Chapter 1: Introduction

The Tiger Crisis

The tiger, classified as an endangered species by the International Union for the Conservation of Nature (IUCN), is disappearing from many parts of its range. Two of the eight tiger subspecies, the Balinese and Caspian, have already gone extinct, and the Javan is thought to have disappeared in the 1980s. Habitat loss has reduced the tiger's range and fragmented its global distribution into an estimated 150 to 200 populations, and protected areas compose only a part of the habitat of many of these populations. Furthermore, drastic increases in tiger poaching during the 1980s and 1990s have strongly impacted all 5 remaining subspecies. For long term survival, some populations are already too small; others will become too small if present population pressures continue. The future of the tiger depends on protecting large blocks of suitable habitat across Asia and halting all tiger poaching, but without baseline data on tiger populations it is nearly impossible to initiate the proactive management needed to alter the effects of poaching and habitat loss.

The Purpose of this Manual

The purpose of this manual is to present standardized methods for gathering data on and monitoring the tiger, its habitat and prey, and for mapping tiger distribution[1]. We describe how to conduct tiger and tiger prey surveys, evaluate tiger habitat, and organize and analyze data. If collected in a consistent manner, these data can become part of a geographic information system to analyze and monitor tiger distribution on a landscape scale. It is hoped that this manual will be seen as a "toolbox" (see Box 1.1) for monitoring efforts across the tiger's range, and will aid in conserving tigers and their ecosystems across Asia.

Who is this manual for?

This manual is for use by a broad range of wildlife rangers and managers. Though it can be used by other individuals and institutions, it has been written primarily for the staff of national wildlife conservation departments; it is not a manual on tiger research. As most of the data referred to are taken from work conducted in the dry tropical forests of Nepal, Thailand, Cambodia and Vietnam, the techniques and guidelines presented are most suitable for use by individuals working in this biogeographic region. However, individuals working in other parts of the tiger's range may find much of the methodology and conceptual framework presented here useful with some modifications.

Box 1.1. A Toolbox for Answering Questions about Tigers in the Wild

Question	To answering the question:	Page
Are tigers present in this area?	• Carry out tiger presence/absence survey	
Is this population of tigers stable?	• Carry out repeated presence/absence surveys	
Can this habitat sustain tigers?	• Carry out habitat evaluation surveys • **Estimate relative prey abundance**	
Is this habitat stable?	• Carry out repeated habitat evaluation surveys	
Is this breeding quality habitat or merely a dispersal zone?	• **Carry out habitat evaluation surveys (tiger presence / absence surveys?)**	
Are tigers in this area part of a larger *metapopulation*?	• **Carry out multiple presence/absence surveys (in different areas)** • Combine data with other investigations in the region • Evaluate data using a GIS	
What is tiger prey base?	• Prey surveys	

Chapter 2: Mapping Tiger Distribution

Landscape-scale considerations in tiger conservation

Conservation efforts within the tiger's range have primarily focused on protected areas, and have had varying degrees of success. Because of the tiger's need for large areas, however, an approach encompassing landscape level considerations will ultimately be necessary to ensure the tiger's long term survival. Large portions of suitable tiger habitat are often outside parks and reserves (Smith et al. 1987, 1998; Wikramanayake et al. 1998) and may provide resources necessary for sustaining viable populations. Wikramanayake et al. (1998) have identified priority areas for tiger conservation (*tiger conservation units*, or TCUs) over the entire range of the species. This manual builds on that work by providing methods and rationale for collecting data that can be used to map the extent of individual tiger populations. It also provides a means to monitor tiger presence and absence and relative tiger and prey density and the tools to assess change or potential change in tiger status over wide areas. To evaluate and monitor tiger status at the ecosystem and landscape scales, standardized methods for data collection are needed and will enable managers to determine whether changes are due to prey depletion or tiger poaching.

The importance of spatially referenced data

Spatially referenced data is simply any phenomena for which the location is clearly defined. This location can be strictly relative (e.g. at certain distances from other points of interest) or referenced using one of many coordinate systems that apply universally. A record of the locations of various phenomena provides an opportunity to analyze information in a multitude of different ways.

There are many levels at which the relationship between elements in an ecosystem can be described. Trophic relationships indicate the relation of elements in terms of energy flow, taxonomic relationships describe evolutionary relationships. Spatial relationships are in many ways the simplest relationships to measure but can yield powerful insight into ecosystems and the roles of various elements within those systems. Because management decisions are typically spatially explicit (e.g. whether or not a certain treatment should to be applied to a particular *point* or *area*), it is important to understand how the various elements of the ecosystem are related to that point or area. As geographically referenced data have become more available, recent studies have combined this information with our knowledge of genetics and population dynamics to shed light on central questions of tiger conservation concerning habitat viability, landscape-scale management, and the ultimate survival of the species (Smith et al. 1987, Wikramanayake et al. 1998, Smith et al. 1998).

Tools for spatial analyses

As new methods and tools for spatial analyses have been developed, biologists, managers, and others considering landscape-scale questions have been quick to add them to their toolbox. Below is a description of some of the most important spatial analysis tools along with a brief discussion of their role in conserving tigers across their range. Although a thorough knowledge of these technologies is not required to utilize this manual effectively, a familiarity with these terms will provide a useful context when collecting and summarizing data.

- **GIS (Geographic Information Systems)**. A GIS is a system of mapping and analyzing spatial data. More formally it is any organized system of people and tools designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information (ESRI 1990). These days, a GIS is typically considered to be a computer-oriented system; that is—a system where the geographically referenced information is entered into, stored in, manipulated, and extracted from a computer. What often gets lost in this conception of a GIS is the critical role that users—actual people—play in creating, maintaining, and deriving value from such a system. This manual takes the perspective that a geographic information system is merely a means to an end. The ultimate value of such a system will depend on the quality and consistency of the data people bring to the system and the questions they ask.

- **Georeferenced data and GPS (Global Positioning System)**. In the past efforts to assess the status of tigers have focused on counting tigers. Often the unit counted has been a protected area rather than an entire tiger population. Because many parks are too small to maintain viable tiger populations, managers need to shift their focus to landscapes. This manual approaches tiger assessment from a land base perspective. To conserve a land base capable of supporting viable tiger populations, it is necessary to map tiger and tiger sign occurance, along with those areas from which tigers are absent, and those areas where prey and habitat quality surveys have been conducted.

  Mapped data is referred to as georeferenced data. When data are mapped precisely, it is possible to return to these areas to see if there has been a change. For example, we may want to determine if tigers still occupy a habitat where they occurred 2 years ago. Or we may want to know if prey density is declining in an area where human activity is increasing.

  Georeferenced data can be recorded by plotting locations directly on 1:25,000 or 1:50,000 maps carried in the field or by recording the location with a global positioning system (GPS). The system involves a receiver, which costs as little as $100.00, that can simultaneously receive and possess signals being broadcast from several of 24 satellites orbiting the earth. A GPS allows someone with a receiver to determine their location with a precision of approximately 15-50 m.

- **Remotely Sensed Data**. In recent years, techniques for acquiring data from both aircraft and satellites have improved dramatically and satellite data are now available for virtually every inch of the earth's surface. These data can serve as both an important baseline data source for evaluating vegetation patterns and as a means of monitoring changes over large areas.

Because this remotely sensed information (typically in the form of either still photos or video footage) is increasingly digitally stored and geographically referenced, it is readily transferred to a GIS where it can be combined with other georeferenced data.

New techniques for classifying and evaluating these data allow known patterns to be extrapolated so that large areas of cover can be classified and used in landscape scale analysis.

Concluding paragrah.

Chapter 3: Tiger Surveys

Our objective in this chapter is to present survey methodologies that will enable investigators, often with only limited resources, to effectively assess the status of tigers in a wide range of habitat types, under potentially difficult field conditions, and to classify tiger habitat as breeding or non-breeding / dispersal habitat. This chapter presents standardized methods for carrying out interviews, sign and camera trap surveys by describing the steps involved in planning, carrying out, and analyzing the results of these surveys.

I. Interviews [needs to be included. Rationale: It is an integral part of the habitat quality assessment methods described below and may be the only tiger survey method available in heavily mined areas in Laos, Cambodia, Vietnam and Burma. We can include basic guidelines on the bare minimum of what information to get as well as how the responses can be evaluated (i.e. in terms of how recent the report was, is it corroborated, etc.)]

Preparation

1) **Purpose of interviews:**
   a) **to obtain preliminary information over a wide area before ground surveys (Vietnam)**
   b) **to seek help finding tiger sign during surveys**
   c) **to gather information for areas that will not be surveyed**
2) **Develop survey questions and form for recording information obtained. It would be good to include the questionnaire which was used in Vietnam.**
3) **Determine target group or individuals to be interviewed (villagers versus select people who spend time in the forest)**
4) **Language issues**
5) **Politics/ Suspicion of interviewer/ Talk to Sharada, Mae Shu, Terri Allendorf for imput**

II. Tiger Sign Surveys

Preparation

1. Assess the administrative requirements of the survey and take steps to coordinate with appropriate agencies.

- Produce a detailed outline of field project, describing methods to be used and information to be gathered.
- Notify and coordinate survey with protected area director.
- If protected area staff are to accompany survey team or conduct survey by themselves, set up and conduct a training workshop. If rangers are conducting surveys, it is important that a team of skilled field staff accompany them on initial surveys and occasionally on subsequent surveys to continue skill training.
- Coordinate with wildlife managers and rangers in different jurisdictions, especially if survey area spans more than one jurisdiction.

2. Assess the logistical needs of the survey and plan accordingly

- For safety reasons at least 2 people are needed to undertake the survey. If the survey team is unfamiliar with the area, it is often most effective to include a local guide in the survey team.
- Field skills: Read and interpret standard topographic maps.

    1. Read, record and interpret UTM coordinates.
    2. Use a hand-held GPS unit to acquire UTM locations.
    3. Recognize mammal sign and distinguish between large carnivores.

- Recommended equipment:

    1. a GPS unit
    2. a tape measure
    3. data forms
    4. topographic maps (at a scale 1:50,000 or 1:100,000)

5. 35 mm camera
6. paper bags for collecting scats and other items (store scats in paper bags)

- Time for individual surveys may vary from ½ a day to several days depending on the size and accessibility of the area.

3. Survey Design

- *Determine the best time of year to conduct surveys.* In general, the wet season should be avoided, and surveys should not be conducted within 4-5 days of a heavy rainfall because tiger sign will be obscured. Surveys should be conducted when tiger sign is likely to be most apparent.
- *Determine where to conduct surveys:* Determining where to carry out surveys requires that all known and potential tiger habitat be identified. Potential habitat can be identified through the use of satellite image maps or good forest cover maps (Figure 6). Known habitats are identified through previous documented sightings of tigers and or by reports of tiger or tiger sign seen by local people. Survey sites can be areas within a protected zone, a habitat fragment outside of a protected area system, a potential corridor for tigers, a fringe area of previously identified tiger habitat, or a variety of other sites. In many cases, specific local knowledge can provide invaluable insight into where tigers may occur.

The Problem of Determining *Absence*

Although establishing the presence of tigers often requires substantial effort and time, doing so is a fairly straightforward business. Tigers are large animals that leave unique signs in the environment, which can be readily documented. ***But when does one conclude that there are no tigers in an area?*** This is a much more difficult question.

Surveys can never demonstrate with 100% certainty that tigers are not present in an area. The best we can do is to develop a framework in which the results of different surveys can be compared. We emphasize the importance of tracking the *effort* that goes into a given survey so that these comparisons will have some degree of consistency.

When no tiger sign is found, one important factor that may help the survey team decide that it has searched long enough is a corresponding lack of tiger prey sign (see chapter 4).

- *Establish survey blocks.* A survey block is defined as an area of contiguous potential tiger habitat limited by either natural features of the landscape, political borders, or constraints such as time, personnel, and or other resources. For example, a survey block may be only a portion of a larger area of contiguous tiger habitat; this block may be limited by an international boundary or time available for the survey, etc. The boundaries of survey blocks should be clearly delineated so that accurate calculations of survey areas can be made. Precise estimates of survey area will allow the survey team to accurately report the intensity of its efforts, ensure the comparability of data collected, and may also provide the basis for rough, relative tiger density estimates.

- *Determine location of survey routes.* The extent of road network will strongly determine the location of survey routes; maps of the area showing roads, trails, streambeds, and/ or other likely tiger travel routes provide the best starting point for selecting survey routes. As the ultimate goal of the survey is to establish the presence or absence of tigers within a survey block, survey routes should focus on areas where the likelihood of detecting tiger sign is highest. Hunters, herdsmen, and other forest users can provide invaluable information about tigers in the area. If there have been reports of sightings of tiger or tiger sign, an effort should be made to integrate reported locations into the earliest planned surveys. If there is no prior information on tiger presence within a survey block, surveys should be planned along ridge tops, roads, river courses, dry streams, and animal and human trails. Under these circumstances it is most effective to work with a local guide if such a person is available.
- *Determine target distance to be surveyed.* A rate of 0.5 km linear transect distance per 1 km^2 area is suggested as the minimum distance necessary to accurately survey an area, though the costs of achieving this level of intensity may be unrealistic or even impossible due to logistical factors in some regions. For example, in survey blocks with limited trails or in extremely rugged terrain, the survey team may have to settle for a lower minimum distance. The tiger survey forms included in this manual (Pages 12 and 13) provide space for accurately recording both kilometers covered and time spent searching for tiger sign along trails. These data allow the team to track and report on the intensity of search efforts between and within survey blocks (see Chapter 5).

- *Distance of individual transects.* In general, given adequate access within a survey block, several shorter transects are preferable to fewer longer transects. A greater number of shorter transects enables the survey team to search more areas within the survey block where the likelihood of encountering tiger sign is highest.

Conducting the survey

- *Documenting the route.* It is important to record the location of the start and end points of the survey route. In addition, the team should record periodic locations so that the survey route can later be plotted on a map and the number of kilometers covered can be determined. Because survey routes will rarely form a straight line, it is important to record locations frequently enough to capture the twists and turns of the route.
- *Documenting tiger sign.* Each time tiger sign is encountered along the route, a UTM waypoint should be taken to mark the location. This allows the team to later calculate the number of signs per kilometer surveyed to establish a sign encounter rate, and provides a standard means of comparison between areas with different survey distances. When tiger sign is encountered, the following variables should also be recorded: type (e.g. tracks, scrapes, spray marks, kills) and age of sign, appropriate measurements, sign placement, substrate sign found in, and cover type and quality. If the team is documenting other animals in the area, then similar data can be recorded for these observations.

Likely Tiger Travel Route Survey

General Location:	**Date**:	**Time since last Rain**:	*Page* ____ *of* ____
	Feature Surveyed (Road, Trail, Streambed, etc.):	**Names of surveyors**:	

Survey Route

Way-point #	UTM Coordinates	Habitat Type	Habitat condition

Way-point #	UTM Coordinates	Habitat Type	Habitat condition

Way-point #	UTM Coordinates	Habitat Type	Habitat condition

Record tiger sign encounters on opposite side of this sheet

DRAFT

Sign Encountered

Way-point #	Species[1]	Type of sign	Age of sign	Measurements	Place-ment	Substrate Type	Substrate Condition	Photo? (Y/N)	Notes

1 Species: record sign of tiger, leopard, other large carnivores and tiger prey species

Summary Information (To be filled out after route has been surveyed)

Estimated total km traveled	# of tiger signs encountered	# of tiger signs encountered / Estimated km traveled	Total time spent surveying this route

Compiling and Analyzing the Results

- *Complete field forms.* Finish filling out summary section of field forms.
- *Tabulate data.* When a computer is available, data should be entered into a spreadsheet (such as Excel) or any database format (see Appendix X for a sample spreadsheet). Tabulated data can in turn be easily imported into a GIS database (such as ArcView) for further analysis.
- *Map data.* Mapping tiger distribution using a GPS or 1:50,000 topographic maps provides a basis for monitoring change in tiger distribution, and gives surveyors an opportunity to return to specific locations to reassess the status of tigers in an area (see chap 6?). Mapping also helps clarify the extent of discrete tiger populations and enables one to calculate statistics on the size and distance among areas occupied by tigers. Ultimately, such information can provide insight on tiger *metapopulation structure* (the size, distance between and degree of connectedness among a group of local populations).

III. Tiger Camera-Trap Surveys

When available, camera traps can provide useful information that may not be available using the methods described above. Furthermore, photos of tigers provide dramatic impact in reports to high level decision makers and can provide information on the sex, age, and/or condition of individuals. Researchers such as Karanth (1995) and [McDougal pers. comm.] have demonstrated that individual identification of tigers is possible using camera trap photographs. These data can potentially be used to calculate minimum home range and rough density estimates. Where substrate is of poor quality, camera traps can document the presence of tigers. This chapter outlines basic camera trap methodology and the technical aspects of designing and deploying a camera trap survey. It does not cover the analysis of mark-recapture data as a method to make density estimates (for mark recapture techniques see Karanth 1995, 1998).

Preparation

1. ***Administrative Considerations.*** Same as for tiger sign surveys.

2. ***Assess the logistical needs of the survey and plan accordingly.***

- The survey team. As with tiger sign surveys, for safety reasons we strongly recommend that at least 2 people undertake the survey.

- Field skills: at least one person in the survey team should be able to:

  1. Set up the camera trap unit to obtain the type of photos desired (See Box XXX.)
  2. Check and maintain the camera trap units during the survey.
  3. Read, record and interpret UTM coordinates.
  4. Use a hand-held GPS unit (if available) to acquire UTM locations.

- Recommended equipment:

  1. Camera trap units (see Box) labeled with unique ID numbers (unit refers specifically to the camera and any other associated equipment).
  2. Film (100 ASA color print). If units will be checked frequently, rolls of 12 exposures may be preferable so that photo data can be examined early on in the survey (see pg. 22).
  3. a GPS unit
  4. tape measure
  5. data forms
  6. topographic maps (at a scale 1:50,000 or 1:100,000)
  7. plastic or paper bags for collecting scats and other items

Box... Camera Trap Units

TrailMaster brand camera-trap units (manufactured by Goodson Associates, Lenexa KS 66215, USA) have been used successfully in India, Nepal, Sumatra and Thailand (Karanth 1995; Conforti U of MN M.S. Thesis 1996; Franklin in prep; Lyman in prep). These units consist of one or two TM-35 camera kits (35mm, autofocus, rangefinder type) triggered by one TM-1500 active infra-red trail monitor. Units can be programmed to take pictures between specified hours, and the duration of time between each photo can be specified to avoid taking numerous photos of the same individual. The units can also be programmed to take pictures of animals only above a predetermined body size by varying the number of pulses that must be broken to set off the camera. Units set to operate after 5 pulses seem to work well for tigers (ref?). Units record date and time for each photo taken. Because tigers regularly use forest roads and trails in many areas (Karanth 1995; Panwar 1979; Sunquist 1981) baiting the camera-traps is not necessary.

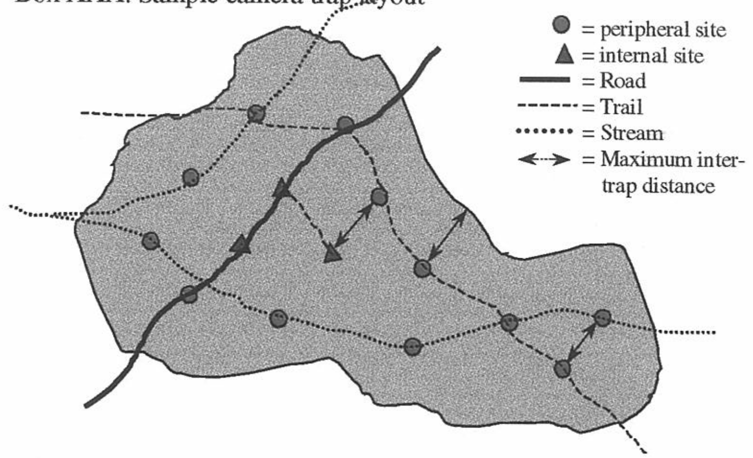
- Time for individual surveys may vary from 2-4 weeks depending on the number of camera traps available, and the size and accessibility of the area to be surveyed. See FigXX and BoxXX.

3. Survey Design

The primary variables involved in a camera-trap survey and their relative importance are outlined below. [later draft to include a flow-chart or decision to facilitate the process of finalizing survey design given the goals and limitations of a particular situation].

- *Determine the best time of year to conduct surveys.* Because camera-trap units are typically weather proof, camera-trap surveys can be conducted during any season of the year. However, if they're going to be used in conjunction with sign surveys (see BoxAAA), they should be used during the same period in which sign surveys are undertaken. See sign survey design for details on when to carry out sign surveys.
- *Determine where to conduct surveys: habitats most likely to be used by tigers.* Same as for Sign Surveys.
- *Establish survey blocks.* Same

Box XXX. Sample camera trap layout



as for Sign Surveys.

- *Determine layout of traps within survey blocks.* Box XXX presents an idealized sampling scheme for an individual survey block. To collect data useful for generating density estimates, traps must be set to maximize the likelihood of photographing all tigers in the area. Logic and knowledge of tiger ecology point to some general guidelines for determining the layout of camera-trap sites within a survey block. The guidelines and associated rationale presented below assume that the survey block under consideration is an area of continuous potential tiger habitat.

    1. Distance between traps should not exceed the diameter of the home range for a female tiger in the survey region. Karanth and McDougal both distributed 15 camera trap sites within approximately 15 km^2 survey area. Neither person has provided criteria for determing the distance between camera traps. Other reserchers developing camera trapping methodology have not published the resultsa of their research (Lyman and Franklin).

- *Determine location of individual camera trap sites.* As discussed in previous sections, tiger sign is likely to be detected along linear features where tigers most often travel. Because camera-traps will be set only at specific points along roads, streambeds, etc., (as opposed to sign surveys, where the entire feature can be searched), it is important that each unit be optimally placed along such features to maximize the liklihood of capture. Such places include the intersection of roads and or other likely travel routes (intersections are often key places because more than one tiger is likely to pass them), the location of previous sightings or signs, and or other strategic locations such as salt licks and water sources.

- *Determine optimum number of trap nights at each site.* In contrast to sign surveys where the persistence of tiger sign renders sign detectable for a significant period after deposition, camera-trap surveys require a tiger to actually pass the trap-site during the time the unit is in operation. Male tigers in Royal Chitwan National Park traversed their territories 3-5 times a month. In Russia where tigers have much larger home ranges we do not know how often tigers patrol their territories therefore we are suggesting that camera trapping be continued for 2-4 weeks (see Box XX).

Box XX. How often do tigers revisit a given portion of their home range? *Implications for survey design*

A tiger's disproportionate use of various parts of its home range (e.g. core areas, frequent marking sites, water sources, etc.) and the shape, size and topography of that range will impact the frequency with which the tiger visits a given point.

In studies of radio-collared tigers in Nepal, Sunquist (1979) reported resident tigresses visiting most parts of their home ranges every few days to 2 weeks. Although it was not documented that the tigers visited *the same* point at these intervals, it is not unrealistic to assume that they pass the same points along established travel routes within these areas. Based on these documented patterns, it is recommended that cameras be left at a single location for a minimum of 3-14 days, depending on other logistical constraints of the survey.

There appears to be a clear inverse relationship between home range size and the frequency with which tigers return to a given part of their range (Smith and MacDougal, in press). Therefore, in areas where tiger home ranges are very large, the period between return visits will likely be longer. This, in turn, will increase the minimum number of trap nights in a given location necessary to achieve the desired likelihood of capture.

- *Number of camera traps to use.* Typically, the number of camera traps used will be limited only by the number available to the survey team. It is recommended that the survey layout and the minimum number of trap nights at each site be primary considerations in designing the survey. If there are not enough units available to sample all sites within a survey block simultaneously, then units can be rotated among sites.

Beyond these minimum guidelines, sampling intensity in a given area can be increased by increasing the density of camera-trap sites or by increasing the number of trap nights in a given location.

It should be noted that camera-trap capture probabilities vary for different tigers based on age, sex and status. For tigers younger than 8-10 months of age, and for small cubs in particular, capture probabilities may be very low or even zero. Estimates for these animals may need to be based on numbers and reproductive status of resident females (Karanth 1995).

Problems generating density estimates

One camera-trapping issue that has not been well resolved is how to define the "catchment" area to which a capture-recapture estimate is applied. Catchment area is the area where the tigers included in the population estimate reside. The camera trap data by itself did not include any information that would lead one to determine the catchment area. Because one needs a catchment area to estimate density this analysis is circular. Density estimates can not be generated through camera-trap data alone.

One way around this issue of catchment area suggested by Karanth (1998) is to expand the trap area to cover an entire protected area. This can be done by dividing the park into blocks which can each be covered by the number of cameras being used, and then rotating the cameras through the blocks on a daily basis until all blocks are covered. The process is repeated until an adequate sample of photos is obtained **(what is an adequate sample of photos?)**. Issues that need to be addressed with this modification include the interval between traps and the duration of trapping.

An alternative strategy is to develop and monitor a relative tiger density index over time. The trapping strategy outlined above could be modified by selecting 2 or 3 key survey blocks and determining the number of tigers present at each site. These blocks could then be surveyed on a regular basis (seasonally or yearly) so that changes in tiger numbers in key areas could be quickly assessed. Though this strategy does not provide a density estimate, it does provide a general idea of numbers in key areas within a park and enables managers to determine when numbers are stable, increasing or declining, which may be more critical than obtaining actual density estimates for an entire area. The first step in developing this approach is to determine the trap effort needed to detect a defined level of change with a giver degree of statistical power.

Conducting the Survey

- *Camera trap set up:*
    1. *Film ID.* When loading film into a particular camera, the ID number of the camera should be clearly labeled on the film canister. This will ensure that photos obtained can later be matched with their correct dates and locations.
    2. *Height of electronic beam above the ground (for active infrared systems).* For "capturing" tigers, a height of 45 cm is recommended (Karanth 1995). This will prevent the unnecessary use of film when smaller animals cross the line of the infrared beam.
    3. *Camera mount.* Precut stakes provide a stable base for cameras. It is important that mounts be stable enough to remain motionless in the event of wind, rain, and other environmental factors that might jar either the transmitter or receiver.

4. *Angle of camera in relation to expected line of travel.* Karanth recommends broadside and he is currently using 2 cameras to take both sides of the animal simultaneously.
5. *Distance from expected line of travel.* The expected distance from the camera lens to the tiger at the time of exposure should be close enough to distinguish detail in the photo yet large enough to encompass the entire tiger if necessary. When seeking a broadside perspective, 3 meters has been found to work well (Karanth 1995).
6. *Automatic film dating.* Most cameras used in camera trap units will have an option for recording the date and time directly onto the film at the time of the exposure. As this information can be critical to sorting the exposures later on, it is important to activate this option and to make sure that the date and time are correctly set on each camera used.

- *Record UTM coordinates of each trap site.* Note which unit (all should be clearly labeled with a unique identifier) has been set at each location and during which dates and time periods it was operating.
- *Check units periodically.* Important data and time can be lost if a unit runs out of film or battery power. Additionally, if any component of the unit moves slightly from it's carefully selected position, the system may not operate properly. It is therefore recommended that units be checked daily or as frequently as is convenient to ensure that each unit is functioning properly and that film and batteries are replaced as necessary. However, in some surveys, units have been left unattended for up to 2 weeks or more due to limited accessibility (Griffiths 1992). In areas where theft of

equipment may be a problem, units may need to be set out in the evening and picked up the following morning.

- *Rotate cameras between trap sites.* When the desired number of trap nights at a specific location has been reached, the unit can be moved to a new site (see preparation section). When units are moved, it is important to record the frame numbers exposed at each site. This will allow the survey team to keep track of specific trap sites where individual photos were taken.
- *Develop film from cameras.* Film should be developed as soon as possible after exposure to allow surveyors to modify trap site layout and / or unit setup, if necessary. Each photo should be labeled with the number of the unit it was taken with so that photos can be matched with UTM locations.

Box …Published Home Range Estimates

Location	Home range sizes (km^2)		Source
	Male	Female	
Nepal	60-100	16-39	1
Russia	800-1000	100-400	2
India	78	65	3
Sumatra	90-140	75-116	4

[1] Sunquist, 1981
[2] Matjushkin et al., 1977
[3] Schaller, 1967
[4] Griffiths, 1992

Analysis of camera trap data

Capture-recapture models

There are several computer programs for estimating animal numbers based on capture-recapture. The most widely used program in tiger research is Capture *which was developed by Gary C. White, Department of Fishery and Wildlife Biology, Colorado State University, Fort Collins, CO 80523, ph: (303)491-6678, e-mail: gwhite@cnr.colostate.edu.* Karanth's (1995) article in Biological Conservation, Estimating tiger populations from cameras-trap data using capture-recapture models, was the first use of Capture to estimate tiger numbers. Griffiths (1992—with Rhinos) also is a good source for information about camera trapping.

IV. Combining data from different types of surveys.

By providing information about individual tigers, camera trap data can be a valuable tool in a coordinated tiger survey effort. When the extent of surveys are limited by such factors as time and money it is recommended that data from all available survey methods be combined whenever possible. The following examples illustrate how this complementary approach might be used.

Box XXX. Identifying individuals

Depending upon what information is being sought, photographs can be taken from several different angles. Individual tigers have been identified by facial markings (Schaller 1967; McDougal 1977), and head-on photos present a clear view of the face. Such views may provide enough information to help produce more accurate density estimates, since individual identification eliminates the problem of counting animals twice. However, frontal views do not always provide information on the size and sex of the animal. Male tigers are about 50% bigger than females, and juveniles can be readily distingushed from adults, especially when there is a combination of tracks and photos to study. Broadside photographs provide more information on sex and age-classes of individuals by presenting a good view of relative body size and genitalia. The flanks present a larger, clearer target and stripe patterns can be used for identification, with the stripes on the limbs, face and tail providing additional supplementary information. Broadside photographs are also easier to compare than frontal views because slight differences in head angle give a different perspective to the frontal view; a potential source of confusion when trying to identify individuals.

If demographic data on individuals is being sought, it is best to use multiple camera traps. In these units 2 cameras are used, with cameras mounted on either side of likely tiger travel route and each camera facing inwards toward the route. This setup can provide pictures of both flanks simultaneously—important for identifying individuals since stripe patterns on the flanks of an animal are asymmetrical (Karanth 1995). However, one problem associated with this setup is mutual interference between the camera flashes. One possible way around this is to angle the cameras away from each other (by approximately 30°) so that the camera flashes are not directed towards the lens of an opposing camera.

Using individual identifications retroactively.

In Sumatra, Griffiths (1992) followed fresh tiger trackways leading away from camera trap sites and was later able to identify the individual that left the tracks by referencing the photos taken at the sites on the days that the tracks were left. In this way, the home range sizes of two male tigers (see table XXX) were more accurately determined than would have been the case with camera trap data alone.

Estimation and extrapolation of home range size.

Telemetry studies (not covered in this manual) (Sunquist 1981, Smith et a. 1989 can be used to estimate home range size in tigers. If tiger presence/absence can be established over a larger area utilizing interviews and sign surveys, home range estimates can then be applied to estimate population size. When estimating abundance in this way, it is important to remember that male and female home ranges will overlap and–in areas of breeding habitat—there will be further overlap by cubs and dispersing juveniles that have not yet established their own home ranges. When making population estimates it is important to stipulate what age or reproductive class you are counting. For example, is the count resident breeding animals, residents and transients or all animals over a certain age. Some researchers have compared density estimates in different protected areas without noting that different age classes were counted in the comparison.

Calibrating/validating sign survey data

In places where sign surveys overlap with camera trap or telemetry surveys, it is important to compare the resulting data. Sunquist (1981) provides such comparative data that provides an important staring point for evaluating the effectiveness of sign surveys. In studies on mountain lion in the US, Van Dyke et al. compared sign survey data with radio-located data to test how track counts could indeed provide a meaningful index for the abundance of mountain lions. Changes in track counts combined with changes in tiger numbers estimated through photos would help to validate track coounts as a method of monitoring changes in relative abundance. It is important to realize that, at best, track counts are likely to provide a very rough estimate of relative density.

Chapter 4: Assessing quality of tiger habitat [UNDER CONSTRUCTION]

In addition to determining where tigers occur and the characteristics of breeding and dispersal habitat, it is critical to monitor habitat quality over time and to gather information on where tigers *should* but *do not* occur because of prey depletion (see Box XX). Although changes in tiger density are ultimately the data needed for monitoring and conserving tiger populations, these data are often very difficult and labor intensive to obtain. Monitoring changes in tiger prey populations may be a more useful indicator of potential change in tiger populations, because prey abundance is the key factor determining tiger habitat quality. Changes in relative prey densities are easier to measure than changes in tiger densities, and provide early warnings of habitat degradation and or increases in levels of prey poaching.

> **Box XX. Tiger prey depletion** has been identified as a major problem for tiger conservation in many tropical ecosystems (ref?). In most tiger range countries there are still many forests in which the vegetation can support adequate numbers of tiger prey, but where prey density is extremely low due to poaching for meat (ref?). Without adequate numbers of prey, otherwise good habitat will be unsuitable for tigers. *Therefore, estimates of relative prey abundance are crucial for accurately monitoring tiger habitat.*

Other factors affecting the quality of tiger habitat include prey availability (see Box XXX), the type and condition of vegetative cover, the location and distribution of water sources in an area, and human related variables such as grazing activities, food and wood harvest, and encroachment. This chapter describes methods for determining local distribution of prey species and measuring relative prey abundance, horizontal cover and human use. These data can be combined to yield a standard index of tiger habitat quality. (Survey techniques presented

> **Box XXX. Prey abundance vs. availability.** A predator's ability to capture prey is a function of both the *abundance* of the prey and its *availability* to the predator. We do not have a direct measure of prey availability, but an indirect measure is the amount of horizontal cover in a given area. Long term surveys in Nepal (ref?) have revealed similar relative prey abundance in 2 different habitats, but one habitat was used only occasionally while the other was used year round (breeding habitat). The habitat that was used occasionally had a smaller percentage of horizontal cover, which limits the tiger's ability to hide and hunt effectively (ref?). Therefore, prey in this habitat type, though equally abundant, are not as available as those in the more densely vegetated habitat, and thus this habitat is not as high quality from the perspective of the tiger.

here are primarily for use in monsoonal forests and may not be suitable for tropical moist forests. Tony Lynam and Neil Franklin have developed techniques for moist forests).

I. Presence / absence of tiger prey species

Local presence / absence of tiger prey species should be recorded during tiger sign surveys and is recorded during tiger camera trap surveys. Prey sign and visual observations of prey should be recorded in the same way that tiger sign is recorded (see Tiger sign survey form). This information is critical for determining areas of severe prey depletion. For example, one reserve in Thailand had gaur, banteng, sambar, wild boar and barking deer in considerable numbers in limited areas, but a large portion of the reserve had no sign of any of these species, so the reserve was mostly unsuitable for breeding tigers.

II. Estimating relative abundance of tiger prey species

Preparation

1. ***Administrative considerations.*** Same as for Tiger sign surveys.
2. ***Logistical considerations.***

- *Survey teams.* Three-person survey teams have proven to be more efficient than 2-person teams (Smith and Josi, pers. obs).
- *Field skills.* In addition to those described for tiger sign surveys, at least one team member should be able to identify prey species sign.
- *Recommended equipment.* In addition to items described for Tiger sign surveys, the team should also have a compass, a Robel pole (a 1.8 m pole painted red and white at 30 cm intervals), and a 1.785 m stick.
- *Time for surveys.* Time will vary from 2 – 4 hours for surveys of 50 – 100 plots.

3. ***Survey Design***

- *Where to conduct surveys.* Relative prey abundance surveys can be conducted in conjunction with tiger sign surveys. Survey sites should be selected so that different vegetation types and topographic strata are well represented. A typical scenario would be to randomly choose points in representative habitats along the tiger sign survey route and establish a random bearing for a 1 km (50 plot) pellet survey (**see diagram**).
- *When to conduct surveys.* Surveys must be conducted at the same time every year (to avoid the issue of pellet deterioration rates; see pellet counting assumptions), preferably towards the end of the dry season to allow maximum time to collect pellets.
- *Methods for estimating relative prey abundance.* Of the range of methods available, pellet counting has proven to be a reliable, easy to learn, and low cost means of assessing relative prey abundance in tropical ecosystems (Mandujano and Gallina 1995, Kloster and Hart 1988). It is recommended that one of the two pellet count methods described below be used to estimate relative abundance of tiger prey. In both methods, pellets are classified by size (small, medium and large) and form (pellet group or dung pile). In Nepal, the small prey class is composed of barking deer (*Muntiacus muntjak)* and four-horned antelope (*Tetraceros quadricornis*); the medium sized class includes chital (*Axis axis*) and hog deer (*Axis porcinus*); the large prey class includes sambar (*Cervus unicolor*), swamp deer (*Cervus duvauceli*), and blue bull (*Boselaphus tragocamelus*). Three other classes of droppings were also identified: wild boar (*Sus scrofa*), primates (*Presbytes entellus* and *Macaca mulatta*), and forest bovids (*Bos* sps. and *Bubalus bubalis*).

In method #1 pellet groups and droppings of ungulates and primates are counted within 10 m^2 circular plots placed at 20 m intervals along transects 1 km long for a total 50 plots per transect. In method #2 we count the number of plots which contain pellet groups in each size class in 1 m^2 plots placed at 10 m intervals along a 1 km transect, for a total of 100 plots.

- *Which method to use?* When sampling low prey density areas in Nepal and Thailand, Method # 1 has proven effective and is suggested for areas of low prey density. Because Method # 2 utilizes smaller 1 m plots, it is much more rapid than Method #1, but at low prey densities too many zero plots will result in an unacceptably low statistical power (Box XXX). Therefore, using this method in low prey density areas will require a larger number of plots and thus an extremely long transect to achieve acceptable statistical power. Because method # 1 utilizes larger plot areas, the odds of encountering pellets increase and one has a better chance of more accurately estimating relative prey abundance.

Box XXX. Statistical Power

Depending upon the level of change we are trying to assess in a prey population, we will need to adjust the number of plots we survey. To determine this number the question of statistical power must be addressed. The power of a statistical test is defined as the probability of rejecting H_o when it should be rejected, or $1-\beta$, where β is the probability of not rejecting H_o when it is wrong, which results in a Type II error. A Type I error occurs when H_o is true and is rejected; this type of error happens with a frequency of α. Another way of defining α is the probability of committing a Type I error; we select the significance level (the probability we're willing to live with) denoted as α, that we require to reject the H_o.

The only way to decrease both types of error simultaneously is to increase *n*; thus, for a given α, larger samples will result in statistical tests with greater power (Zar 1974). However, at some point, increasing the number of plots surveyed becomes too labor intensive for what we're trying to accomplish; so we have to decide on how powerful we need our tests to be. A power of 80% is usually an acceptable level of power (Fleiss 1973) In Nepal, changes < 20% did not shift tigers from breeding to non-breeding habitat. To detect a 20% change with a power of 80% and an $\alpha < 0.1$ approximately 100 plots would be required.

Conducting the survey: Method #1

- Once representative survey sites have been selected, a randomly chosen direction is selected to begin the survey transect (Appendix XX).
- GPS locations should be taken at the beginning and end of survey transects so that surveys can be used in spatial analysis and so that sites can be revisited for long term monitoring.
- To measure horizontal cover, one team member paces 20 m from the starting point and places a robel pole on the site of the survey plot. Another team member remains at the starting point and reads the robel pole, counting the 30 cm increments visible from 0-1.2 m (the height of a tiger) and records the number (0-4).

- The radius of the plot is measured with the 1.785 m stick and leaves are carefully raked from the plot. Discrete pellet groups of each species are then counted and recorded. Although older groups have fewer pellets, groups will be counted equally. Sometimes groups are spread out in a line when an animal is moving while defecating and these lines are classified as a single group.
- After pellet groups are counted, grazing and cutting are noted in a 25 m semicircle in the direction of travel. Cutting is recorded as new (fresh coloration) or old (gray and weathered cuts), (so that current use can be estimated). The survey team then proceeds to the next survey plot site and progresses along the transect until all plots are surveyed.

Conducting the survey: Method #2

Survey methods are the same as for Method #1, with the following modification:

- At each plot size classes are recorded as present, but the number of pellet groups is not counted.

Tiger Prey Survey Form (for either method)

Start Utm:							Finish Utm:					
Date:					Habitat:							
				Number of Pellet groups or dung encountered by size class/species.								
Plot #	% horizontal cover	Human use		Chital / Hog Deer	Sambar / Bluebull	Barking deer / 4-horned antelope	Monkey	Gaur	Wild boar	Total	Presence / absence	Sambar units
		Cut	Graze									
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
…												
…												
49												
50												
total												
mean												

The following information is summarized: mean # of pellet groups for each species size category per plot (method #1); % of plots with pellets; percent of horizontal cover in each plot; percent of plots with human use: and average sambar units per plot. Sambar units are a relative index of prey biomass, showing the abundance of various prey sizes relative to sambar (Table ?). (See Appendix XXX for results from a prey survey in a Sal forest habitat in Nepal.)

Table ?. Size classes of prey in terms of sambar units.

Species	Sambar units
barking deer	0.11
chital	0.28
wild boar	0.31
Blue bull	1.0
water buffalo	3.5
Banteng	3.5
gaur	4

Compiling and Analyzing the Results

- *Complete field forms.*
- *Tabulate data.* Tabulated data (e.g. Excel, or DBH file) can easily be imported into a GIS database (such as ArcView) for further analysis.
- *Map data.* Mapping tiger prey distribution using a GPS or 1:50,000 topographic maps provides a basis for monitoring change in tiger habitat quality, and gives surveyors an opportunity to return to specific locations to reassess the quality of tiger habit in an area.
- *Detecting spatial and temporal changes in relative prey abundance.* In addition to determining relative prey abundance, pellet count surveys can be utilized to assess changes in prey numbers and habitat quality, both temporally and spatially. Surveys can be conducted seasonally or yearly to determine if prey populations in a given area are stable or changing. Survey data can also be compared from one area to the next to determine if prey populations are changing over different habitat or terrain. When looking at changes in prey populations, it is important to determine what level of change will be meaningful for tigers. In order to do this, the researcher must know the minimum or *threshold* level of relative prey abundance needed to support breeding tigers year round. This information can be obtained by comparing relative prey abundance in tiger breeding and

dispersal habitats, and determining 1) the lowest level of prey that still supports breeding tigers; and 2) the prey level at which an area will no longer be used by breeding tigers.

Once this information has been determined, one can then assess the % change in relative prey abundance that will be significant for tigers. Based on data from Nepal, a relative prey abundance of 0.5 sambar units/10m^2 was determined to be the threshold level needed to support breeding tigers (**Figure from thesis**). At this level of relative prey abundance, a 20% change in prey abundance will result in a shift from breeding to non-breeding habitat. In a very abundant habitat (one that was well over the *threshold* level), you may need a 50% change in prey abundance before it would be significant for tigers. In a habitat that was at or just above the *threshold* level, a change of 10% may be enough to drive tigers from that area.

Chapter 5: Reporting the Results of the Survey [UNDER CONSTRUCTION]

Reporting Survey Effort

Classifying habitat as breeding or non-breeding / dispersal habitat.

We use 3 criteria to establish breeding habitat:

1. reports of sightings of tiger cubs or cub tracks by informants or cub tracks found during our survey
2. reports from several informants that tigers occur in an area year round
3. repeated surveys throughout the year in which tiger sign is always present

If sign is only observed occasionally during the year, the area should be classified as non-breeding/dispersal habitat. However, in habitat with low tiger density, such as that found in Bhutan and the Fareast of Russia, tiger home ranges are so large that sign may be infrequently found in areas that are breeding habitat.

If we are unsure about how to classify the area, we revisit the site during a different season and continue to obtain more information.

As a general guideline, for sites that are classified as breeding habitat, we assume that a male and female are resident. For lowland habitat on the Indian subcontinent, we estimate that the minimum home range of a breeding pair is contained within a 6 km radius of the survey site. Based on this assumed minimum area, our next survey site will be at least 6-12 km from the previous site. Where the habitat appears to be similar to the previous survey site, based on satellite photos and ground inspection, we often travel > 12 km between survey sites. Then, if tigers are determined as breeding at both sites, we extrapolate that the intervening area is also breeding habitat. Of course, these distances may have to change based upon what is known of tiger ecology in the area and the physical features of the landscape. For example, in Russia when tiger sign is found within a river drainage, tiger presence is extrapolated to the entire drainage system [check with Dale Miquelle].

DRAFT

Camera Trap Survey: Report of Raw Data

Instructions: Fill in the information below (refer to page 4 for definitions of selected terms and explanations of numbered items). Include the following in a bound report:

1. Summary report (these pages)
2. A map of labeled trap locations and access routes (use Location ID #s from table 1 below), and
3. A set of labeled photos for each **capture** (use photo ID #s from table 2 below)

General information

[1]**General location of survey:**	
[2]**Dates of survey:**	
[3]**Survey performed for:**	

Personnel

[4]Names of persons who carried out survey:	[5]Primary contact (Name, position, address, ph. fax., etc.):

Equipment

6 Average number of camera traps deployed:

7 Camera Trap
- 7a Type:
- 7b Sensitivity setting:
- 7c Photo delay:

8 Type of camera used:

9 Film
- 9a Brand of film used:
- 9b Slide / print (circle)
- 9c Speed:

10 Other equipment used:

Time Investment

[11]**Activity** (includes associated travel)	[12]**# of man/hours spent**
11a Installing traps	
11b Checking/maintaining traps	
11c Removing Traps	
Total	

Costs

13 **Item**	14 **Price per unit**	15 **Quantity**	16 **Total Cost**
13a Film			
13b Film Processing			
13c Batteries			
13d Fuel			
13e Other field expenses (List individually)			
		Grand Total	

<u>Summary of results</u>

Table 1: Location Summary

17 Location ID	[18]UTM Coordinates	[19]Access (road, trail, streambed, etc.)	20 Forest Type	[21]Physical Feature (Road, streambed, etc.)	[22]# of trap days	[23]Date(s) trap active	[24]Active period (24 hrs., 1900-700 hrs., etc.)	[25]Captures	[26]Film roll ID
				Totals					

Table 2: Capture summary

[27]Photo ID	[17]Location ID(see above)	[26] Film roll ID (see above)	[28]Date	[39]Time	[30]Species Name	[31]Activity	[32]Individual ID available?

Table 3: Success rate summary

[20]Forest Type	[22]# of trap days	[33]Total # of exposures	[34]Captures	[35]Captures of target sp. (or spp.)
Totals				

[36]**Logistical/design problems** (Attach additional sheets if necessary):

[37]**Equipment problems** (Attach additional sheets if necessary):

[38]**Acknowledgements** (Attach additional sheets if necessary):

[39]**Other Notes** (Attach additional sheets if necessary):

Definitions

Camera active period--the period of a given 24 hour period during which the camera traps are set to be active (e.g. 1900-700 hrs.).
Capture--a photo of an animal obtained using camera trap equipment.
GPS Unit--A device capable of calculating and displaying a precise location from signals received from 3 or more navigational satellites in orbit around the earth.
Survey area--Commonly recognized name(s) for the general location(s) of the survey.
Survey Leader--the person responsible for coordinating the design, logistics, and reporting of the survey. This should be someone directly involved in the fieldwork aspect of the survey who will be responsible for documenting relevant information.
Target species-- the primary species or group of species for which photo documentation is sought.
Trap day--a 24 hour period during which a single camera trap was active for all or a fraction of the 24 hrs. (e.g. 5 camera traps set to be active from 1900-700 hrs. and left to operate for 3 full 24 hr. periods would represent 15 trap days).
UTM Coordinates--Universal Transmercator Coordinates. A set of two numbers indicating the distance East and North of a known location on the face of the Earth. This is the coordinate system used on standard 1:50,000 scale topographical maps in Thailand.

Explanations of numbered items:

1. Enter a common name for the general area of the survey (exp. Khao Nung Rum Research Station)
2. Enter the first and last day that camera traps were active.
3. Enter the name of the agency and/or individual that the survey was performed for.
4. Enter complete names of all individuals involved in carrying out the surveys.
5. Enter the name and contact information for the person most knowledgeable about the specifics of the survey (this will typically be **Survey Leader**).
6. Enter the average number of cameras (per day) that were active during the period of the survey.
7a. List specific model names and numbers if possible.
7b+c. Refers to settings available on *Trailmaster* brand camera trap sets.
10. This may include GPS units, mounting equipment for cameras, bait holders, etc.
12. Refers to the number of man/hours spent carrying out the activities specified in 11a-c. These numbers can be estimated and should include travel associated with the categories 11a-c.
17. Enter a unique name or code for each location at which a camera trap was set. These names will be used to indicate trap locations on the map accompanying this report.
18. Enter **UTM coordinates** 1) directly obtained from a **GPS unit** or 2) estimated from mapped locations on a 1:50,000 scale topographic map of the **survey area**.
19. List the type of route(s) used to access the trap location (i.e. road, trail, streambed, etc.
20. Use one of the following codes to idicate forest type: DE=Dry Evergreen, DD=Dry Dipterocarp, MD=Mixed Deciduous, HE=Hill Evergreen, G=Grassland, S=Secondary Forest
21. Indicate the linear or point feature for which the camera trap site has been selected (e.g. a road, streambed, saltlick, water hole, etc.).
22. See definition of **Trap Days** above.
23. List the date or range of dates during which a trap was active at this particular site.
24. List the period of the day during which a camera trap was set to trigger at this location (e.g. 0730-1930).
25. List the total number of **captures** obtained at each site.
26. Enter a unique name or code for each individual roll of film used in the survey.
27. Enter a unique name or code for each photo representing a **capture**.
28. Indicate the date on which this capture was obtained.
29. Indicate the time at which this capture was obtained.
30. Indicate the Latin name of the species captured in the photo.
31. Indicate the activity of the animal in the capture photo.
32. Indicate whether an individual ID of the captured animal is possible given this particular photo.
33. Record the total # of exposed frames (for each forest type and total). This should include exposures that do not include an animal.
34. List the total number of **captures** obtained in each forest type.
35. Record the number of captures of the **target species**.
36,37. Describe problems encountered in the course of the survey. Please refer to specific dates, locations, and equipment where applicable.
38. Please mention those (who have not already been mentioned) that assisted the survey in any way. If possible list the assistance that was provided and contact information.
39. List anything else that you feel may help someone better understand what you did or the results you obtained.

Chapter 6: Monitoring Tigers and Tiger Habitat [UNDER CONSTRUCTION]

- Indices –good enough for monitoring
- Detecting changes in the population—what level change do you want to detect?

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Appendix I. Tiger sign.

Tigers leave evidence of their presence in several forms. The following notes describe the ecological and behavioral context of these signs as well as notes on how to best detect and record their occurrence.

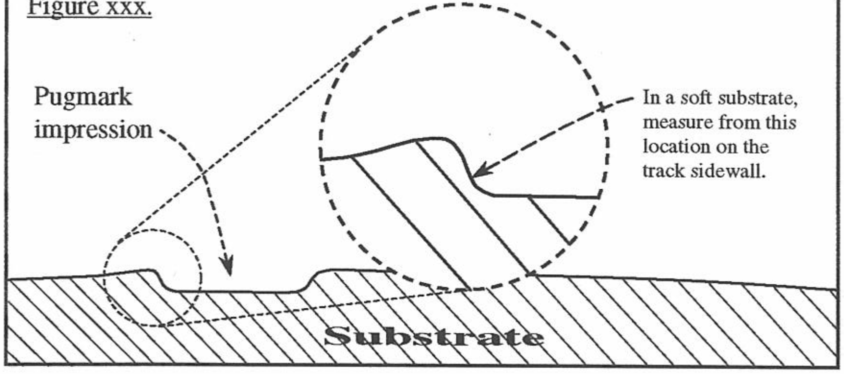
<u>Tracks (pugmarks)</u>: Generally, all cat tracks have a similar appearance. They have 4 toes, do not show claw marks, and have a multi-lobed pad that is considerably larger than the toes. In most cases, three basic measurements of tracks can distinguish 1) tiger from leopard; 2) front tracks from rear tracks; 3) males from females. These measurements are pad width, total track width and total length (figure ….).

One difficulty in obtaining accurate measurements is that, depending on the substrate they were made in, tracks of the same individual can vary in size. Tracks in soft, large grained sand tend to appear larger than those made in a thin layer of finer grained substrate over a hard base. Therefore, for measurements to be meaningful, it is important to measure tracks in a standard way. After years of research at Royal Chitwan National Park (Tamang, McDougal, Seidensticker, Sunquist, Smith and Miquelle), it was determined that the size of tracks in a fine grained, thin substrate should be used as the standard for measuring tracks. When measuring tracks in deep sand it is important to develop a point on the sidewall of the track that will result in a similar measurement as that of a track left in a thin substrate. We recommend a point approximately 1/3 of the way up the sidewall of the impression (Figure xxx).

<u>Table 1</u>. Average front and rear measurements of pad width, total track width and length, based on multiple measurements of 13 females and 9 males.

		Front Tracks			Rear Tracks		
		Pad Width	Total Width	Total Length	Pad Width	Total Width	Total Length
Females	Mean	8.8	12.5	12.1	8.0	10.3	12.7
	Min	8.4	11.7	11.4	7.6	9.6	11.8
	Max	9.2	13.7	12.7	8.4	10.9	13.3
Males	Mean	10.4	14.4	13.9	9.4	12.1	14.1
	Min	9.7	13.0	12.8	8.6	11.0	12.5
	Max	11.5	16.0	15.4	10.0	14.0	15.4

<u>Figure xxx.</u>



- *Distinguishing* ***tiger tracks from those of leopard****.* Leopards are roughly 1/3 the size of tigers. Females weigh 30 - 40 kg versus 120 - 160 kg female tigers; males weigh 40 - 68 kg versus 200 - 270 kg male tigers. Compare track measurements--adult female tigers have pad widths ≥ 7.5 cm; adult male leopards have pad widths ≤ 6.0 cm. Tiger cubs < 6 months old have tracks ≤ 6.0 cm, but these will nearly always occur with larger adult female tracks.

- *Distinguishing* ***front from rear*** *tracks.* Observe the position of tracks. The rear track is always in front of or occasionally on top of the front track (figure 2). When a single track occurs one can usually still determine whether it is a front or rear track by measurements. A front track is wider than it is long and has a larger pad width than a rear track, which is longer than it is wide.

- *Distinguishing* ***male from female*** *tracks.* Female tracks are smaller than males in all measurements. Female front pad widths are generally ≤ 9 cm, while those of males are generally > 10 cm; female rear pad widths are generally ≤ 8.4 cm and male rear pad widths are generally ≥ 9.0 cm (Table 1).

<u>Scrapes and feces:</u> Scrapes are made by alternately pumping the rear feet back and forth; a small mound of vegetation is pushed up at the back of the scrape. The scrape marks from each foot are usually parallel to one another but occasionally are V-shaped, as those made by leopards usually are. However, tiger scrapes can be distinguished from those of leopard by simple measurements: scrapes made by tigers are wider than 19 cm and usually longer than 35 cm while those of leopard are ≤ 15 cm wide and ≤ 25 cm long (Figure 4). Scrape length is measured from the base of the vegetation pile at the rear of the scrape to the longest side of the scrape; the mean length, width and distance from line of travel 57 cm, 27 cm, and 53 cm respectively (N = 50). When scrapes are parallel, width is measured across both tracks; when scrapes are V-shaped, width is measured across both tracks at the apex of the V (Figure 5). Tiger feces are > 4.0 cm in diameter, while leopard feces are < 3.0 cm in diameter. Scrapes and feces are usually found along travel lanes within a meter of the road or trail edge, or in the grass strip of a 2 track forest road. Older scrapes are sometimes partially covered by leaves; they can often be clearly identified by removing the leaf litter. Occasionally, an elephant will make a scrape at the edge of a road with one foot but it can be distinguished from that of a tiger, because it is usually wider and does not have 2 scrape tracks. About 17% of scrapes have feces associated with them; the majority are scent marked at the base of the scrape, but the odor lasts only a day or two where as scent sprays on trees can be detected more than 3 weeks.

<u>**Urine sprays**</u>: Usually found within 3 meters of a road on trees > 30 cm DBH, usually placed 75 – 120 cm above ground. They are recognizable as tiger sprays by their distinct odor, which is similar to buttered popcorn. This distinctive odor, found in tiger and lion urine, but not in that of leopards and smaller cats, is a result of a high level of triglycerides in the urine.

Tiger kills (natural and domestic): Tiger kills can be distinguished from those of leopard by examining the extent of broken bones in the rib cage of carcass larger than *Muntjacus* such as *Axis* and *Cervus* species. Leopards usually leave the rib cage intact, and they also remove more of the meat from bones, leaving a cleaner and more intact carcass.

Appendix II. Sample Tiger Survey Report

Appendix III. Sample Habitat Survey Report

Table ? shows the format and results of a tiger prey survey conducted in a Sal Forest habitat in Nepal using Method # 1. Each potential prey species is listed, and for each plot, the number of pellet groups for each individual species is recorded. To calculate the percent of plots with pellets, pellet presence / absence for each plot . Information on the % of the plot under cover is recorded, and amount of human use within a plot, in terms of the number of new (nc) or old (oc) forest cuttings, is noted. The amount of prey available in each plot is given in terms of sambar units (Table X shows the conversion to sambar units for each prey species).

Table ?. Format and results of a tiger prey survey in a Sal Forest habitat in Nepal.

Site : South of Gaida Tented Camp											
Date: 4/2/97					Habitat: Sal Forest after fire						
			Number of Pellet groups or dung encountered by species								
Plot #	% horizontal cover	Human use	Chital	Sambar	Bark.	Monkey	Rabbit	Wild boar	Total	Presence /absence	Sambar units
1	0		1	1					2	1	1.28
2	25		0						0	0	0
3	25		1						1	1	0.28
4	25		0						0	0	0
5	50		1	1					2	1	1.28
6	12.5		0						0	0	0
7	50		0						0	0	0
8	75			1					1	1	1
9	0		1						1	1	0.28
10	0		2						2	1	0.56
11	50		0						0	0	0
12	25		2						2	1	0.56
13	25		4						4	1	1.12
14	12.5		1						1	1	0.28
15	12.5		2	1					3	1	1.56
16	12.5		0						0	0	0
17	12.5		0						0	0	0
18	12.5		0						0	0	0
19	12.5		2						2	1	0.56
20	75		0						0	0	0
21	50		0						0	0	0
22	25			2					2	1	2
23	12.5		1	2					3	1	2.28
24	0		1						1	1	0.28
25	0	lopping	0						0	0	0
26	12.5	lopping			1		1		2	1	0.135
27	100		2						2	1	0.56
28	100	lopping	0						0	0	0
29	100		1	1					2	1	1.28
30	50		2				1		3	1	0.585
31	75		0						0	0	0
32	100		3				1		4	1	0.865
33	100	lopping	0						0	0	0
34	75	lopping	0						0	0	0
35	50		0						0	0	0
36	75	lopping	1						1	1	0.28
37	50	lopping	1					1	2	1	0.59
38	75	lopping	2	3					5	1	3.56
39	50	lopping	1						1	1	0.28
40	25	lopping	3	2					5	1	2.84
41	25		4						4	1	1.12
42	25	lopping	1						1	1	0.28
43	25		0						0	0	0
44	25		5	1					6	1	2.4
45	50			1					1	1	1
46	25	lopping	3	1					4	1	1.84
47	50			3					3	1	3
48	25	lopping	2		2				4	1	0.78
49	75							1	1	1	0.31
50	25		2						2	1	0.56
total			52	20	3	0	3	2			
mean	39.75		1.18 1	1.53	1.5	0	1	1	1.59	0.65306	0.7147

Chapter X: Ask Dave

1. We're wondering to what extent this manual should provide info on analyzing spatial patterns, especially at the landscape/metapopulation scale, and how is this manual going to relate to this "tiger information network"? We're telling users to collect data in a specific and consistent manner in order to be usable by whoever is going to conduct an analysis or compare data at a larger landscape scale.

A score of tiger signs against kilometer per hour is suggested as a feasible means of addressing this need.

Table 2. Number of signs observed and amount of trail searched.

Study site	Habitat type	Trail covered	Tiger signs recorded
Kerinci Seblat NP, Indonesia	Dense primary forest, both hill and montane	4,000 km total	85 signs
Way Kambas NP, Indonesia	Secondary forest and grasslands, lowland	85 km per week	5-6 signs per week

4. Average minimum tiger home range size for a breeding pair. Specific to region. [pertains to abundance methodology which is not yet developed and is being de-emphasized in this manual.]

"Radio-tracking is very time consuming and expensive. Pug-mark censusing involves a lot of guesswork and can be quite subjective. One method that appears to adequately sample tiger populations with relative ease and low cost is that of camera-trapping (Karanth 1995). This manual describes how camera-traps may be used to document tiger presence, estimate tiger population sizes, and acquire important demographic data (e.g., age structure of population, sex ratios, etc.) by obtaining information on individual animals."