2 Acoustic Detection.....	19
4.2.3 Light Tagging.....	24
4.2.4 Precautions and Limitations.....	25
4.3 Protocol: Presence/Not detected & Relative Abundance	27
4.3.1 Office procedures.....	27

Biodiversity Inventory Methodology - Bats

4.3.2 Sampling design 27

4.3.3 Sampling effort 27

4.3.4 Personnel 27

4.3.5 Equipment 28

4.3.6 Preliminary fieldwork 29

4.3.7 Field Procedures 29

4.3.8 Data analysis 32

5. Absolute Abundance 33

5.1 Roost counts 33

5.1.1 Hibernacula 33

5.1.2 Radio Telemetry 34

5.2 Protocol: Absolute Abundance 36

5.2.1 Office procedures 36

5.2.2 Sampling design 36

5.2.3 Sampling effort 36

5.2.4 Personnel 36

5.2.5 Equipment 37

5.2.6 Preliminary fieldwork 37

5.2.7 Field procedures 38

5.2.8 Data analysis 39

Glossary 40

Literature Cited 43

Appendix A. 49

List of Figures

Figure 1. Forearm (FA) and other measurements (From van Zyll de Jong, 1985).	9
Figure 2. Finger joint of (a) juvenile (tapered, and epiphyseal plates should be visible with the aid of a flashlight illuminating the wing) and (b) adult (nobby and opaque) (From Nagorsen and Brigham, 1993).	10
Figure 3. RIC species inventory survey design hierarchy with examples.	11
Figure 4. Example of mist net placement. Note that the net is placed in the vegetation such that a potential flight corridor is covered by the net. (From Kunz and Kurta, 1988).	16
Figure 5. Mist net components and dimensions.....	17
Figure 6. Examples of harp trap placement, a) along a forest trail, (b) at the entrance to a cave (From Kunz and Kurta, 1988).	18
Figure 7. Harp trap design and detail. (design from Tuttle 1974, drawn by Tom Swearingen).	18
Figure 8. Sonogram of echolocation calls (frequency versus time).....	22

List of Tables

Table 1. Species of bat found in British Columbia and relevant natural history (information from Nagorsen and Brigham, 1993; British Columbia 1996 Red and Blue List for Terrestrial Vertebrates).....	3
Table 2. Recommended combinations of techniques to assess presence/not detected, relative abundance, and absolute abundance of bats.	12
Table 3. Types of inventory surveys, the data forms needed, and the level of intensity of the survey.....	13
Table 4. Recommended sampling methods for B.C. bats and location of summer roosts (roost information from Holroyd <i>et al.</i> , 1994; Nagorsen and Brigham, 1993).	14
Table 5. Identification key for use with a tunable bat detector for identifying selected species of bat found in British Columbia	23
Table 6. Characteristics of the ultrasonic calls of selected bat species as viewed with a period meter/oscilloscope (Modified from Fenton <i>et al.</i> , 1983; Thomas and West, 1989).....	24

1. INTRODUCTION

Bats are a diverse groups of mammals, second only to rodents in terms of number of species. With 16 species, British Columbia has the most diverse bat fauna in Canada (Table 1). All 16 species belong to the family Vespertilionidae and feed exclusively on arthropods, most of which are flying insects. Eight of these 16 bat species appear on B.C.'s Blue-list (vulnerable or sensitive) or Red-list (endangered or threatened; Table 1), and most of them are near the northern extent of their range within B.C. This combination of vulnerability and peripheral distribution may have important implications for the biology of the province's bats, and ultimately for their conservation. Further, organisms at the limit of their range may prove to be both more susceptible to disturbance and more genetically variable.

Because of their nocturnal nature and their ability to fly, bats have been the subjects of relatively few studies and our knowledge of them lags behind that of other more conspicuous mammals. As a result, little is known about such basic aspects of bat biology as the timing and nature of reproduction, the requirements and mechanisms for overwintering, and the use and selection of critical habitats (Nagorsen and Brigham, 1993). Typically we have no idea where species spend the winter and what sort of habitat requirements they have during this time. Our knowledge of summer roosts is similarly limited, and tends to be biased toward studies of females. In addition, it is only in recent years that we have begun to learn of some species' reliance on and interaction with forest habitats (e.g., Perkins and Cross, 1988; Thomas, 1988; Rainey *et al.*, 1992; Grindal 1996; Vonhof 1996). Given the active forest sector in British Columbia, this type of information may have important implications for maintenance of biodiversity in the province (Barclay and Brigham 1996).

Because bats often aggregate in colonies, are usually non-territorial, and are highly mobile (due to their ability to fly), their distribution tends to be very patchy in space. Many techniques and sampling protocols used to assess habitat use or abundance for other animals are therefore inappropriate for bats. The purpose of this manual is to discuss some of the techniques used to obtain presence/not detected, relative abundance, and absolute abundance data for the 16 species found in British Columbia. The problems associated with obtaining abundance estimates for bats will be addressed. This manual will provide a standardized sampling protocol for assessing community composition and relative abundance of bats.

2. INVENTORY GROUP

Data on the biology, natural history, and distribution, including range maps, of the 16 species of bat found in British Columbia can be found in Nagorsen and Brigham (1993), and van Zyll de Jong (1985). Table 1 summarizes relevant background biology for each of these species.

Table 1. Species of bat found in British Columbia and relevant natural history (information from Nagorsen and Brigham, 1993; British Columbia 1996 Red and Blue List for Terrestrial Vertebrates).

Species	Provincial Status Listing	Overwinter Strategy	Roosting Strategy	Mass (g) Mean (range)
Spotted Bat (<i>Euderma maculatum</i>)	Blue	Hibernates	Colonial	17.9 (16.2-21.4)
Townsend's Big-eared Bat (<i>Plecotus townsendii</i>)	Blue	Hibernates	Colonial	8.6 (6.0-13.5)
Pallid Bat (<i>Antrozous pallidus</i>)	Red	Hibernates	Colonial	17.0 (12.0-24.3)
Big Brown Bat (<i>Eptesicus fuscus</i>)	Yellow	Hibernates	Colonial	15.2 (8.8-21.9)
Western Red Bat (<i>Lasiurus blossevilli</i>)	Red	Migrates	Solitary	10.8 (7.2-18.5)
Hoary Bat (<i>L. cinereus</i>)	Yellow	Migrates	Solitary	31.5 (20.1-37.9)
Silver-haired Bat (<i>Lasionycteris noctivagans</i>)	Yellow	Migrates Hibernates?	Colonial?	9.0 (5.8-12.4)
California Myotis (<i>Myotis californicus</i>)	Yellow	Hibernates	Colonial	4.4 (3.3-5.4)
Western Small-footed Myotis (<i>M. ciliolabrum</i>)	Blue	Hibernates	Colonial	4.6 (2.8-5.5)
Western Long-eared Myotis (<i>M. evotis</i>)	Yellow	Hibernates	Colonial	5.5 (4.2-8.6)

Biodiversity Inventory Methodology - Bats

Species	Provincial Status Listing	Overwinter Strategy	Roosting Strategy	Mass (g) Mean (range)
Keen's Long-eared Myotis (<i>M. keenii</i>)	Red	Hibernates	Colonial	5.1 (4.0-5.9)
Northern Long-eared Myotis (<i>M. septentrionalis</i>)	Red	Hibernates	Colonial	6.5 (5.0-10.0)
Little Brown Myotis (<i>M. lucifugus</i>)	Yellow	Hibernates	Colonial	6.2 (6.2-10.4)
Fringed Myotis (<i>M. thysanodes</i>)	Blue	Hibernates	Colonial	7.1 (5.4-8.4)
Long-legged Myotis (<i>M. volans</i>)	Yellow	Hibernates	Colonial	7.2 (5.5-10.0)
Yuma Myotis (<i>M. yumanensis</i>)	Yellow	Hibernates	Colonial	6.6 (4.0-8.5)

3. Protocol (General)

Due to their unique biological and ecological features, bats present a challenge to those attempting to sample them in the field. Bats are volant, highly mobile, often colonial, and only active at night. They often avoid being trapped repeatedly (Kunz and Kurta, 1988), and exhibit temporal and spatial heterogeneity (i.e., they use different areas at different times of the day or year and tend to be clumped in suitable roost or foraging sites rather than being uniformly or predictably distributed; Thomas and West, 1989). For some species, males and females use different habitats (Barclay, 1991). Therefore, the choice of methods used to sample bats at the three survey intensities (presence/not detected, relative abundance, and absolute abundance) will depend upon both the species of bat being examined and the type of question(s) being asked, or data required.

Methods which are useful for sampling certain bat species may be inappropriate for others. If the aim of a study is to sample an area for all possible bat species, several techniques will need to be employed. No technique currently exists to measure the absolute abundance of bats, except in extremely localized areas such as single roosts (Thomas and LaVal, 1988). It is therefore impossible to get accurate absolute counts of bats at either the population or habitat level, and even estimates of relative abundance are hard to obtain. In most studies, investigators are limited in the number of sites that can be visited over the three or four months of the year that bats are active in British Columbia. Effectively, only a small number of closely situated sampling stations can be attended to by a team of two to three people in one night. In addition, it may be necessary to repeat sampling several times, and yet not all nights will be suitable for sampling due to constraints of weather (e.g., Grindal *et al.*, 1992). Further, bat activity tends to vary with ambient air temperature, humidity, lunar phase, and insect availability, all of which change throughout the season. In addition, the catchability and detectability of bat species differs, complicating the comparison of data between different areas. These various factors require that adequate sample sizes, and repeated sampling of the same study areas (ideally under the same conditions), are necessary to produce an accurate inventory. Therefore, the sampling effort that can be achieved for bats within a project will be even more sensitive to variables such as the size of the project area, the number of study areas within it, and the number of nights spent per study area than it may be for other animals. Because the results of a bat inventory are susceptible to such variability, it is important that biologists planning to survey bats be especially vigilant in their attempts to control these factors wherever possible.

Because absolute abundance of bats cannot be determined in most cases, it is difficult to estimate the number of study areas that should be established within a project area, or the length of time that should be spent sampling each one. Therefore, statements regarding adequate sample sizes are difficult to make. Instead, attempts should be made to maximize sampling effort, taking into consideration the goal of the study or survey. For presence/not detected studies, it is recommended that each study area be visited more than once. Limitations of current sampling methods, and the spatial and temporal heterogeneity exhibited by bats, may give an inaccurate representation of species present at a site during any given night. Furthermore, the failure to find evidence for the presence of a species should be viewed with caution as it may reflect the rarity of a species or a sampling artifact, rather than the true absence of that species. The confidence in such results will increase with repeated sampling at the same location. For studies involving larger scale geographic areas, it

is recommended that at least two circuits of the project area be made during the sampling season to account for seasonal variation in distribution or abundance (i.e. sample at each station, then return and sample all stations again, later in the season). Another potential sampling problem is that some techniques (those using ultrasonic detection) can not always allow for precise discrimination between species, only between 'species groups' that contain several species which share similar characteristics (Fenton *et al.*, 1983; Thomas and West, 1989).

With these limitations in mind, questions that can presently be addressed by the various sampling methods include:

- What species (or species groups) exist in a given study area?
- Which habitat types are being used by bats in a given study area?
- Are there relatively more of a given species using one study area than another?
- Does the relative abundance of a species using a study area differ over time?

It is virtually impossible to determine the absolute number of bats present in an area and comparisons of relative abundance of different species either within an area or between areas may not be possible, as explained below.

Two major classes of methods for sampling bats can be recognized: **(1) capture** and **(2) detection**. Both of these methods may be applied at roosts or away from roosts (e.g., foraging or commuting areas). This manual will focus on protocols for sampling in areas where the presence or abundance of bats is not known (i.e., away from roosts).

3.2 Survey Standards

3.2.1 Time of Year

- Sampling should be conducted between the beginning of May and the end of August, depending on latitude and altitude. A more condensed sampling period will occur farther north or at higher elevations.
- The time of year or stage of the reproductive cycle will influence sampling in several ways (Thomas and West, 1989).
 - During lactation, females must make at least one return trip to the maternity roost to nurse their young, before returning to foraging areas to feed (to meet their increased energy demands). This may give the impression of higher levels of bat activity than during other stages of the reproductive cycle, even though there may be no actual change in the number of bats present.
 - A real increase in the number of bats present and correspondingly, in the levels of bat activity, will occur when young of the year "fledge" and are recruited into the population. In addition, because males and females have different energetic requirements during the breeding season, they may forage and use different habitats (Barclay 1991). This may result in a bias in relative abundance estimates or a failure to identify critical habitats for a species.

3.2.2 Time of Day

- Bats are inactive during daylight hours, except in very rare circumstances (e.g., eclipses) and will only be found in roost sites. For most species, several distinct periods of high activity can be recognized during the night (Thomas and West, 1989). The first of these is during roost emergence, when the bats first leave the roost to forage. This usually occurs shortly after dusk, but some species such as *E. maculatum* tend to emerge later. Activity by most species tends to decrease over the course of a night, but often a peak is seen around 24:00 to 01:00, often followed by a final increase just prior to dawn as bats return to roost sites.

3.2.3 Environmental Conditions

- Environmental conditions will also influence bat activity (e.g., Grindal *et al.*, 1992). The presence of precipitation, strong winds or temperatures below 10° C all tend to cause a decrease in levels of bat activity. Therefore, no sampling should be done on nights with heavy precipitation or when the ambient temperature at sunset is below about 10° C, as bat activity will be low and sampling unproductive. However, in areas farther north or at higher elevations where temperatures at sunset are lower, bat activity has been regularly documented (L. Wilkenson, pers. comm., SDG, pers. obs.). Therefore, in these areas, a lower temperature threshold at sunset (e.g., 5° C) can be used.
- Typically sampling is unsuccessful before snow is gone and local lakes are ice free.
- Increased levels of moonlight may tend to decrease capture success.
- Moderate to high winds may also influence capture success - blowing mist nets are less likely to capture bats.

3.2.4 Morphometric Measurements, Sex, Age, & Reproductive Assessment

- Once a bat is removed from a net or trap, it should be placed individually in a cloth holding bag (about 20 cm X 30 cm) with a drawstring closure. Individuals should be held for an hour prior to measuring mass to ensure that the contents of the digestive tract have been processed. Females in late stages of pregnancy, or lactating females, should not be held for longer than one hour and should be released on the night of capture to allow them to return to their roosts and dependent young.
- Body mass of the bat can be measured with a portable Pesola spring scale or digital electronic balance and should be recorded to the nearest 0.1 g. Bats can be weighed in the cotton holding bags, and the weight of the bag subtracted.
- Forearm length (Fig. 1) indicates overall size and is the standard morphometric character measured. The forearm length is measured from the base of the thumb to the end of the ulna, using calipers to the nearest 0.5 mm. It is often advisable to take three measurements of the forearm and record either the average or the most consistent measurement.
- Individuals can be readily sexed, based on the obvious presence of male external genitalia (Racey, 1988). Reproductive condition in males can be assessed by testes size. The testes become enlarged in individuals capable of reproducing. For females, gentle palpation of the abdomen is used to determine whether the female is carrying a fetus, although early pregnancy cannot be differentiated from a full stomach. Lactating females can be recognized by enlarged nipples surrounded by bare skin, which when gently massaged will express milk. Post-lactating females also have bare patches around the nipple, but milk can not be expressed (Racey, 1988),
- Juveniles (young of the year) can be distinguished from adults by the presence of cartilaginous epiphyseal plates in the finger bones (Anthony, 1988). These make the finger joints of juveniles appear tapered and less knobby than in adults (Fig. 2). Degree of tooth wear is sometimes used as a relative indicator of age (Anthony, 1988), but this is not always reliable as degree of tooth wear may also depend on the hardness of insects in the diet.
- Most species can be identified using a key to external features (e.g., Nagorsen and Brigham, 1993). However, several problems exist for identifying certain species in the field. Herd and Fenton (1983) noted that in some areas of their range (in British Columbia) it was not possible to use external characters to reliably distinguish *Myotis lucifugus* from *M. yumanensis*. Similarly, Firman *et al.* (1992) and Holroyd *et al.* (1993) were unable to accurately distinguish among the long-eared bats (*M. keenii*, *M. evotis*, and *M. septentrionalis*) based on presently available keys to external characters. The use of highly variable or subjective characters, such as fur colour, to identify bats should be avoided. Until reliable features have been found that can be used to identify the aforementioned species¹, care should be taken positively assigning a species identity to captured bats (Van Zyll de Jong and Nagorsen 1994). To this end, accompanying dataforms include space where a biologist should enter morphometric data or other observations which provide evidence for a particular species (especially when it is difficult to distinguish). References to voucher photographs may also be useful.

¹ This is presently being examined by the National Museum in Ottawa.

Similarly, data forms for bat detection include space to enter computer filenames for digital sonograms or labels for cassette tapes which include high quality reference calls or evidence of rare and endangered bats. Where appropriate, voucher calls and photographs should accompany project deliverables.

- **Biologists are cautioned to be conservative when classifying bats as to taxonomy.** Accompanying data forms allow biologists to identify each bat observation to the taxonomic level at which they are certain. Additionally, the Taxonomic Group form (included in the bat data forms) allows a biologist to identify and attach a label to a group of bat species which cannot be distinguished. This provides valuable information that an observed bat was one of several species, even if a single species could not be positively identified.

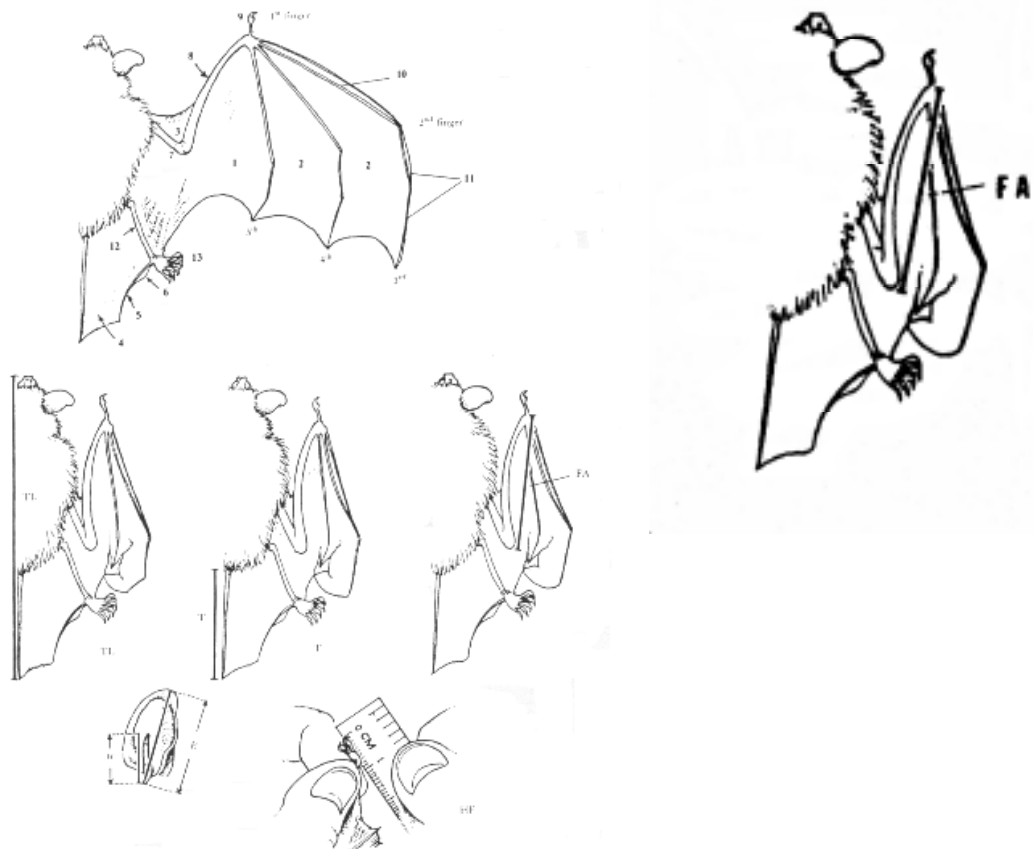


Figure 1. Forearm (FA) and other measurements (From van Zyll de Jong, 1985).

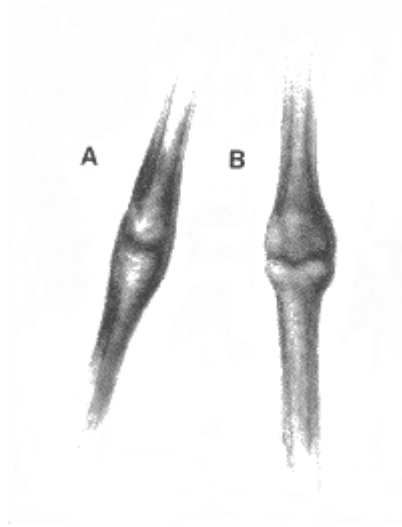


Figure 2. Finger joint of (a) juvenile (tapered, and epiphyseal plates should be visible with the aid of a flashlight illuminating the wing) and (b) adult (nobby and opaque) (From Nagorsen and Brigham, 1993).

3.2.5 Habitat Standards

A minimum amount of habitat data must be collected for each survey type. The type and amount of data collected will depend on the scale of the survey, the nature of the focal species, and the objectives of the inventory. As most provincial-funded wildlife inventory projects deal with terrestrial-based wildlife, the terrestrial Ecosystem Field Form developed jointly by MOF and MELP (1995) should be used. However, under certain circumstances, this may be inappropriate and other RIC-approved standards for ecosystem description may be used. For a generic but useful description of approaches to habitat data collection in association with wildlife inventory, consult the introductory manual, *Species Inventory Fundamentals (No. 1)*.

Accompanying data forms provide guidance as to standard description of roosts, whether located in cliff, caves, trees, or buildings.

3.2.6 Survey Design Hierarchy

Bat surveys follow a survey design hierarchy which is structured similarly to all RIC standards for species inventory. Figure 3 clarifies certain terminology used within this manual (also found in the glossary), and illustrates the appropriate conceptual framework for detection and capture surveys for bats. A survey set up following this design will lend itself well to standard methods and RIC data forms.

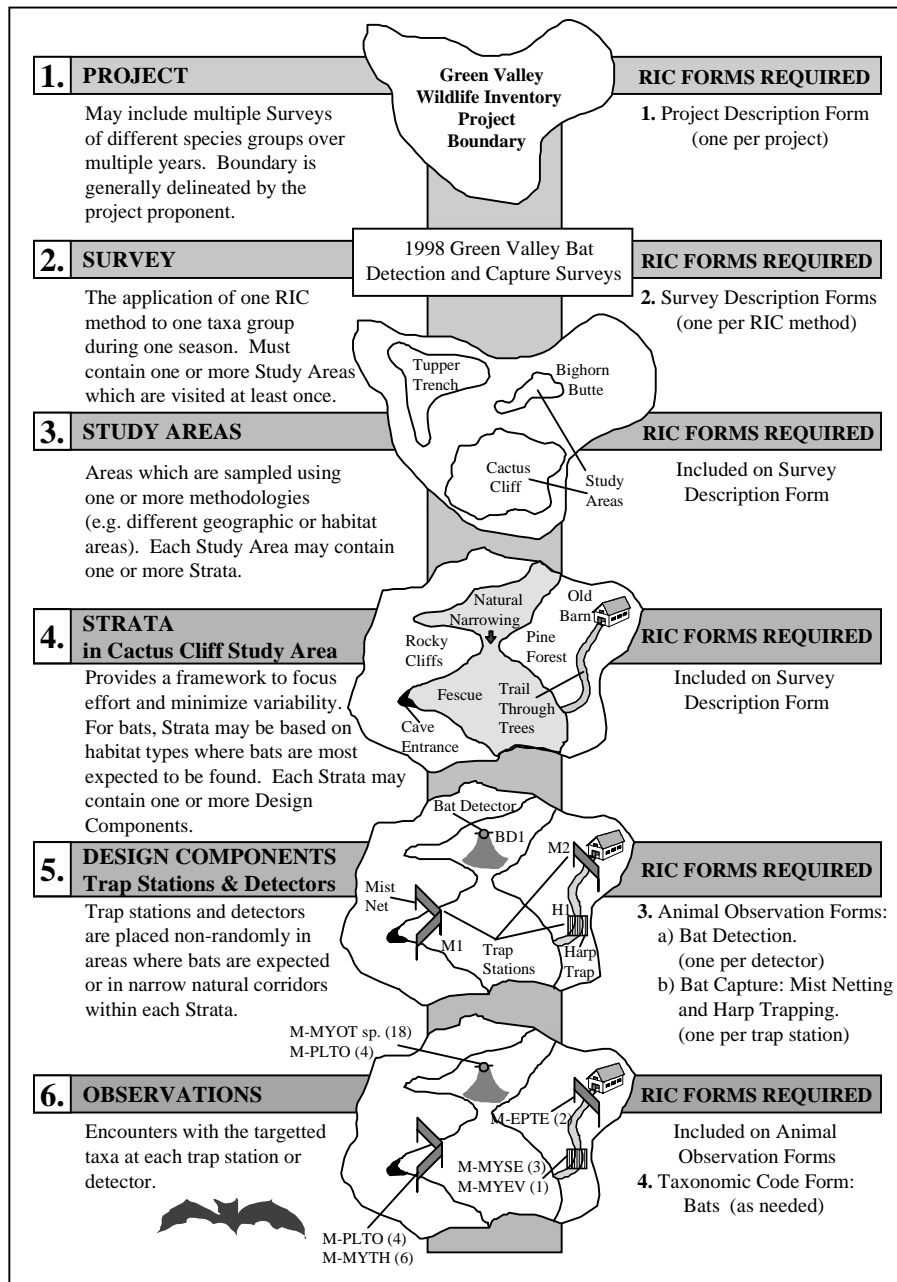


Figure 3. RIC species inventory survey design hierarchy with examples.

3.2.7 Combining Techniques to Survey Bats

Because no one technique can adequately sample all bat species present in British Columbia, it is recommended that several techniques be used in combination to obtain presence/not detected and relative abundance data (Table 2). The same general techniques are used to assess both these levels of intensity, and therefore data on species presence and their relative levels of activity can be collected at the same time. Relative abundance of a bat species can be compared between areas or over time, but reliable comparisons between species are not possible, because species differ in their degree of catchability or detectability. Absolute abundance estimates are not possible, except at specific roosts.

In British Columbia, mist nets, harp traps, ultrasonic bat detectors, and listening for *E. maculatum* should all be employed to determine presence/not detected and relative abundance of bats, as these methods tend to complement one another. The species that tend to be under-estimated or missed by one method are often sampled by one of the other methods. For example, the presence of certain species (e.g., *M. keenii*) may be difficult to determine given their indistinct morphology, low vulnerability to trapping, and/or limited species identification ability based on the current resolution of bat detectors. With two to three workers, it is quite easy to employ all four methods simultaneously in a study area. However, the emphasis on specific survey methods employed may vary for different survey intensities (Table 2, 3) and/or the target species under examination (Table 4).

Table 2. Recommended combinations of techniques to assess presence/not detected, relative abundance, and absolute abundance of bats.

Objective	Recommended Combination of Techniques
Presence/Not Detected	Capture Techniques (Mist netting; harp trapping) used simultaneously with Ultrasonic Detection and Listening for <i>E. maculatum</i> .
Relative Abundance	Capture Techniques (Mist netting; harp trapping) used simultaneously with Ultrasonic Detection and Listening for <i>E. maculatum</i> .
Absolute Abundance	Roost counts (emergence or surface area); possibly in conjunction with telemetry (to locate roost).

Table 3. Types of inventory surveys, the data forms needed, and the level of intensity of the survey.

Survey Method	Forms Required	*Intensity
Mist Netting / Harp Trapping	<ul style="list-style-type: none"> • Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Animal Observations Form - Bat Capture: Mist Netting / Harp Trapping • Taxonomic Code Form - Bats • Ecosystem Form 	<ul style="list-style-type: none"> • PN
Bat Detection	<ul style="list-style-type: none"> • Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Animal Observations Form - Bat Detection • Taxonomic Code Form - Bats • Ecosystem Form 	<ul style="list-style-type: none"> • PN • RA
Roost Count	<ul style="list-style-type: none"> • Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Animal Observations Form- Bats Roost Count • Ecosystem Form 	<ul style="list-style-type: none"> • PN • RA
Any Survey Type	<ul style="list-style-type: none"> • Wildlife Inventory Survey Collection Label - is used whenever a voucher specimen is collected. 	<ul style="list-style-type: none"> • PN • RA

* PN = presence/not detected; RA = relative abundance; AA = absolute abundance

Table 4. Recommended sampling methods for B.C. bats and location of summer roosts (roost information from Holroyd *et al.*, 1994; Nagorsen and Brigham, 1993).

Species	Summer Roost	Recommended Sampling Method
Spotted Bat (<i>Euderma maculatum</i>)	Cliffs	Listen with unaided ear
Townsend's Big-eared Bat (<i>Plecotus townsendii</i>)	Caves, Mines, Buildings	Mist net/Harp trap
Pallid Bat (<i>Antrozous pallidus</i>)	Rock Crevices, Foliage	Mist net at ground level
Big Brown Bat (<i>Eptesicus fuscus</i>)	Buildings, Tree Cavities, Rock Crevices	Mist net (5-10m high) / Bat Detector
Western Red Bat (<i>Lasiurus blossevilli</i>)	Foliage	Bat Detector
Hoary Bat (<i>L. cinereus</i>)	Foliage	Bat Detector
Silver-haired Bat (<i>Lasionycteris noctivagans</i>)	Tree Cavities	Mist net/Harp trap; Bat Detector
California Myotis (<i>Myotis californicus</i>)	Buildings, Tree Cavities, Rock Crevices	Mist net(1-3 m high) / Harp trap
Western Small-footed Myotis (<i>M. ciliolabrum</i>)	Rock Crevices	Mist net(1-3 m high) / Harp trap
Western Long-eared Myotis (<i>M. evotis</i>)	Rock Crevices, Tree Cavities, Buildings	Mist net / Harp trap (roads & cut lines through trees)
Keen's Long-eared Myotis (<i>M. keenii</i>)	Rock Crevices	Mist net/Harp trap
Northern Long-eared Myotis (<i>M. septentrionalis</i>)	Tree Cavities	Mist net / Harp trap (roads & cut lines through trees)
Little Brown Myotis (<i>M. lucifugus</i>)	Buildings, Tree Cavities, Rock Crevices	Mist net (over water at water level) / Harp trap
Fringed Myotis (<i>M. thysanodes</i>)	Buildings, Caves, Rock Crevices	Mist net / Harp trap
Long-legged Myotis (<i>M. volans</i>)	Rock Crevices, Tree Cavities	Mist net / Harp trap
Yuma Myotis (<i>M. yumanensis</i>)	Buildings, Tree Cavities	Mist net (over water at water level) / Harp trap

4. Presence/Not detected & Relative Abundance

Recommended methods: Capture (mist nets, harp traps) and detection (ultrasonic bat detectors and listening for *E. maculatum*) should be employed simultaneously to determine presence/not detected and relative abundance of bats (Table 3). Note that relative abundance can only be estimated using detection sampling and detection indices.

4.1 Capture

Anyone involved in the capture and handling of live bats should be familiar with the manual, *Live animal capture and handling guidelines for wild mammals, birds, amphibians, and reptiles* (No. 3).

Capture of bats allows positive species identification (see Nagorsen and Brigham, 1993, for identification key), age and sex determination, the collection of mass and other mensural data, and an assessment of reproductive condition (Anthony, 1988; Racey, 1988). However, this obviously requires some handling of and disturbance to the animal and not all species or sexes are equally catchable, if catchable at all.

The two most common methods of capture involve the use of mist nets or harp traps, although several other methods (e.g., hand nets, funnels) have been used in the past (e.g., LaVal and LaVal, 1977; Youngson and Mckenzie, 1977; Fenton and Bell, 1979; Kunz and Kurta, 1988). Many of these other techniques require sampling at or in roost sites, and are not recommended because they tend to be disruptive to the bats and may cause them to abandon the roost. Conservation of bats and critical habitats, as well as minimization of disturbance must be considered for all potential sampling protocols.

4.1.1 Mist Nets

Mist netting is the most common method used to capture bats (Kunz and Kurta, 1988). Catching bats in mist nets depends on careful selection of netting sites (Fig. 4). Productive netting sites (i.e. areas of high bat activity) can be determined by direct observation of bats or by using bat detectors (see below).

The major advantages of using mist nets to sample bats are that they are relatively inexpensive, highly portable and easy to use and set up. The disadvantages are that they have certain biases associated with them, in terms of which species can be caught, and they require constant monitoring to ensure that bats do not chew their way out, become badly entangled or cause injury to themselves. A further disadvantage is the recent difficulty in obtaining suitable mist nets from suppliers. The success of mist nets at a location decreases if a net is set up at the same location more than once (Kunz and Brock, 1975). In addition, certain species are adept at avoiding mist nets or fly at heights that make their capture difficult, even though they may be present in a study area. For example, *Lasiurus blossevilli*, *L. cinereus* and *Eptesicus fuscus* tend to fly higher than the location of most mist nets and gleaning species such as *Myotis evotis*, *Plecotus townsendii*, and *Antrozous pallidus* seem

better able to detect and avoid mist nets, particularly now that monofilament nets are unavailable. Setting nets higher in the canopy can increase the success of capturing these high flying species, and numerous designs for canopy netting is described in Kunz (1996). Also, juveniles may be more susceptible to capture than older age classes creating a biased interpretation of population composition. In addition, environmental factors may influence the effectiveness of mist netting. The presence of wind may decrease capture success by causing the mist net to billow and thus become more detectable (Nyholm, 1965). Rain also adheres to mist nets, rendering them more “visible” to bats.

Equipment

Mist nets used for capturing bats are usually black, 6 to 36 m in length, 2 m high, have four shelves, a mesh size of 36 mm and are constructed from 50 or 70 denier/2 ply nylon (Fig. 5; Kunz and Kurta, 1988). Unfortunately, recent restrictions by the Japanese manufacturers and a government trade ban by Japan have made mist nets very difficult to obtain and monofilament nets, the most effective ones for capturing bats, are no longer available. Nets less than 12 m in length tend to be easier to handle, especially for one person. Poles made of 3 m lengths of aluminum tubing are often used to support the nets. The tubing should have a wall thickness of about 1.6 mm and should be at least 2.5 cm in diameter. Thin-walled electrical conduit is inexpensive and readily available and makes excellent mist net poles. Connectors (e.g., 20-30 cm long solid aluminum shafts that fit the inside diameters of poles) can be made to join lengths of pole to make sections of the necessary length. To keep mist nets in place, guy lines can be attached to the poles and anchored to vegetation or rocks.

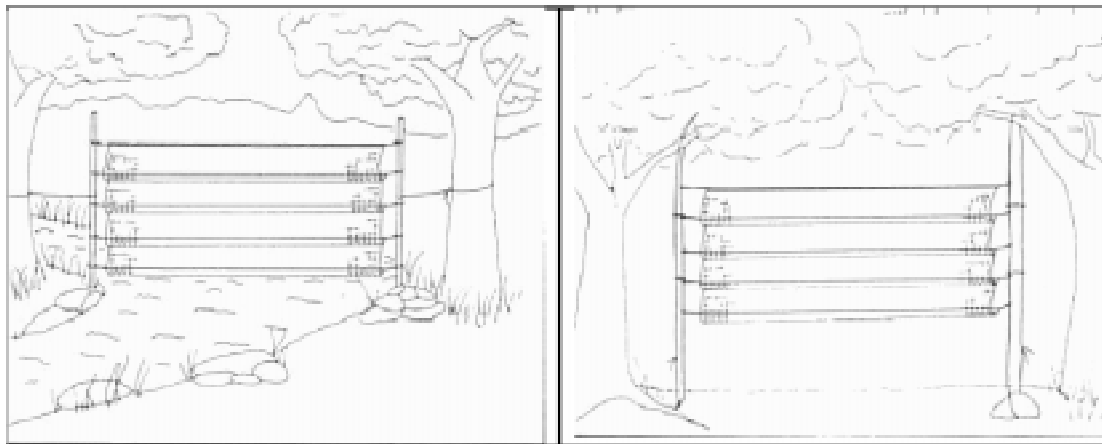


Figure 4. Example of mist net placement. Note that the net is placed in the vegetation such that a potential flight corridor is covered by the net. (From Kunz and Kurta, 1988).

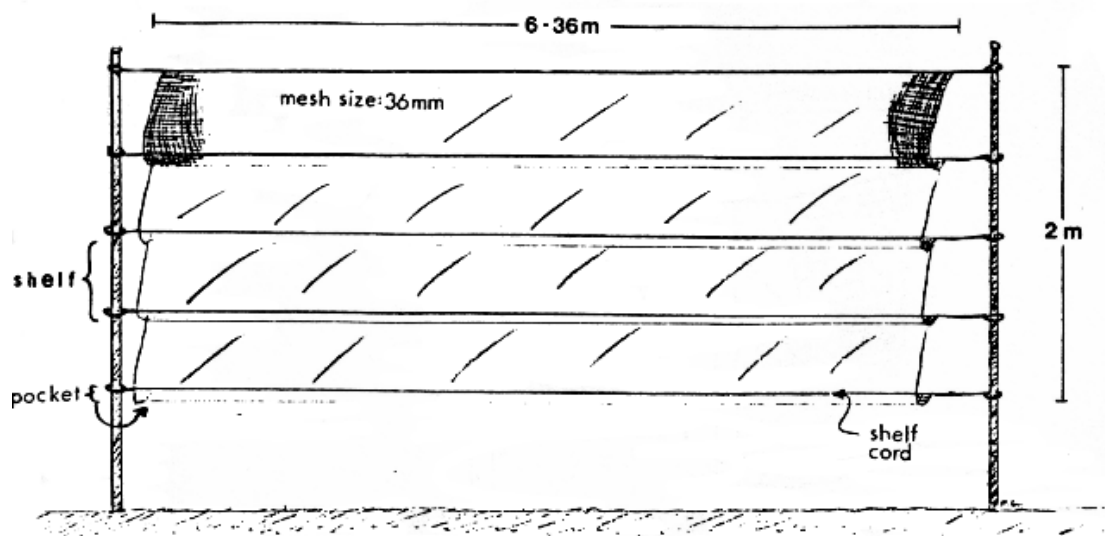


Figure 5. Mist net components and dimensions.

4.1.2 Harp Traps

Harp traps, specifically designed for capturing bats, were first described by Constantine (1958) and later modified by Tuttle (1974). Unlike mist nets, harp traps may be set up and left unattended. Similar considerations as those for setting mist nets are used for the placement of harp traps (Fig. 6). Harp traps may be hoisted off the ground by ropes or positioned outside at entrances to buildings, caves, or mines. As for mist nets, trapping success tends to decrease with each successive night in the same location (Kunz and Anthony, 1977).

The major advantages of using harp traps to sample bats are that they are less labour intensive, they do not require constant supervision (thus several can be set up per night) and they can be used to catch species that tend to avoid mist nets (such as *Myotis ciliolabrum* and *Myotis evotis*, Holroyd *et al.*, 1994). Disadvantages include the small area sampled by the trap (only about 2 m² as opposed to several times that for each mist net used), its limited portability, which may limit its use to areas accessible by roads, and its greater cost (approximately \$500 CAN). A collapsible, 7 kg harp trap described by Tidemann and Woodside (1978) which takes 30 minutes to set up or dismantle at least partly solves the portability problem.

Equipment

Harp traps (Fig. 7) consist of two 2 m by 1.8 m frames of aluminium tubing. Vertically strung across each frame is a bank of 6 - 8 pound (3 - 3.5 kg) monofilament fishing line. Lines are strung 2.5 cm apart. The two frames are spaced 7 to 10 cm apart. Attached to the bottom of the frame is a canvas bag, lined with polyethylene. The trap works on the principle that a flying bat can not easily detect or avoid the bank of lines and will become trapped

between the monofilament lines and fall into the holding bag below. The bats drop into this bag and are unable to crawl out over the slippery polyethylene. If a bat manages to fly straight through the first set of lines, it is impeded by the second set. The degree of tension on the lines may have to be increased if bats are able to fly straight through without becoming trapped, or decreased if they simply 'bounce off'.

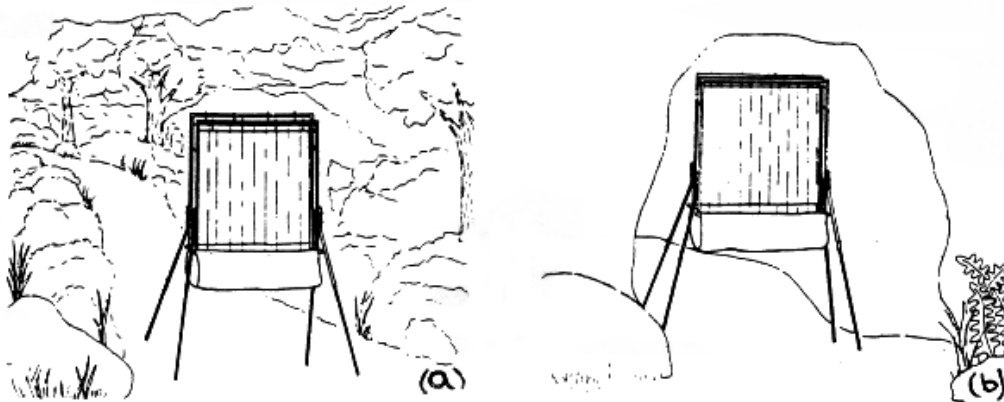


Figure 6. Examples of harp trap placement, a) along a forest trail, (b) at the entrance to a cave (From Kunz and Kurta, 1988).

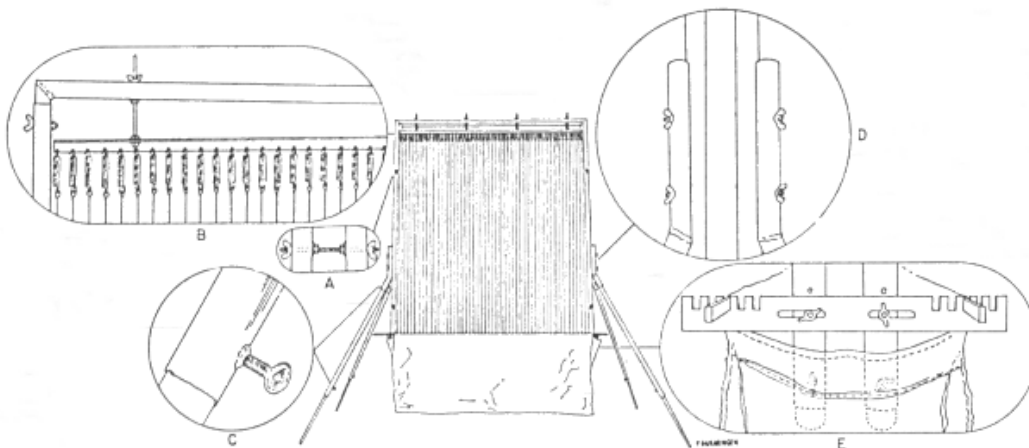


Figure 7. Harp trap design and detail. (design from Tuttle 1974, drawn by Tom Swearingen).

4.2 Detection

Detection involves sampling bats either by visual or acoustic means. Unlike netting and trapping, no handling is involved and therefore disturbance is minimized. However, positive species identification is not always possible nor is an assessment of age, sex, or reproductive condition. Therefore the question being asked and the type of information required will generally dictate whether this sampling method is useful.

4.2.1 Visual Detection

Visual detection has been used at sites where bats are known to roost, in order to count the number of bats exiting the roost at or shortly after dusk (e.g., Swift, 1980). This provides a useful and accurate census of the total number of bats using a roost site, provided that all exits from the roost are identified and monitored and that any bats that re-enter the roost are accounted for (Thomas and LaVal, 1988).

It may still be necessary to trap bats at the roost to obtain a positive species identification and ensure that only one species is using the roost. One obvious drawback to this method is that it can only be applied at known roost sites and usually only one roost exit per night per observer can be monitored. In order to accurately extrapolate the results of censuses at a roost to larger geographic areas or populations, it is necessary to locate and census every roost in the area and information regarding home ranges of individuals must be known and taken into account (Thomas and LaVal, 1988). In practice, this is very difficult, if not impossible.

Electronic counting devices such as photo-electric beam splitters, which record each flying bat that interrupts the light beam, have also been used to census bat roosts (e.g., Voute *et al.*, 1974). Although this method does not require an observer to be present, its use in sampling British Columbia bats is limited given the relatively small roost sizes compared to much larger colonies located outside B.C. (Nagorsen and Brigham, 1993), for which the method is usually used.

Only one study has attempted visual censusing of bats away from roost sites. Gaisler (1979) used visual counts along transects in a city environment to census bat populations. However, this approach would be of limited use given the higher species diversity and dense vegetation and canopy that often occurs in B. C. This method may be applicable to urban sites with streetlights or in northern regions where twilight never ends. However, positive species identification is not always possible and at minimum, a highly experienced observer would be required.

4.2.2 Acoustic Detection

Bats in B.C. typically rely on vocalizations for communication (Fenton, 1985) and orientation when commuting or foraging (Griffin, 1958). It is possible to eavesdrop on these vocalizations (i.e., echolocation calls) to detect the presence of bats, assess whether a bat is foraging or commuting, and potentially identify the species emitting the call. Such vocalizations can be used in much the same way that bird song is used to census bird populations, the major difference being that the majority of bat sounds are beyond the range of human hearing and thus require specialized equipment to monitor them. Most humans can

only detect sounds with frequencies less than 20 kHz. Sounds above this limit are termed ultrasonic. The calls of all but one species of bat in B.C. are restricted to the ultrasonic range.

Bats emit ultrasonic signals in order to echolocate. By emitting a series of discrete calls and listening for returning echoes, bats are able to locate objects, including prey items (Griffin, 1958). Echolocation signals have a frequency, a duration, and an intensity associated with them (Simmons *et al.*, 1979). The signal may consist mainly of a constant frequency or it may sweep over a range of frequencies. The signal may also include harmonics, in addition to the fundamental (lowest) frequency. Differences in these features allows for a limited degree of species recognition (Fenton and Bell, 1981), although there is considerable geographic and individual variation in call design (Thomas *et al.*, 1987; Brigham *et al.*, 1989; Hayes 1997). In addition, some bats have the ability to change their echolocation call characteristics, depending on the habitat type (e.g., open versus interior forest; Kalko and Schnitzler 1993), which can further complicate species identification.

The repetition rate at which calls are given varies with the activity of the bat and provides a means for discriminating between different behaviours in the field (Thomas and West, 1989). Commuting bats or bats searching for prey emit approximately 10 calls per second. This rate increases to 100 or more pulses per second when a potential prey item has been detected and the bat closes in to attack. This results in a characteristic 'feeding buzz' (Griffin, 1958) and gives a positive indication that the bat is foraging in an area. Thus, it is possible to determine what habitats are important as foraging areas, by detecting the presence of feeding buzzes.

When using detectors to eavesdrop on bats, two pieces of information should be recorded (on a per unit time basis): (1) the number of bat passes and (2) the number of feeding buzzes. A bat pass is defined as a sequence of two or more echolocation calls registered as a bat flies within range of an observer or the detecting equipment (Fenton, 1970; Thomas and West, 1989).

Knowledge about the number of bat passes detected does not allow for an estimate of the number of bats present in a study area because there is not a one to one relationship between the number of bat passes and the number of bats responsible for those passes (Fenton, 1970). That is, it is not possible to discriminate between several bat passes made by a single bat flying repeatedly through the study area versus several bats each making a single pass. Therefore, bat passes do not allow a direct estimate of population densities. However, the technique does allow a relative measure of bat activity in an area and allows for comparisons between areas or over time to be made.

***Euderma maculatum* Detection**

One species found in British Columbia, the spotted bat (*Euderma maculatum*), uses echolocation calls that sweep in frequency from 15 to 9 kHz, and are thus readily audible to the unaided human ear and require no specialized equipment to detect (Leonard and Fenton, 1984; Fenton *et al.*, 1987). Although, young individuals and females tend to have better high frequency hearing, and are better able to detect *E. maculatum*. There is evidence that *E. maculatum* forage in circuits along specific, well-defined routes and thus repeatedly fly through the same area while foraging (Woodsworth *et al.*, 1981; Navo *et al.*, 1992). Therefore, it seems likely that several feeding buzzes or bat passes detected at a sampling location represents the same bat and not several individuals.

Ultrasonic Detection

To detect the other 15 species of bats found in British Columbia, some type of commercially available ultrasonic bat detector is required. Two types of detectors are available; tunable narrow band detectors and divide-by-n broad band detectors. Both detector types can be operated either remotely or manually, as described below. The ability to discriminate and identify individual species depends to some extent on the sophistication of the detecting equipment. The simplest and least expensive detectors are tunable narrow band (heterodyne) detectors, whereas the divide-by-n broad band detectors generally provide more information, yet at a greater expense.

The audio output from the detector will depend on the structure and energy of the incoming ultrasonic signal. Figure 8 shows the frequency-time displays (sonograms) of some hypothetical signals and describes the corresponding output as heard on a tunable narrow band detector. It is possible using an identification key (e.g., Table 5) to identify some species based on the output from the detector (but see “Precautions and Limitations” below). A tunable detector is particularly useful for identifying the presence of red and hoary bats (*Lasiurus* spp.), which are rarely captured in mist nets or harp traps. However, it is not possible to discriminate between the different *Myotis* species, based on the output of a tunable detector, due to the similarity of their calls.

By coupling the tunable narrow band detector with a micro-cassette recorder it is possible to leave the detector unattended in the field and thus sample a number of study areas on any given night. The amount of data that can be collected is limited by the length of tape, from which the data must later be transcribed. It is also possible to sample at different heights in the canopy by using a microphone with a long lead suspended at different heights (Thomas and West, 1989). The major disadvantage of a tunable narrow band detector is that they must be set at one and only one frequency and therefore not all bat species can be sampled, unless several detectors are set at different frequencies and left in the study area.

An advantage of divide-by-n detectors over tunable, narrow band detectors is that they are broad-band and are able to monitor all frequencies (and thus detect most bat species) simultaneously. Therefore, sampling effort can be increased, because it is unnecessary to constantly tune to different frequencies to detect different species. Also, information regarding the time and frequency characteristics of the fundamental frequency are retained, as well as call harmonics when using some detectors (e.g., Petterssen detector). This allows a greater degree of species resolution, although some of the *Myotis* species still cannot be distinguished from one another (Fenton *et al.*, 1983; Thomas and West, 1989).

The output of a divide-by-n detector can be analyzed by using a zero-crossing period meter coupled with an oscilloscope (Simmons *et al.*, 1979). The period meter displays a frequency-time display (a sonogram) of the fundamental frequency on the oscilloscope screen, which can be used to identify species or species groups (e.g., Table 6; see below for cautionary note regarding the identification of species from echolocation calls). The use of a period meter to identify calls requires many hours of training and experience with free-flying individuals of a known species (Thomas and West, 1989).

Some divide-by-n detectors (e.g., ANABAT or Petterssen systems) can be operated remotely as well as manually. Such a set-up allows automatic monitoring of bat calls, thus freeing the worker for other tasks, and will detect all species unlike a tunable narrow-band detector

which can only be set at (and therefore detect) a single frequency at a time. Sampling effort can be greatly increased by using several automated detectors. However, time must still be spent analyzing the recorded signals, although this can be done subsequent to field work. The analyses of data from the ANABAT or Petterssen systems are based on visual representations of bat calls, similar to those in Figure 8. In addition, characteristics such as maximum frequency, minimum frequency, average frequency, duration, and time between calls are available, which generally permits a more accurate assessment of the species or species group of the recording. However, there are limitations (see "Precautions and Limitations" below) which must be considered when interpreting data.

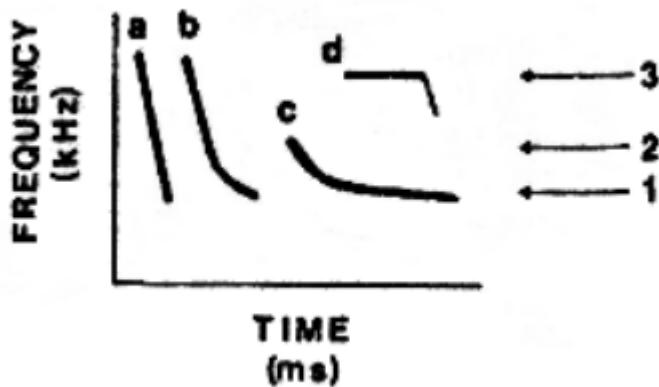


Figure 8. Sonogram of echolocation calls (frequency versus time).

A tunable narrow band detector tuned to frequency 1 would register call "a" as a sharp "tick", call "b" as a "putt" sound, and call "c" as a tonal "chirp"; call "d" would not be detected. At frequency 2 calls "a", "b", and "c" would all be registered as sharp "ticks". At frequency 3 calls "a" and "b" would produce sharp "tick", call "c" would not be detected, and call "d" would result in a long tonal output (Modified from Fenton, 1988).

Equipment - Ultrasonic

One commonly used ultrasonic bat detector is the QMC mini bat detector² (about \$300 CAN, UltraSound Advice, 23 Aberdeen Road, London, N5 2UG, UK). These detectors superimpose an internally generated pure tone on the inaudible ultrasonic signal, thus rendering it audible when the detector is tuned to a frequency near that of the incoming signal (Miller and Andersen, 1984). They can detect frequencies between 10 and 180 kHz, but can only scan a single narrow frequency band (about 3-5 kHz) at a time. If the detector is tuned to 35 kHz it can detect any bat within range that is using an echolocation signal with a 35 kHz component to it. Tunable detectors only sample a small portion of the total frequency range of any call. They do not preserve the time and frequency characteristics of a call's

² References to specific company names or equipment are provided for convenience and do not represent an endorsement by either the authors or the British Columbia Ministry of Environment. Appendix 1 contains a list of selected suppliers of equipment mentioned in this manual.

fundamental frequency. By changing the tuning of the detector it is possible to sample for several bat species, which employ calls with different frequency components. The detector has a directional range of about 120° (Downes, 1982). It is crucial to calibrate tunable bat detector to a pure tone before using them in the field (Thomas and West, 1984).

Another class of bat detectors are known as divide-by-n (or countdown) detectors. These detectors contain a broad-band microphone coupled with a countdown circuit that produces one cycle for every n cycles (where n is usually 10) of the input frequency, thus giving an audible output (Miller and Andersen, 1984). For example, a call sweeping from 100 kHz to 40 kHz becomes audible as a sweep from 10 kHz to 4 kHz with a divide-by-10 detector (Thomas and West, 1989). This divided output can potentially be recorded for later analysis, or it can be analyzed in the field.

Commercially available divide-by-n detectors are available such as the QMC S200 (about \$1500 CAN, QMC Instruments Ltd.) and the ANABAT II detector system (about \$2025 CAN, Titley Electronics, P.O. Box 19, Ballina N.S.W. 2478 Australia). The ANABAT II detector systems includes a broad band detector (\$ 625), delay switch (\$550), timer (\$250), and zero-crossing analysis interface module (ZCAIM; \$600). The delay switch automatically turns on a tape recorder whenever a call is detected, accompanied by a time cue and calibration tone (40 kHz). The timer can be used to turn the detector system on or off for set durations of time at certain periods of the night. The ZCAIM is used to link the information from the recorded tapes through the delay switch, or data directly from the detector, to a computer. The system comes with software for use on a PC computer (a laptop is convenient in the field) for analyzing calls (rather than using a period meter).

Table 5. Identification key for use with a tunable bat detector for identifying selected species of bat found in British Columbia

(Modified from Fenton *et al.*, 1983).

1	Audible to unaided ear	<i>Euderma maculatum</i>
1'	Not audible	2
2	20 kHz, calls detectable	<i>Lasiurus cinereus</i>
2'	20 kHz, calls not detectable	3
3	25-35 kHz, output a tonal chirp	<i>Lasionycteris noctivagans</i>
3'	25-35 kHz, output a "put" sound	<i>Eptesicus fuscus</i>
3"	25-35 kHz, calls not detectable	4
4	40 kHz, output a tonal chirp	<i>Lasiurus blossevilli</i>
4'	40 kHz, output a sharp "tick"	<i>Myotis species</i>

Table 6. Characteristics of the ultrasonic calls of selected bat species³ as viewed with a period meter/oscilloscope (Modified from Fenton *et al.*, 1983; Thomas and West, 1989).

Species	Call Characteristics
<i>Lasionycteris noctivagans</i>	Call starts with 1-2 ms sweep from 30-25 kHz. Call lasts about 10 ms.
<i>Lasiurus cinereus</i>	Similar to <i>L. noctivagans</i> , but call initially sweeps in 25-30 kHz range.
<i>Lasiurus blossevilli</i>	Similar to <i>L. noctivagans</i> , but call initially sweeps in 45-40 kHz range.
<i>Eptesicus fuscus</i>	Call sweeps from 33-28 kHz in first 3 ms. Ends with a 2-7 ms constant
<i>Myotis thysanodes</i>	frequency (CF) tail around 28 kHz.
<i>M. volans</i>	Call sweeps from >60-35 kHz in 5 ms. Call has no inflection point.
<i>M. californicus</i>	2-4 ms call sweeping from >60-40 kHz no inflection point
<i>M. ciliolabrum</i>	
<i>M. lucifugus</i>	2-4 ms call sweeping from >60-40 kHz Inflection point near middle of
<i>M. yumanensis</i>	call.
<i>M. evotis</i>	1-2 ms call, steep sweep from >100-40 kHz.
<i>M. septentrionalis</i>	1-2 ms call, sweep from 80-40 kHz.
<i>Plecotus townsendii</i>	6-7 ms call, straight sweep from 40-28 kHz.

4.2.3 Light Tagging

To make ultrasonic reference recordings for particular bat species, it is necessary to first capture and visually mark bats. These reference recording will assist in species identification for a particular study area. A small chemiluminescent light tag, such as a miniature light stick (2.9 mm X 24 mm), can be glued to the fur on a bat (Buchler, 1975; Barclay and Bell, 1988;

³ Because of the existence of individual and geographic variation in calls, this table provides only a general outline of call characteristics and may not be applicable to all areas of B.C. (see below). This table is presented for illustrative purposes and represents a composite of characteristics described by Fenton *et al.* (1983) and Thomas and West (1989). There are considerable differences in call characteristics for the same species in the two studies.

Horvorka *et al.* 1996). This light tag will act as a short term visual mark to keep track of the bat as it's echolocation calls are being recorded. Light tags are also a useful means for determining foraging ranges, habitat use, the vertical distribution of activity and for making behavioural observations (see Barclay and Bell, 1988 for details).

Once the light tag is affixed, the bat can be released and reference calls recorded. Fenton (1988) describes how to record bat calls. Ideally a high speed tape recorder (76 cm/sec) should be used, to preserve the sound characteristics exactly as they were produced, but the high cost (\$20,000) of such tape recorders may be prohibitive. Alternately the output from a divide-by-n detector (i.e. a divided call) could be recorded. This should provide enough information about the time and frequency characteristics of a call to make a usable reference recording. Such a recording, along with a corresponding sonogram will help facilitate species identification by experienced field workers. At the very least, the output from a tunable detector set at various frequencies should be recorded to provide verification of species identity in different geographic regions. If possible, several individuals of each species from several areas in the province should be recorded, to allow an assessment of variation in calls between individuals or over geographic regions.

4.2.4 Precautions and Limitations

Caution should be exercised when identifying species on the basis of echolocation calls, because it has been shown that calls can vary quite widely between individuals or over geographic areas and this may lead to misidentification (Thomas *et al.*, 1987; Brigham *et al.*, 1989). The extent of this variation has yet to be fully determined. The keys presented in this manual were developed by Fenton *et al.* (1983) for identifying bats in the Kootenay, Glacier and Mount Revelstoke National Parks of B.C. Their applicability to other regions of B.C. is unknown and requires verification. Until this is determined, we strongly recommend the production of reference tapes of each species' call for different regions of B.C. to provide a comparison for field recordings (Thomas and West, 1989), and to assess the prevalence of variation in calls. A library of reference calls is currently being compiled for bats in North America, and can be found on the web site at: <http://sevilleta.unm.edu/~wgannon/batcall>.

The exact distance over which a bat detector can detect an echolocating bat depends mainly on the intensity of the echolocation call (Downes, 1981; Fenton, 1988). Maximum detection distances are relatively constant for a species, but differ among species (Thomas and West, 1989). Some species such as *P. townsendii*, *M. evotis* and *M. septentrionalis* use low-intensity calls or high frequency calls which attenuate rapidly (Faure *et al.*, 1990) and are only detectable at a distance of a few metres. These species will thus be under-represented in sampling compared to other species. In contrast *M. lucifugus* is detectable at a range of over 10 m with a QMC mini bat detector (Downes, 1982), and *L. cinereus* is detectable up to 30 or 40 m away. Because detection distances vary between species (i.e. species have different degrees of detectability), reliable comparisons of relative abundance between species can not easily be made (Thomas and West, 1989). Further, caution must be exercised when using broad band detectors (e.g., ANABAT or Petterssen) to discriminate between species based on the audible output of the detector. Because these detectors are generally more sensitive than tunable narrow band detectors, and detect the bats over a range of frequencies, differences in the audible output may not be as distinct for different species or species groups. Experience is needed to accurately distinguish species or species groups based on the audible output when using sensitive broad band detectors.

Biodiversity Inventory Methodology - Bats

The methods discussed so far are designed towards sampling bats at sites away from roosts. It is also possible to net, trap, or use bat detectors near known roosts to estimate the number of bats using that roost. However it may first be necessary to locate such roosts and as noted below (section 5.1), disturbance at roosts can lead to bats abandoning these sites.

4.3 Protocol: Presence/Not detected & Relative Abundance

4.3.1 Office procedures

- Review the introductory manual, *Species Inventory Fundamentals (No. 1)*.
- Obtain suitable maps of the project area. Typically 1:50 000 are used, but a larger scale such as 1:20 000 may be useful.
- Based on the maps and other knowledge of the project area (previous reports, local resource specialists) identify strata which are of most interest. It may also be useful to identify specific study areas (i.e. sites) at which sampling will take place. Properly identified objectives will hasten this process.
- Consult Nagorsen and Brigham (1993) for species distribution information in order to compile a checklist of potential bats to be encountered in the study area. Discuss the bat community with local resource specialists along with amateur naturalists to further refine the expected list.

4.3.2 Sampling design

- Presence/not detected: Non-random. Choose study areas where bats are most likely to occur (Table 3).
- Relative abundance: Stratified random sampling. Stratify project area (e.g., different habitat types, stand age class), and establish study areas which allow you to sample randomly within each strata. Use the same type of detectors and capture devices throughout study.

4.3.3 Sampling effort

- Effectively, only one study area per night can be sampled (mist netting and manual ultrasonic detection) by a team of two to three people. Two person teams are adequate, if remote detector systems (e.g., ANABAT detectors) are available.
- When using remote detector systems, the number of detection stations sampled is limited only by the number of detectors.
- Each study area should be sampled more than once, and effort should be made to maximize replication. The confidence in the results will increase with repeated sampling of the same study area.
- For larger scale geographic areas, it is recommended that at least two circuits of the project area be made during the sampling season to account for seasonal variation in distribution or abundance.

4.3.4 Personnel

- All crew members should have up-to-date vaccinations against rabies and tetanus.
- The crew leader must be a biologist with experience mist-netting and identifying local bat species.
- The crew leader must have previous experience attaching light-tags before attempting this procedure.

Biodiversity Inventory Methodology - Bats

- One crew member should be familiar with the use of bat detectors and should possess some ability to identify species by their calls using bat detectors.
- At least two crew members should be used for netting.
- All personnel should thoroughly review the Animal Capture and Handling manual before commencing with a RIC wildlife inventory survey that requires capture and/or handling.

4.3.5 Equipment

Capture:

- Mist nets, poles, and lines
- Harp trap(s)
- 'Hands-free' headlamp (e.g., Petzel) with a spare batteries, for each field person
- Spotlight (optional)
- Leather or cotton gloves
- Cloth holding bags (for holding captured bats)
- Pesola spring scale (50 g capacity)
- Calipers
- Thermometer
- Identification key (Nagorsen and Brigham 1993; van Zyll de Jong 1985)
- Field note books
- Compass
- Camera with macro-lens and flash (to record voucher photos)

Ultrasonic Detection:

- Narrow-band
 - Bat detectors with fully charged rechargeable batteries
 - Spare rechargeable batteries
 - Thermometer
 - Microcassette recorder(s) for use with detectors(s)
 - Talking clocks (remote detection only)
 - Stands raising the detectors at least 1 m off the ground are recommended in forest habitats.
 - During periods of questionable weather, the equipment (remote detection only) should be protected by water proof containers.
- Broad-band (e.g., ANABAT system)
 - for remote detection: translucent plastic case (e.g., Rubbermaid container) with hole cut for microphone, bat detector, delay switch, timer (optional), tape recorder, 12 V battery, patch cords (to provide power from the battery to the various components)
 - for manual sampling: bat detector, tape recorder or laptop (with delay switch and ZCAIM)

Light Tagging:

- Miniature light tags
- Surgical adhesive (e.g., Skinbond®)
- Microcassette recorder(s) for voice notes

4.3.6 Preliminary fieldwork

- During the day, all personnel should visit the study area in order to check out access, locate suitable areas for nets (trap stations), set up equipment, and make sure detectors are working.
- Generate a habitat description of the study area (Ecosystem Field Form FS 882(1) HRE 96/4).
- Personnel should be aware of the various ecosystem distributions (i.e., biogeoclimatic zones), and the major (if any) land use practices in the project area.
- Landowners should be contacted for permission to sample on private land.

4.3.7 Field Procedures**Mist Netting**

- At least two crew members are needed to be responsible for mist netting and harp trapping of bats.
- Up to five nets can be set up and managed by the two workers. A trap station (as specified in the accompanying data forms) may consist of more than one net.
- Environmental conditions (e.g., air temperature, cloud cover, wind, precipitation) at sunset should be recorded (see RIC standard data form).
- Net placement:
 - Place nets near roosts, near openings to caves, mines or buildings, over streams, ponds, and small bodies of calm water, and along flyways such as riparian gaps, trails, along cliffs, cut lines, and tertiary roads (Kunz and Kurta 1988). Note that nets should not be set up directly in front of day roost openings because of potential disturbance to maternity colonies.
 - A bat detector can be used to verify the presence of bat activity and thus ensure nets are set up at productive sites.
 - Nets should be positioned to take advantage of topographic and vegetative features that could be used to 'channel' bats into the nets (Mills et al. 1996; e.g., Fig. 4).
 - When setting nets across streams or trails, capture success is increased if the net is positioned beneath overhanging branches or canopy, which tend to channel bats into the net (Fig. 4). Often the spaces around nets can be closed by using loose, dead branches or rope. This also tends to induce bats to fly through the area occupied by the net.
 - It is often easier to capture bats along commuting routes (such as flyways) rather than where they feed, because they may orient via spatial memory while

commuting rather than by sensory perception (echolocation), and thus often fail to avoid a mist net (Mueller and Mueller 1979). In feeding areas, bats rely on their echolocation system, which increases their probability of detecting a mist net, and decreases netting success.

- In forested areas, nets can be set up at canopy height by using a system of guy ropes and pulleys (see Kunz and Kurta 1988). Presently, little is known about the vertical distribution of bats within the canopy (Thomas and West 1989; Bradshaw, 1996). Unless an effort is made to sample at different heights within the canopy, the presence of some species in a study area may go undetected.
- Nets should be set at several different heights to increase the chances of catching all species (see also Table 3).
- If netting on successive nights in the same area, the location of the nets should be changed each night to increase capture rate.
- Nets should not be opened before dusk, to prevent catching late flying birds. Occasionally owls and goatsuckers may be caught. Owls should be removed from the net by getting a firm hold of the feet (to protect the crew member); the beak is not a concern, although it looks like it should be.
- Nets must be monitored constantly from about a half hour before sunset to about 24:00 or 01:00 (or later at higher latitudes) depending on levels of bat activity. Capture success will typically decline as the night progresses.
- Each net should be checked at least every 10-15 minutes. Bats should be removed from a net from the same side as they entered, as determined by the position of the pocket relative to the shelf cord that separates each shelf (Figure 5; Kunz and Kurta 1988). Bats removed quickly from the net typically become less tangled and do less damage to the net. It may help to wear a loose fitting leather or a cotton glove on the left hand (for right-handed individuals). This gives a bat something to chew on other than your hand. There is no agreed upon method for removing a bat from a mist net. Freeing a wing or the tail first seems to work well. Some people find the use of a crochet hook helpful to remove a section of net from a bat's body.
- When a bat is caught, it should be removed immediately and placed in a cotton draw-stringed holding bag.
- Bats should be held until the netting session ends (to prevent recapturing the same individual) except for females that are in late stages of pregnancy or lactation. These should not be held for extended periods of time but should be released after processing at their site of capture.
- Bats should not be weighed until at least an hour after capture to allow food to clear the digestive tract.
- The species, sex, age, reproductive condition, mass, and forearm length of each bat should be recorded (see Section 3.4) as indicated on the accompanying dataforms. Note that for certain species which are difficult to key out (e.g., *M. keenii* and *M. evotis*), other morphometric measurements should be taken. These measurements include length of the third and fifth metacarpals; tragus and ear; and tibia.
- Bats are released by letting them fly off the hand or placing them on a tree trunk to fly off on their own accord. If bats have become torpid, they will need to be rewarmed in the hand before release.
- If bats are to be held overnight for any reason, proper ventilation and water should be provided.

Harp Trapping

- Similar consideration should be given to the placement of harp traps, as was done for the placement of mist nets (see above).
- Harp traps do not require constant attention. However, they should be checked hourly when pregnant or lactating females are likely to be caught.
- Bats removed from harp traps should be treated in the same way as those taken from mist nets.
- Placing captured bats in cloth bags and hanging these near or on the harp trap or mist-net will often attract other bats to the area.

***Euderma maculatum* Detection**

- The two crew members responsible for netting and trapping should also listen *ad libitum* for *E. maculatum* echolocation calls, starting about a half hour after sunset.
- At roost sites (steep cliffs) the number of individuals can be directly counted by listening to echolocation signals as the bats emerge after dusk.
- *Euderma maculatum* emerge quite late and listening at roost sites should continue for at least an hour after sunset. Listening should continue all night at potential foraging sites.
- It is not advisable to use ultrasonic detectors while listening for spotted bats as the static 'roar' of the detectors often reduces the observer's ability to hear *E. maculatum* calls.

Ultrasonic Detection

- During the day, battery levels of the detector components (e.g., detectors, voice activated tape recorders, talking clocks, etc.) should be checked. If possible, bat detectors should be calibrated using a pure tone (Thomas and West 1984).
- One crew member should be designated for set up and monitoring the bat detection equipment and data collection.
- For remote detection monitoring, bat detector systems (e.g., narrow-band detectors with talking clocks and voice activated tape recorder, or broad-band ANABAT system) are set up in the habitat of choice. The location of the detection stations may be similar to those chosen for mist netting.

Narrow-band Detectors:

- Each study area should have at least two tunable detectors set at 25 kHz and 40 kHz (also 30 kHz if possible). Each detector has its own talking clock and recorder. The voice activated tape recorders should be calibrated so they are set off by the talking clock and bat recorder, but not by background noise (e.g., wind, rain, insects, frogs). Detector set-ups can be collected in the morning. The tape should be labeled and tested. If habitats are being compared (i.e., relative abundance), it is imperative to have equipment set up in both strata.
- For manual detecting with tunable narrow band detectors, the crew member should tune the detector to and monitor at frequencies of 20 kHz, 30 kHz, and 40 kHz. Each frequency should be monitored for five minute intervals, and any species heard should be noted, including the number of bat passes and feeding buzzes heard. After five minutes, the detector should be tuned to the next frequency.

Broad-band Detectors:

- With the ANABAT system, the ZCAIM, and delay switch can be used with a portable computer. This increases the quality of the recordings, as the data do not need to be transferred from an analog format, and are recorded directly to a digital format. As the ANABAT records calls at all frequencies and records time, the set-up is less complicated. Tapes are analyzed to determine the number of bat passes, minutes of bat activity by species, and compared with reference calls to identify species or species groups.

Light Tagging

- After bats are captured (see above), light tags are activated by breaking the inner capsule in miniature light sticks.
- A small amount of Skinbond[®] surgical adhesive is applied to the activated light tags, then attached to the back (for low flying bats, e.g., *M. lucifugus*) or abdomen (for higher flying species, e.g., *E. fuscus*) of the bat.
- Once the tag is affixed, the bat should then be released in an area of low bat activity and the echolocation calls recorded as the bat departs. Forest clearings make good release sites as the bat will tend to circle several times before flying out of range (D. Thomas, Personal communication).
- For behavioural observations, numerous observers (as many as possible) should be stationed at vantage points in the study area where the light tagged bats may be flying. Voice records of bat observations can be collected on tape recorders.
- For collecting reference calls, bat detector systems can record echolocation calls once the tagged bat is released.

4.3.8 Data analysis

- For each study area, the number of species captured or detected should be tabulated.
- For each species, sex, and reproductive class (if known) the following should be calculated:
 - Number of bats caught per net-night or per hour (a net-night is equivalent to one six metre length of net set up for one night).
 - Number of bats caught per night or hour of harp trapping.
 - Number of bat passes/unit time.
 - Number of feeding buzzes/unit time.

5. Absolute Abundance

Recommended method: Roost counts. Note that roost counts can only give an absolute abundance estimate within a localized area, and only if one can be sure that all roost sites in the area are known and accounted for. These conditions are generally not realistic. Roost counts, however, will provide a fairly accurate estimate of colony size for a given roost.

5.1 Roost counts

Suitable roost sites are of paramount importance to bats (Kunz 1982). Roost sites may be night roosts (sites used temporarily between feeding bouts during the evening), day roosts (sites that bats use during the day), or hibernacula (sites where hibernation occurs during the winter months). Roosts may also serve as maternity colonies where adult females aggregate to raise young. Bats tend to be more faithful to day roost sites and hibernacula, and have more stringent requirements for characteristics such as the thermal properties of roosts (Brigham et al. in press).

Recent research suggests some species of bat in B.C. regularly change day roosts (trees; Vonhof and Barclay 1996, Rasheed and Holroyd 1995). Many species have very specific requirements for roosts in terms of shelter, temperature, humidity, and environmental stability (Kunz 1982). These requirements must be met if a bat is going to be able to use torpor in an energetically efficient way. This is especially true for hibernacula. The limited number of suitable roost sites may set an upper limit on bat population sizes. In contrast, the solitary species that roost in foliage, such as *Lasiurus cinereus* and *L. blossevilli*, do not seem to have special requirements for roost sites. The advantage of roost monitoring is that roosts tend to be permanent and can be logistically easy to study (Thomas and Laval 1988).

Locating roosts is largely a matter of identifying potential roost sites (such as cliffs, buildings, caves and mines; see also Table 3). These sites should then be observed (visually and with detectors) around dusk to see if bats emerge. If they do, then visual counts or counts with bat detectors can be made to assess the size of the colony. Some species of bat use trees as roosts, particularly older trees and snags, with cavities or crevices in the bark (Kunz, 1982). It may be possible to identify roost trees by signs such as urine stains on trunks, feces accumulations on the ground or by hearing audible bat sounds (Mayle, 1990).

5.1.1 Hibernacula

During the winter, bats use a wide variety of sites for hibernation in British Columbia, including caves, mines, buildings, and trees (Nagorsen *et al.* 1993). Identification of these sites is important in order to improve our understanding of bat ecology, and to improve the protection of important hibernation sites. Hibernacula should generally not be entered as this causes disturbance of the roosting bats and may lead to abandonment. However, in some circumstances, entering hibernacula may be warranted. These may include annual checks on the status of a site, long-term studies of changes in bat numbers, or scientific studies of hibernation and arousal mechanisms. If winter hibernacula are identified, they should be periodically monitored from the inside (we suggest every five years) by experienced individuals, to assess if any changes in population size are occurring. However, disturbance

should be kept to a minimum and hibernacula should be afforded protection. At present very few hibernacula are known in B.C. (Nagorsen and Brigham, 1993), although this presumably means they are relatively free from disturbance.

If it is necessary to enter a hibernacula, safety of the surveyors must be a prime consideration, as well as minimizing disturbance to bats. Repeated disturbance to bats in hibernation sites can reduce their survival by forcing them to use valuable stored food reserves (Thomas et al., 1990, Speakman et al. 1992). The acceptable frequency of surveys to hibernacula will vary with the configuration of the site, the number of bats, and the purpose of the survey. Surveys should last for only short periods, in order to minimize disturbance to bats. Maximum party size should be related to the size of the hibernacula, and the density of bats. However, generally only two (for safety purposes), or a few trained and experienced individuals should be involved in the survey. Hibernacula should only be entered once in the winter (between November and March), preferably when the maximum number of bats is present. For most sites, the peak in occupancy probably occurs during January or February, although there is likely variation between sites and species in British Columbia. If extensive mapping of the hibernacula is required, this should take place during the summer when bats are absent (Kunz et al. 1996).

5.1.2 Radio Telemetry

Although not a method for assessing absolute abundance of bats, radio-telemetry is a technique for locating and identifying roost sites. By clipping the fur on the backs of bats and attaching radio-transmitters, it is possible to track them to a roost site. However, certain species (e.g., *P. townsendii*, *E. maculatum*) are particularly sensitive, and should not have their hair clipped for tagging purposes. In addition, smaller species (e.g., *M. californicus*, *M. ciliolabrum*) may be inappropriate for tagging because of their mass relative to that of a radio tag (see below). Adult male bats of appropriate size can be tagged without great concern. However, only adult females that are in early pregnancy, non-parous, lactating, or post-lactating should be tagged. Adult females during late pregnancy and juveniles should not be tagged.

For flying animals, the recommended maximum mass that should be attached is 5 percent of body mass. Note that for bats, the calculation of body mass does not include a stomach full of insects. Additional mass will have significant effects on an animal's behaviour (Aldridge and Brigham, 1988). If this '5% rule' is followed then only 6 of the 16 species of bat in B.C. are suitable for radio-telemetry using a 0.44 g transmitter (see masses of bats in Table 1). However, there is some controversy as to the effects of putting a transmitter on smaller bats (D. Thomas, Personal communication). Although there is no doubt additional mass may change a bat's behaviour, especially when foraging, it can be argued that carrying around a transmitter is not that much different from carrying around a fetus (which typically weighs more than the smallest transmitters) which adult females obviously do each year. However, it is unclear what effects changing the center of gravity may have on a bats flying ability, especially on males that are unaccustomed to such weight gains (see also Kalcounis and Brigham 1995 for effects of weight on bats).

Arguably, radio-telemetry may be appropriate for locating the roosts of most species of bat. However, this assumes that the roosting habitat of tagged bats are the same as those for untagged individuals. Radio-telemetry is a useful, though expensive and time consuming

(Wilkinson and Bradbury, 1988) method for locating roost sites, but it is not useful for obtaining realistic information on foraging habitats or behaviour of smaller species.

Equipment

The smallest transmitters currently available weigh about 0.44 g, have a battery life of 8 to 10 days and a maximum detection distance of 2 to 3 km which varies depending on topography. Larger transmitters (0.7 g) may last 3 to 4 weeks, with slightly greater detection distances. Transmitters usually remain attached for 1 to 14 days. However, some species are more adept at removing (via chewing or grooming) the transmitter, thereby reducing its effective life.

5.2 Protocol: Absolute Abundance

5.2.1 Office procedures

- Review the introductory manual, *Species Inventory Fundamentals (No. 1)*.
- Obtain suitable maps of the project area. Typically 1:50 000 are used, but a larger scale such as 1:20 000 may be useful. Based on the maps and other information (previous reports, local resource specialists) identify potential roost sites. Properly identified objectives will hasten this process.
- Consult Nagorsen and Brigham (1993) and Table 3 for summer roost preferences for species of bat likely to be encountered in the project area. Discuss the bat community with local resource specialists along with amateur naturalists to further define potential roost sites.

5.2.2 Sampling design

Non-random (for roost counts). Observations should be conducted at known roost sites (Table 3). See above for protocols for mist netting (to acquire bats for radio-telemetry).

5.2.3 Sampling effort

For emergence data, usually only one roost exit per night per observer can be monitored. Data should be collected on more than one night to account for emergence number variation.

Counts of emerging bats provide an estimate of population size for that specific roost (Thomas and LaVal 1988). However, to extrapolate the information to larger geographic areas or populations, a researcher must:

- 1) establish the geographic limits to the study or project area;
- 2) determine the number and size of all roosts in the project or study area;
- 3) determine how far individuals disperse on a daily or seasonal basis compared to the size of the project or study area; and
- 4) determine whether other individuals disperse into the study or project area. In practice, this is currently logistically and economically impossible.

Due to these constraints, population estimates should reasonably be limited to individual roosts. If large colonies or winter hibernacula are identified, they should be periodically monitored from the inside (we suggest every five years) by experienced individuals, to assess if any changes in population size are occurring. However, disturbance should be kept to a minimum and large colonies or hibernacula should be afforded protection.

5.2.4 Personnel

When conducting roost counts:

- One crew member should be familiar with the use of bat detectors and should possess some ability to identify species by their calls using bat detectors.
- For hibernacula surveys, the crew leader must be a biologist with previous experience conducting these surveys.

- When relevant, all crew members must be familiar with safety procedures for entering structures (e.g., mines, caves, old buildings).

When conducting radio-telemetry:

- All crew members should have up-to-date vaccinations against rabies and tetanus.
- The crew leader must be a biologist with experience mist-netting and identifying local bat species.
- The crew leader must have previous experience attaching radio-tags before attempting this procedure.
- One crew member should be familiar with the use of bat detectors and should possess some ability to identify species by their calls using bat detectors.
- At least two crew members should be used for netting.
- All personnel should thoroughly review the Animal Capture and Handling manual before commencing with a RIC wildlife inventory survey that requires capture and/or handling.

5.2.5 Equipment

- Hand held counter or laptop computer programmed to count on key depression.
- Headlamp with deep red filter
- Bat detectors
- Thermometer
- Hygrometer
- Wind meter

Radio-telemetry

- Radio transmitters (0.44-0.7 g)
- Radio telemetry receiver (e.g., Lotek scanner)
- Antennae (double or multiple (e.g., 6) elements) and coaxial cable
- Surgical rubber based skin adhesive (e.g., Skinbond[®] brand)
- Scissors (high quality. e.g., dissecting type)
- Portable soldering iron (e.g., butane pen type)
- Solder

5.2.6 Preliminary fieldwork

- During the day, all personnel should visit the study area in order to check out access, and when applicable, locate suitable areas for nets (trap stations), set up equipment, and make sure detectors are working.
- Generate a habitat description of the study area (Ecosystem Field Form FS 882(1) HRE 96/4).
- Personnel should be aware of the various ecosystem distributions (i.e., biogeoclimatic zones), and the major (if any) land use practices in the project area.
- Landowners should be contacted for permission to sample on private land.

5.2.7 Field procedures

Roost Counts

- Caution! Roost sites (particularly hibernacula) should only be entered with extreme care, preparation, and for a worthwhile purpose, as this causes disturbance of the roosting bats and may lead to abandonment of roosts. Entering roosts may also cause structural damage to the roost (e.g., dead trees, abandoned mines).
- Identify potential roost sites such as suitable wildlife trees, cliffs, buildings, caves, and mines (Table 3).
- Once a roost is located, determine whether an emergence count (bats are observed emerging at dusk) or an inside count is most appropriate.
- For emergence counts, station observer in good viewpoint one half hour before dusk, and use a hand held counter or laptop computer programmed to count on key depression. Ensure that all exits from the roost are identified and monitored and that any bats that re-enter the roost are accounted for.
- Emergence data should be collected on more than one night to account for any variance in numbers of bats emerging.
- It may be necessary to trap bats at or near the roost to obtain a positive species identification and ensure that only one species is using the roost.
- For inside roost counts, use direct counting method when bats are easily visible, or use surface area and packing density to estimate numbers in larger roosts.
- Use red lights to inspect bats, limiting the time that bats are disturbed.
 - **Direct counting:** Within the roost, it is possible to make direct counts of roosting bats within conspicuous locations with a minimum of disturbance. A deep red filter (Kodak Wratten 29) over the headlamp causes less disturbance to bats.
 - **Surface area and packing density:** To make a count of bats which hibernate in densely packed clusters and hide in crevices, it is necessary to estimate surface area and mean packing density within a cluster and then extrapolate this for the roost site. Bats are able to hide in extremely small crevices and therefore it is easy to underestimate numbers within a roost.

Radio Telemetry

- Once a bat is captured (see section 3.3.1), weigh it and evaluate whether to radio-tag based on 5% rule, sex, and current reproductive state.
- Activate radio-tag (this may require removing a magnet, or soldering a wire connection) and verify that it is working with receiver. Check and record the frequency.
- Hold bat on soft surface (e.g., bat bag), and carefully clip an area of hair approximately the size of the radio-tag between shoulder blades. Hair removal is not recommended for *P. townsendii* and *E. maculatum*. Be sure not to clip the skin of the bat. If the bat is cut, do not attach a radio-tag. This bat must either be immediately released or maintained in captivity for a short period until infection is determined to be unlikely. See details in Wilson (1988) on maintaining captive bats for short periods.
- Once the hair is removed, apply a small amount of surgical adhesive (e.g., Skinbond[®]) to the clipped area, and to one surface of the tag that will be in contact with the bat. Allow the glue to become tacky (i.e., when it begins to bubble; approximately 2-3 minutes).

- Place the tag on the bat, and hold in place for approximately 3 to 5 minutes. Tag should be placed between the shoulder blades, with the antennae oriented towards the posterior of the bat.
- Once radio tagged, the bat should be released that night (within 1 hour if lactating female),
- Radio-tracking can be conducted on foot, or by mounting an antennae on a pole, and attaching it to the window on the driver side of vehicles. In this manner, bats can be tracked while on route, and larger areas covered. When tracking from vehicles, diesel engines produce less electric interference with telemetry equipment than gasoline engines (S. Grindal, pers. obs.).
- Track bat to the roost during next day. Note that the first roost selected by the bat after being released may be biased due to stress resulting from capture and handling. Therefore, the data from the first roost may not be valid, and should generally not be used.
- Observe and count emergence of bats that evening.

5.2.8 Data analysis

- Number and density of each species, sex, and age class (if known and applicable) for roost sites.
- Number of bats emerging, and the time of emergence
- Emergence location at the roost (e.g., tree cavity, under building roof)

Glossary

ABUNDANCE: An estimate of the number of individuals in a population. Absolute abundance is expressed as number present per area (density), but this can not be reliably assessed for bats. Relative abundance is expressed as number caught or detected per unit time (frequency). Relative abundance can be compared between localities or over time, but reliable comparisons of relative abundance can not be made between different species of bat.

BAT DETECTOR: Any device used to render the ultrasonic calls of a bat audible to the unaided human ear.

BAT-PASS: A sequence of two or more echolocation calls registered as a bat flies within range of a bat detector. Used to measure relative bat activity.

BIODIVERSITY: Jargon for biological diversity: the variety of life forms, the ecological roles they perform, and the genetic diversity they contain (Wilcox 1984 cited in Murphy 1988).

DENIER: The number of grams in 9000 metres of fibre. A unit for measuring the fineness of mist nets. The lower the number, the finer the net.

DIVIDE-BY-n (COUNTDOWN) DETECTOR: A bat detector that divides the frequency of an incoming ultrasonic signal by a factor of 'n', thus bringing the signal into the human range of hearing.

ECHOLOCATION: The use of acoustic signals by animals to locate objects or prey in their environment. Often in the ultrasonic range. The most sophisticated form of echolocation is used by bats.

EPIPHYSEAL PLATES: Cartilaginous areas where growth takes place in bones. Their shape in finger joints can be used to differentiate juvenile from adult bats (see Fig. 2).

FEEDING BUZZ: The characteristic high repetition-rate of echolocation calls given by a bat as it closes in and attacks a potential prey item.

FLY-WAY: Any corridor used by bats commuting between roost and foraging areas. Flyways make excellent sites for capturing bats in mist-nets and harp traps. Often delimited by physical structures, such as vegetation or buildings.

FREQUENCY: A measure of the number of cycles in the propagation of a (sound) wave. Measured in hertz or kilohertz.

HARP TRAP: A specialized trap designed exclusively for capturing bats.

HIBERNACULUM: Any overwintering site used by hibernating bats. Bats in hibernacula are particularly vulnerable to human disturbance.

KILOHERTZ (kHz): A unit to measure frequency. One hertz is equal to one cycle per second.

LACTATION: The period of milk production by female mammals nursing young.

NET-NIGHT: A measure of mist-netting effort. One net-night is equivalent to setting up one 6 m length of net for one evening.

OVERWINTERING STRATEGY: The behaviour exhibited by species or individuals at times outside the breeding season. This can include either migration or hibernation.

PRESENCE/NOT DETECTED: A survey intensity that verifies that a species is present in an area, or states that it was not detected (thus not likely to be in the area, but still a possibility).

PROJECT AREA: An area, usually politically or economically determined, for which an inventory project is initiated. A project boundary may be shared by multiple types of resource and/or species inventory. Sampling generally takes place within smaller study areas within this project area.

RANDOM SAMPLE: A sample that has been selected by a random process, generally by reference to a table of random numbers.

ROOST: Any site used by bats for rest, sleep, torpor, food digestion, shelter etc. A distinction can be made between **DAY** and **NIGHT** roosts. Day roosts tend to be used on a more permanent basis, whereas night roosts are sites used temporarily at night between foraging bouts.

ROOSTING STRATEGY: The behaviour exhibited by roosting bats. Bats may either be solitary or colonial.

SONOGRAM: A visual display of the time (x-axis) and frequency (y-axis) components of a sound.

STRATIFICATION: The separation of a sample population into non-overlapping groups based on a habitat or population characteristic that can be divided into multiple levels. Groups are homogeneous within, but distinct from, other strata.

STUDY AREA: A discrete area within a project boundary in which sampling actually takes place. Study areas should be delineated to logically group samples together, generally based on habitat or population stratification and/or logistical concerns.

SURVEY: The application of one RIC method to one taxonomic group for one season.

SYSTEMATIC SAMPLE: Samples are selected at a predetermined interval or frequency (e.g., every 10 m along a transect). Contrasted with random sample (q.v.).

TORPOR: An energy saving behaviour during which a bat lowers its metabolic rate and body temperature and enters an inactive state.

TUNABLE NARROW BAND DETECTOR: A type of bat detector that uses an internally generated pure tone to render ultrasonic signals at the tuned frequency audible. Can only measure a narrow (3-5 kHz) frequency band at any one time.

ULTRASONIC: Any sound above 20 kHz, which is generally inaudible to human hearing.

VERSPERTILIONIDAE: The taxonomic family to which all bats found in Canada belong. The so-called 'mouse-eared' or 'plain-nosed' bats.

VOLANT: Possessing the ability to fly.

Literature Cited

- Aldridge, H. D. J. N., and Brigham, R. M. 1988. Load carrying and maneuverability in an insectivorous bat: a test of the 5% rule of radio-telemetry. *Journal of Mammalogy*, 69:379-382.
- Anthony, E. L. P. 1988. Age determination in bats. In Kunz, T. H., ed. *Ecological and behavioural methods for the study of bats*. Washington, DC. Smithsonian Institution Press. pp. 47-57.
- Barclay, R. M. R. 1991. Population structure of temperate zone insectivorous bats in relation to foraging behaviour and energy demand. *Journal of Animal Ecology*, 60:165-178.
- Barclay, R. M. R. and Bell, G. P. 1988. Marking and observational techniques. In Kunz, T. H., ed. *Ecological and behavioural methods for the study of bats*. Washington, DC. Smithsonian Institution Press. pp. 59-76.
- Bradshaw, P. 1996. The physical nature of vertical forest habitat and its importance in shaping bat species assemblages. Pages 199–212 in R.M.R. Barclay and R.M. Brigham, editors. *Bats and Forests Symposium: October 19–21, 1995, Victoria, B.C., Canada* Resources Branch, Ministry of Forests, Victoria, B.C. Work paper 23/1996.
- Brigham, R. M., Cebek, J. E., and Hickey, M. B. C. 1989. Intraspecific variation in the echolocation calls of two species of insectivorous bats. *Journal of Mammalogy*, 70:426-428.
- Brigham, R. M., Grindal, S. D., Firman M., and J. Morissette. 1997. The influence of structural clutter on activity patterns of insectivorous bats. *Canadian Journal of Zoology* 75:131-136.
- Brigham, R.M., Vonhof, M.J., Barclay, R.M.R., & Gwilliam, J.C. 1997b. Roosting behavior and roost-site preferences of forest-dwelling California bats (*Myotis californicus*). *Journal of Mammalogy* 78: in press.
- Buchler, E. R. 1976. A chemiluminescent tag for tracking bats and other small nocturnal animals. *Journal of Mammalogy*, 57:173-176.
- Cannings, R.A. and A.P. Harcombe (eds). 1990. *The vertebrates of British Columbia: scientific and English names*. Royal British Columbia Museum Heritage Record No.20; Wildlife Report No. R24. Ministry of Municipal Affairs, Recreation and Culture and Ministry of Environment. Victoria, BC. 116 pp.
- Constantine, D. G. 1958. An automatic bat-collecting device. *Journal of Wildlife Management*, 22:17-22.
- Downes, C. M. 1982. A comparison of the sensitivities of three bat detectors. *Journal of Mammalogy*, 63:343-345.

Biodiversity Inventory Methodology - Bats

- Faure, P. A., Fullard, J. H., and Barclay, R. M. R. 1990. The response of tympanate moths to the echolocation calls of a substrate gleaning bat, *Myotis evotis*. *Journal of Comparative Physiology A*, 166:843-849.
- Fenton, M. B. 1970. A technique for monitoring bat activity with results obtained from different environments in southern Ontario. *Canadian Journal of Zoology*, 48:847-851.
- Fenton, M. B. 1985. *Communication in the Chiroptera*. Indiana University Press, Bloomington. 161 pp.
- Fenton, M. B. 1988. Detecting, recording and analyzing vocalizations of bats. In Kunz, T. H., ed *Ecological and behavioural methods for the study of bats*. Washington, DC. Smithsonian Institution Press. pp. 91-104.
- Fenton, M. B., and Bell, G. P. 1979. Echolocation and feeding behaviour of four species of *Myotis* (Chiroptera). *Canadian Journal of Zoology*, 57:1271-1277.
- Fenton, M. B., and Bell, G. P. 1981. Recognition of species of insectivorous bats by their echolocation calls. *Journal of Mammalogy*, 62(2):233-243.
- Fenton, M. B., Merriam H. G., and Holroyd, G. L. 1983. Bats of Kootenay, Glacier and Mount Revelstoke National Parks in Canada: identification by echolocation calls, distribution and biology. *Canadian Journal of Zoology*, 61:2503-2508.
- Fenton, M. B., Tennant, D. C., and Wysecki, J. 1987. Using echolocation calls to measure the distribution of bats: the case of *Euderma maculatum*. *Journal of Mammalogy*, 68:142-144.
- Firman, M., Getty, M., and Barclay, R. M. R. 1992. Status of Keen's long-eared bat (*Myotis keeni*) in British Columbia. Report submitted to Wildlife Branch, Ministry of Environment, Victoria, B. C.
- Gaisler, J. 1979. Results of bat census in a town (Mammalia:Chiroptera). *Vestnik Ceskoslovenske Spolecnosti Zoologicke*, 43:7-21.
- Griffin, D. R. 1958. *Listening in the dark*. Yale University Press, New Haven. 413 pp.
- Grindal, S. D. 1995. Impacts of forest harvesting on habitat use by foraging bats in southern British Columbia. M.Sc. Thesis, University of Regina, Saskatchewan.
- Grindal, S.D. 1996. Habitat use by bats in fragmented forests. Pages 260-272 in R.M.R. Barclay and R.M. Brigham, editors. *Proceedings of bats and forests symposium*, October 19-21, 1995, Victoria, B.C., Canada. Resources Branch, Ministry of Forests, Victoria, B.C. Work paper 23/1996.
- Grindal, S. D., Collard, T. S., Brigham R. M. and Barclay, R. M. R.. 1992. The influence of precipitation on reproduction by *Myotis* bats in British Columbia. *American Midland Naturalist*, 128:339-344.
- Hayes, J.P. 1997. Temporal variation in activity of bats and the design of echolocation-monitoring studies. *Journal of Mammalogy* 78:514-524.

- Holroyd, S. L., Barclay, R. M. R., Merk, L. M., and Brigham, R. M. 1994. A survey of the bat fauna of the dry interior of British Columbia: a summary by species with recommendations for future work. Ministry of the Environment, Lands and Parks, Victoria, B.C. WR-63. 80 pp.
- Hovorka, M.D., Marks, C.S., and E. Muller. 1996. An improved chemilucifer tag for bats. *Wildlife Society Bulletin* 24:709-712.
- Kalko, K.V. and Schnitzler, H.U. 1993. Plasticity in echolocation signals of European pipistrelle bats in search flight: Implications for habitat use and prey detection. *Behavioural Ecology and Sociobiology* 33:415-428.
- Kalcounis, M.C. and R.M. Brigham. 1995. Intraspecific variation in wing loading affects on habitat use by little brown bats (*Myotis lucifugus*). *Canadian Journal of Zoology*.
- Kunz, T. H. 1982. Roosting ecology. In Kunz, T. H., ed. *Ecology of bats*. New York, NY. Plenum Press. pp. 1-55.
- Kunz, T. H. 1988. *Ecological and behavioural methods in the study of bats*. Washington, DC. Smithsonian Institution Press. 533 pp.
- Kunz, T. H. and Anthony, E. L. P. 1977. On the efficiency of the Tuttle bat trap. *Journal of Mammalogy*, 58:309-315.
- Kunz, T. H., and Brock, C. E. 1975. A comparison of mist nets and ultrasonic detectors for monitoring flight activity of bats. *Journal of Mammalogy*, 56:907-911.
- Kunz, T. H., and Kurta, A. 1988. Capture methods and holding devices. In Kunz, T. H., ed. *Ecological and behavioural methods for the study of bats*, Washington, DC. Smithsonian Institution Press. pp. 1-28.
- Kunz, T.H., Thomas, D.W., Richards, G.C., Tidemann, C.R., Pierson, E.D., and Racey, P.A. 1996. Observational techniques for bats. In Wilson, D.E., Cole, F.R., Nichols, J.D., Rudran, R., and Foster, M.S., eds. *Measuring and Monitoring Biological Diversity: Standard Methods for Mammals*. Smithsonian Institution Press, Washington. Pp. 105-114.
- LaVal, R. K., and LaVal, M. L. 1977. Reproduction and behaviour of the African banana bat *Pipisrellus nanus*. *Journal of Mammalogy*, 58:403-410.
- Leonard, M. L., and Fenton, M. B. 1984. Echolocation calls of *Euderma maculatum* (Chiroptera: Vespertilionidae): Use in orientation and communication. *Journal of Mammalogy*, 65:122-126.
- Mayle, B. A. 1990. Habitat management for woodland bats. Forestry Commission Research Information Note 165:1-4. Forestry Commission, Edinburgh.
- Miller, L. A., and Andersen, B. B. 1984. Studying bat echolocation signals using ultrasonic detectors. *Zeitschrift Saeugetierkunde*, 49:6-13.

Biodiversity Inventory Methodology - Bats

- Mills D J. Nortojn T W. Parnaby H E. Cunningham R B. Nix H A. 1996. Designing surveys for microchiropteran bats in complex forest landscapes: A pilot study from south-east Australia. *Forest Ecology & Management* 85:149-161.
- Mueller, H. C., and Mueller, N. S. 1979. Sensory basis for spatial memory in bats. *Journal of Mammalogy*, 60:198-201.
- Nagorsen, D. W., and Brigham, R. M. 1993. *The Mammals of British Columbia 1. Bats*. Royal British Columbia Museum, Victoria, B.C., Canada. UBC Press. 166 pp.
- Navo, K. W., Gore, J. A., and Skiba, G. T. 1992. Observations on the spotted bat *Euderma maculatum* in northwestern Colorado. *Journal of Mammalogy*, 73:547-551.
- Nyholm, E. R. 1965. Zur Ökologie von *Myotis mystacinus* (Leisl.) und *M. daubentoni* (Leisl.) (Chiroptera). *Ann. Zool. Fenn.*, 2:77-123.
- Perkins, J. M., and Cross, S. P. 1988. Differential use of some coniferous forest habitats by hoary and silver-haired bats in Oregon. *Murrelet* 69:21-24.
- Racey, P. A. 1988. Reproductive assessment in bats, pp 31-43. In *Ecological and Behavioural Methods for the Study of Bats*, (Thomas H. Kunz, ed.). Washington, DC. Smithsonian Institution Press. 533 pp.
- Rainey, W. E., Pierson, E. D., Colberg, M., and Barclay, J. H. 1992. Bats in hollow redwoods: seasonal use and role in nutrient transfer into old growth communities. In *proceedings of the 22nd Annual North American Symposium on Bat Research*, Quebec City, Quebec.
- Rasheed, S.A. and S.L. Holroyd. 1995. Roosting habitat assessment and inventory of bats in the MICA Wildlife Compensation Area. Report prepared for B.C. Hydro, B.C. Environment, Lands and Parks, and Parks Canada.
- Simmons, J. A., Fenton, M. B., Ferguson, W.R., Jutting, M., and Palin, J. 1979. Apparatus for research on animal ultrasignals. *Life Sciences Miscellaneous Publication Royal Ontario Museum*, 1-31.
- Speakman, J.R., Bullock, D.J., Eales, L.A., and Racey, P.A. 1992. A problem defining temporal pattern in animal behaviour: clustering in the emergence behaviour of bats from maternity roosts. *Animal Behaviour* 43:491-500.
- Swift, S. M. 1980. Activity patterns of Pipistrelle bats (*Pipistrellus pipistrellus*) in north east Scotland. *Journal of Zoology of London*, 190:285-295.
- Thomas, D. W. 1988. The distribution of bats in different ages of Douglas fir forests. *Journal of Wildlife Management*, 52(4):619-626.
- Thomas, D. W., Dorais, M., and Bergeron, J. M. 1990. Winter energy budgets and cost of arousals for hibernating little brown bats, *Myotis lucifugus*. *Journal of Mammalogy*, 71(3):474-475.

- Thomas, D. W., Bell, G. P. and Fenton, B. B. 1987. Variation in echolocation call frequencies recorded from North American vespertilionid bats: a cautionary note. *Journal of Mammalogy*, 68:842-847.
- Thomas, D. W., and LaVal, R. K. 1988. Survey and census methods. In Kunz, Thomas H., ed *Ecological and behavioural methods for the study of bats*. Washington, DC. Smithsonian Institution Press. pp. 77-89.
- Thomas, D. W., and West, S. D. 1984. On the use of ultrasonic detectors for bat species identification and the calibration of QMC Mini Bat Detectors. *Canadian Journal of Zoology*, 62:2677-2679.
- Thomas, D. W., and West, S. D. 1989. Sampling methods for bats. In: Carey, A. B., and Ruggiero, L. F. (eds.). *Wildlife-habitat relationships: sampling procedures for Pacific Northwest vertebrates*. U.S. Department of Agriculture, Forest Service, Portland, OR. General Technical Report PNW-GTR-243.
- Tidemann, C. R., and Woodside, D. P. 1978. A collapsible bat-trap and a comparison of results obtained with the trap and with mist-nets. *Australian Wildlife Res.*, 5:355-362.
- Tuttle, M. D. 1974. An improved trap for bats. *Journal of Mammalogy*, 55:475-477.
- Vonhof, M.J. 1996. Roost-site preferences of Big Brown bats (*Eptesicus fuscus*) and Silver-haired bats (*Lasionycteris noctivagans*) in the Pend D'Oreille Valley in southern British Columbia. Pg. 62-80. in *Bats and Forest Symposium* (R.M.R. Barclay and R.M. Brigham eds.). *Proceedings of First International Bat-Forest Interactions Symposium*. Held at Victoria, B.C., 19-21 October 1995. Research Branch B.C. Ministry of Forests, Victoria, B.C. Working Paper 23/1996.292 pp
- Vonhof, M.J., & R.M.R. Barclay. 1996. Roost-site selection and roosting ecology of forest-dwelling bats in southern British Columbia. *Canadian Journal of Zoology* 74:1797-1805.
- Voute, A. M., Sluiter, J. W., and Grimm, M. P. 1974. The influence of the natural light-dark cycle on the activity rhythm of pond bats (*Myotis dasycneme* Boie 1825) during summer. *Oecologia*, 17:221-243.
- Wilkinson, G. S., and Bradbury, J. W. 1988. Radiotelemetry: techniques and analysis. In Kunz, Thomas H., ed *Ecological and behavioural methods for the study of bats*. Washington, DC. Smithsonian Institution Press. pp. 105-120.
- Wilson, D.E. 1988. Maintaining bats for captive studies. In Kunz, Thomas H., ed *Ecological and behavioural methods for the study of bats*. Washington, DC. Smithsonian Institution Press. pp. 247-263.
- Woodsworth, G. C., Bell, G. P., and Fenton, M. B. 1981. Observations of the echolocation, feeding behaviour and habitat use of *Euderma maculatum* (Chiroptera: Vespertilionidae) in south central British Columbia. *Canadian Journal of Zoology*, 59:1099-1102.
- Youngson, W. K., and McKenzie, N. L. 1977. An improved bat-collecting technique. *Bulletin of the Australian Mammal. Society*, 3:20-21.

Biodiversity Inventory Methodology - Bats

van Zyll de Jong, C. G. 1985. Handbook of Canadian Mammals. 2. Bats. Publication of the National Museum of Natural Sciences, National Museum of Canada, 212 pp.

Appendix A.

Selected Suppliers Of Equipment Used For Bat Inventory.

Equipment Type	Commercial Suppliers
Capture Mechanisms: <i>Mist Nets:</i>	Avinet Inc. P.O. Box 1103 Dryden, New York 13053-1103 USA http://www.avinet.com/
	Northeastern Bird Banding Association Manomet Bird Observatory Box 936 Manomet, Massachusetts 02345 USA
<i>Harp Traps:</i>	Not commercially available.
Bat Detectors: <i>Tunable, Narrow Band:</i>	Bat Conservation International P.O. Box 162603 Austin, Texas 78716 USA http://www.batcon.org/
	Pettersson Elektronik AB Tallbacksvagan 51 S-756 45 Uppsala Sweden Tel: +46 1830 3880 Fax: +46 1830 3840 e-mail: pettersson@bahnhof.se URL: http://www.bahnhof.se/~pettersson

Biodiversity Inventory Methodology - Bats

Equipment Type	Commercial Suppliers
	Ultra Sound Advice 23 Aberdeen Road London N5 2UG UK (QMC mini-bat detector)
<i>Divide-by-n:</i>	Titley Electronics P.O. Box 19, Ballina, N.S.W. 2478 Australia 61 (66) 86 6617 - Fax (ANABAT II bat-detector)
	Ultra Sound Advice Address as above. (QMC S200 bat-detector)
<i>Oscilloscopes:</i>	Nicolet Instrument 5225 Verona Road Madison, Wisconsin 53711 USA
	Non Linear Systems Box N Delmar, California 92014 USA
Telemetry Equipment: <i>Radio-transmitters:</i>	AVM Instrument Co. 2368 Research Drive Livermore, California 94550 USA
	Holohil Systems Ltd. 3387 Stonecrest Road RR 2, Woodlawn, Ontario K0A 3M0 (model BD-2B, a reliable 0.7g transmitter)
	Wildlife Materials Inc. RR 2, Giant City Road Carbondale, Illinois 62901 USA

Biodiversity Inventory Methodology - Bats

Equipment Type	Commercial Suppliers
<i>Receivers:</i>	AVM Instrument CO. Address as above.
	Custom Electronics 2009 Silver Court West Urbana, Illinois 61801 USA
	Lotek Enginerring Inc. 34 Berczy Street Aurora, Ontario L4G 4J8
	Wildlife Materials Inc. Address as above.
<i>Antennas:</i>	AVM Instrument Co., - Custom Electronics, - Lotek Engineering Inc., - Wildlife Materials Inc., Addresses as above.
<i>Cyalume Light Sticks:</i>	American Cyanamid Corp. Organic Chemicals Division Bound Brook, New Jersey 08805 USA
	- Forestry Suppliers Inc. P.O. Box 8397 Jackson, Mississippi 39204 USA
<i>Tape Recorder (76 cm/s):</i>	Racal Thermionic Ltd. Hythe, Southampton UK