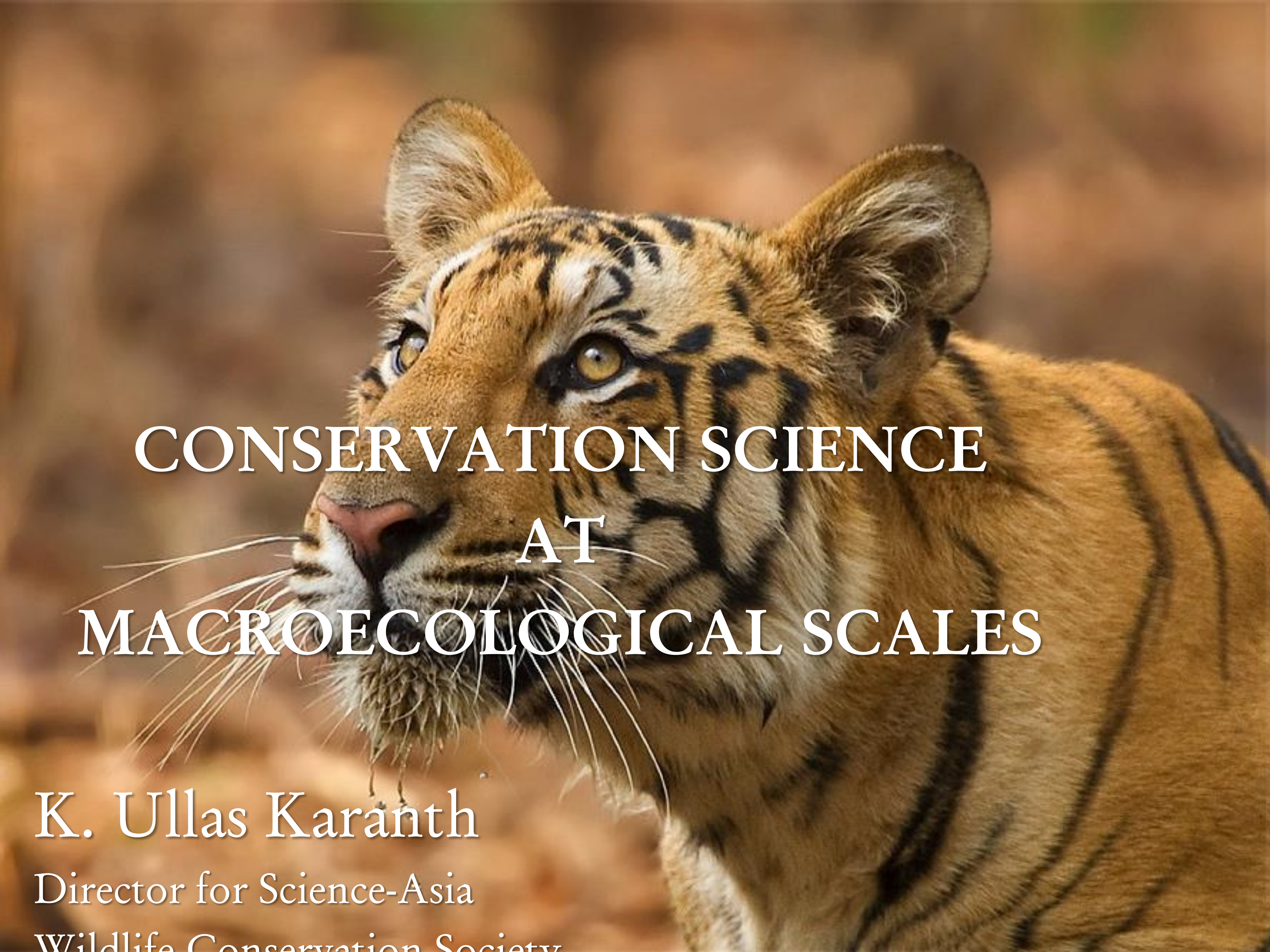
Wildlife Conservation Society

CENTRE FOR WILDLIFE STUDIES

WILDLIFE CONSERVATION SOCIETY



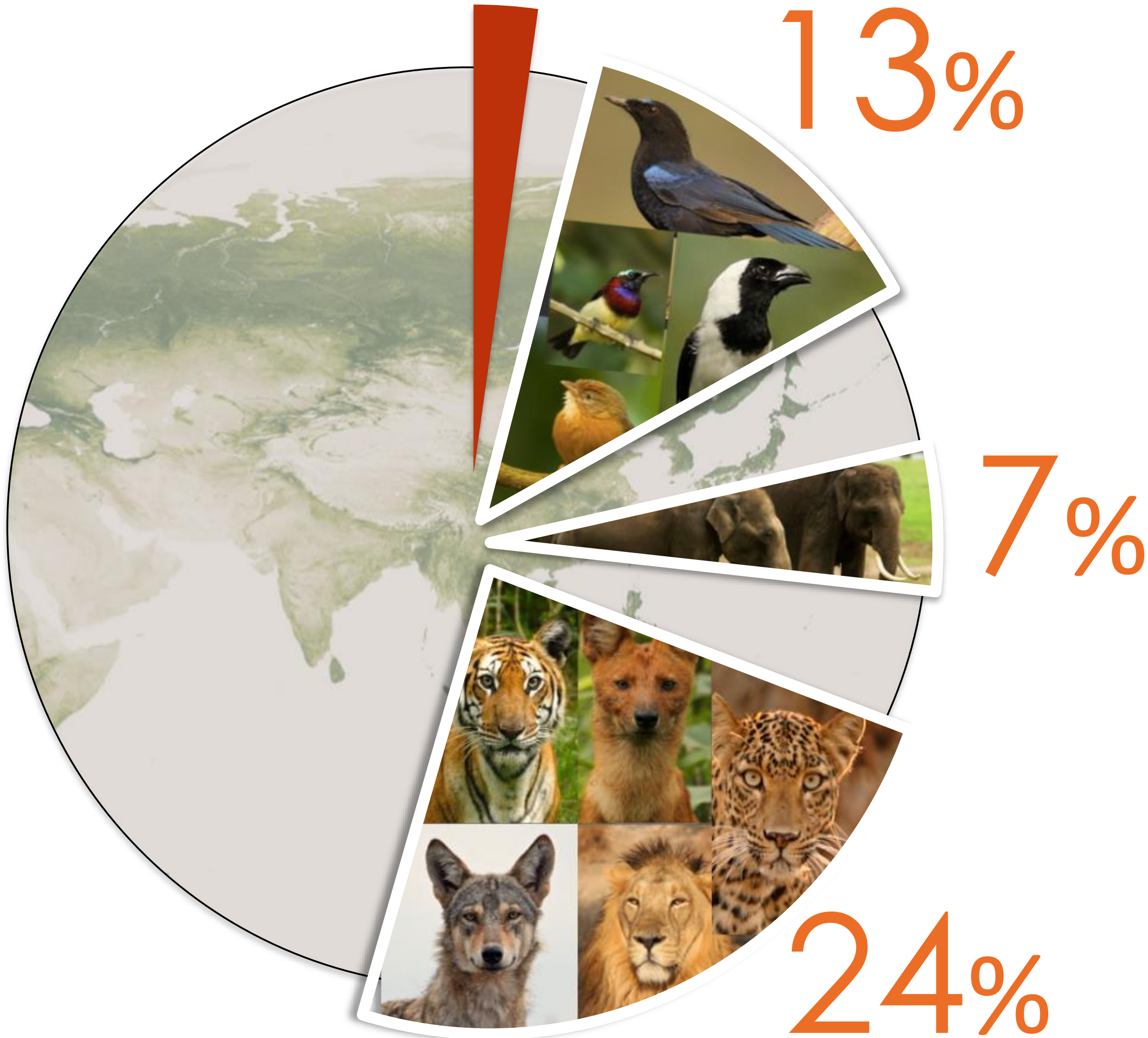
CONSERVATION SCIENCE AT MACROECOLOGICAL SCALES

K. Ullas Karanth
Director for Science-Asia
Wildlife Conservation Society


Photos: S. Dalvi/K. Karanth

Photos: R. Sreenivasan

INDIA: 2.2% of earth's land area




K. Varma


K. Varma

K. Varma


K. Varma


K. Varma

K. Varma


K. Varma

INDIA: THE CONTEXT FOR SAVING NATURE

Human population 4 times; Area 1/3 of USA.

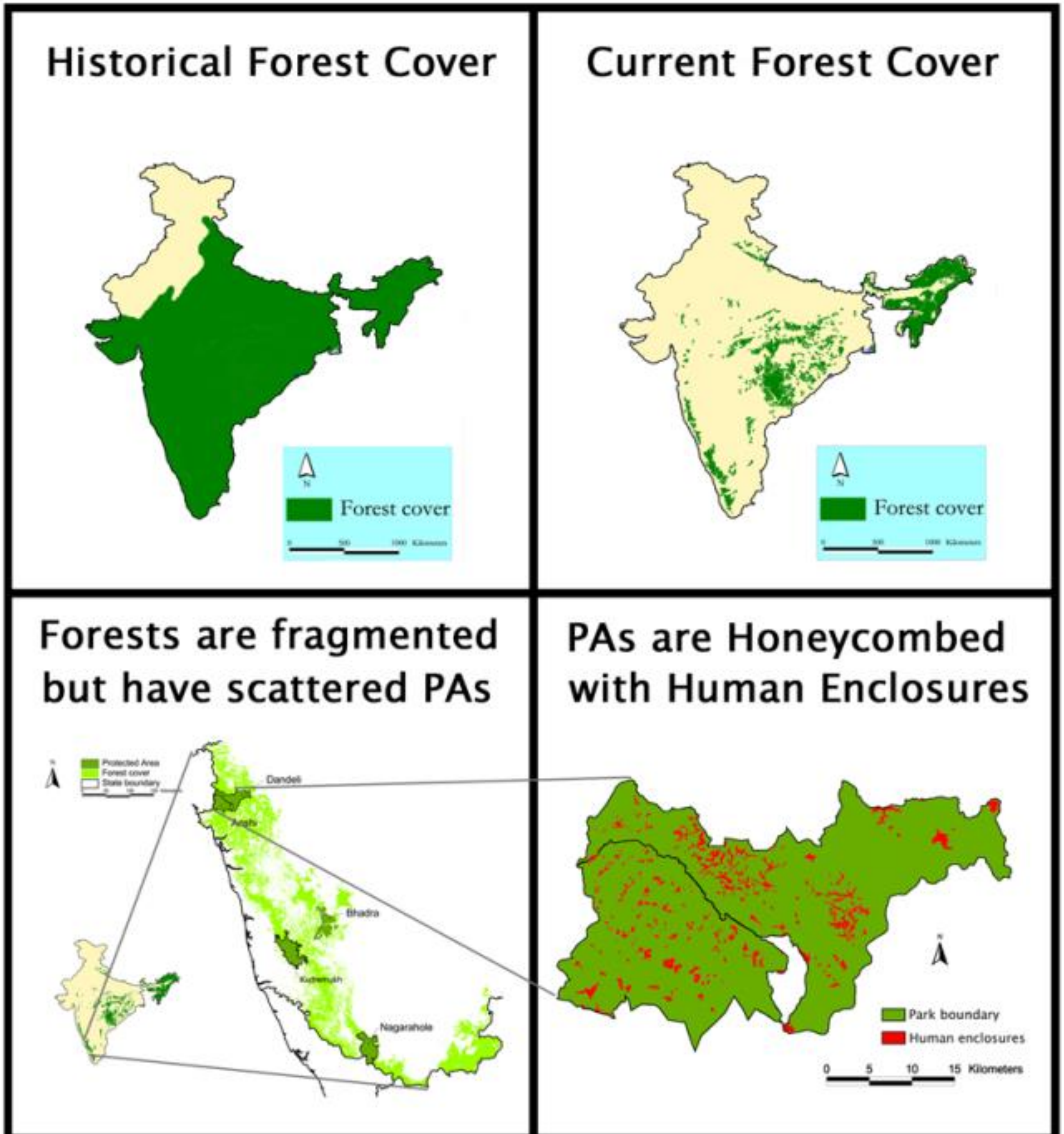
Over 60% are poor, rural, rely on agriculture/animal husbandry

Over 60% use wood/biomass for energy + shelter

A modern economy growing at 6-9 % per year.

“Natural” forests cover 10%, “Parks” only 3% of land

“Effective Protection” covers only about 1%


Historical Forest Cover
Forest cover
Current Forest Cover
Forest cover
Forests are fragmented
but have scattered PAs
Protected Area
Forest cover
State boundary
Dandeli
Anshi
Bhadra
Kudremukh
Nagarahole
PAs are Honeycombed
with Human Enclosures
Park boundary
Human enclosures
0 5 10 15 Kilometers

…BUT, IS THERE ROOM FOR TIGERS HERE?

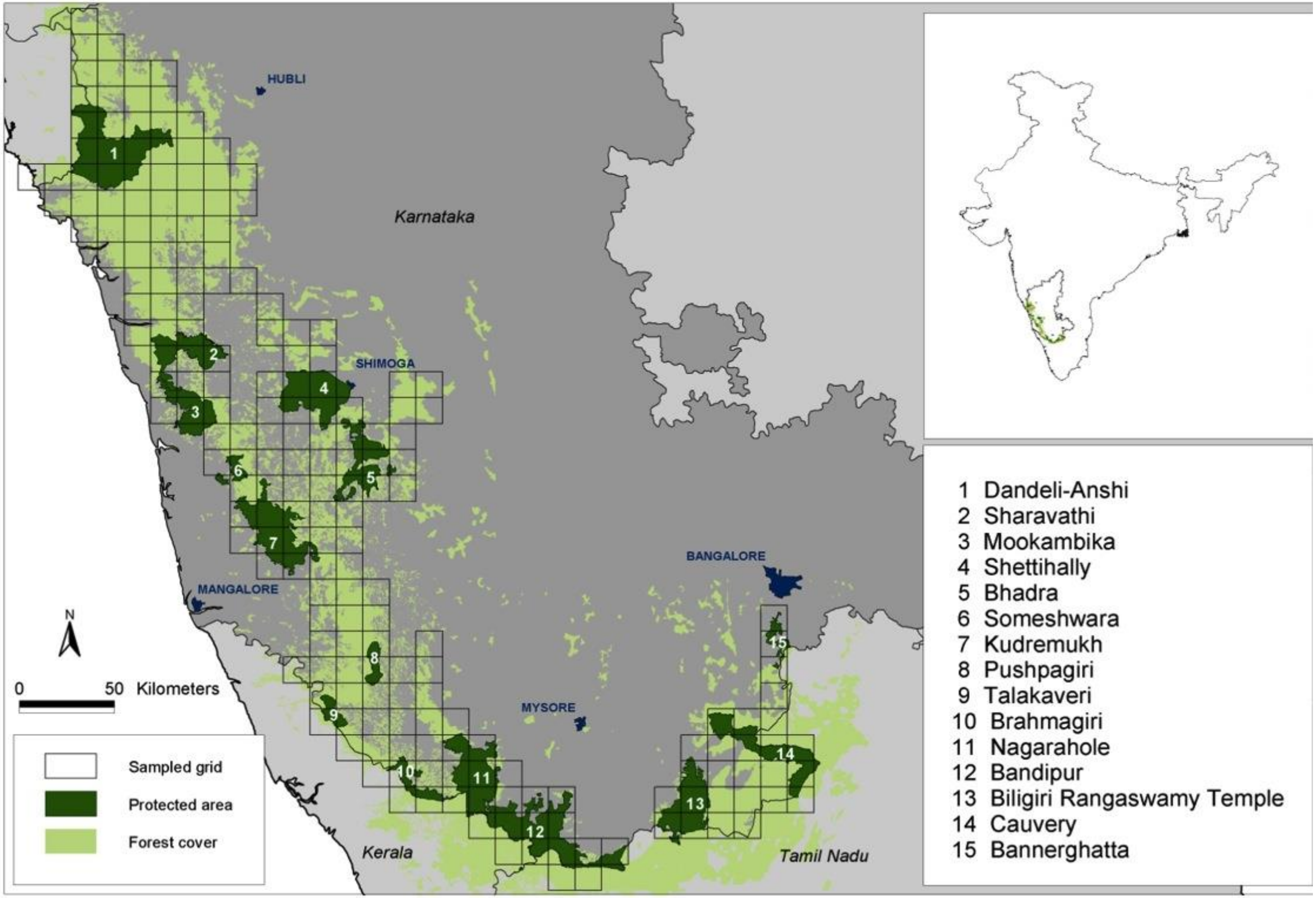
Courtesy:
WCS Wildlife Crime Unit

Prey over-hunting: Key driver of tiger declines


KARNATAKA
NAGARAJA TRDERS
HINDU PURE . 08556.220193.

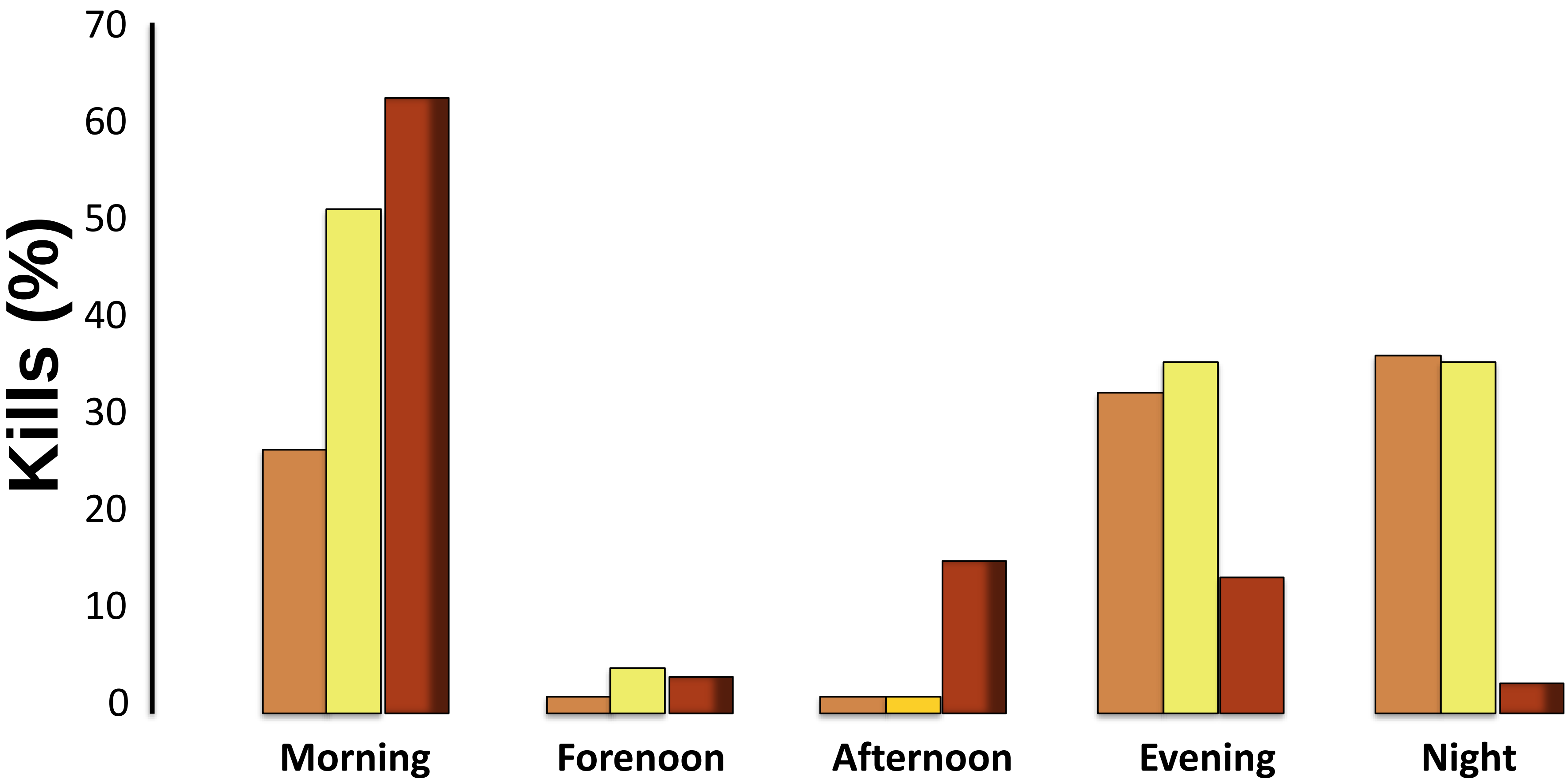

58
VAN VIHAR RESORT
76
HR 26
P-8200

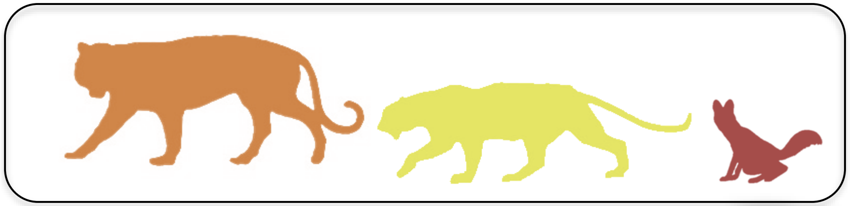
MALENAD TIGER LANDSCAPE



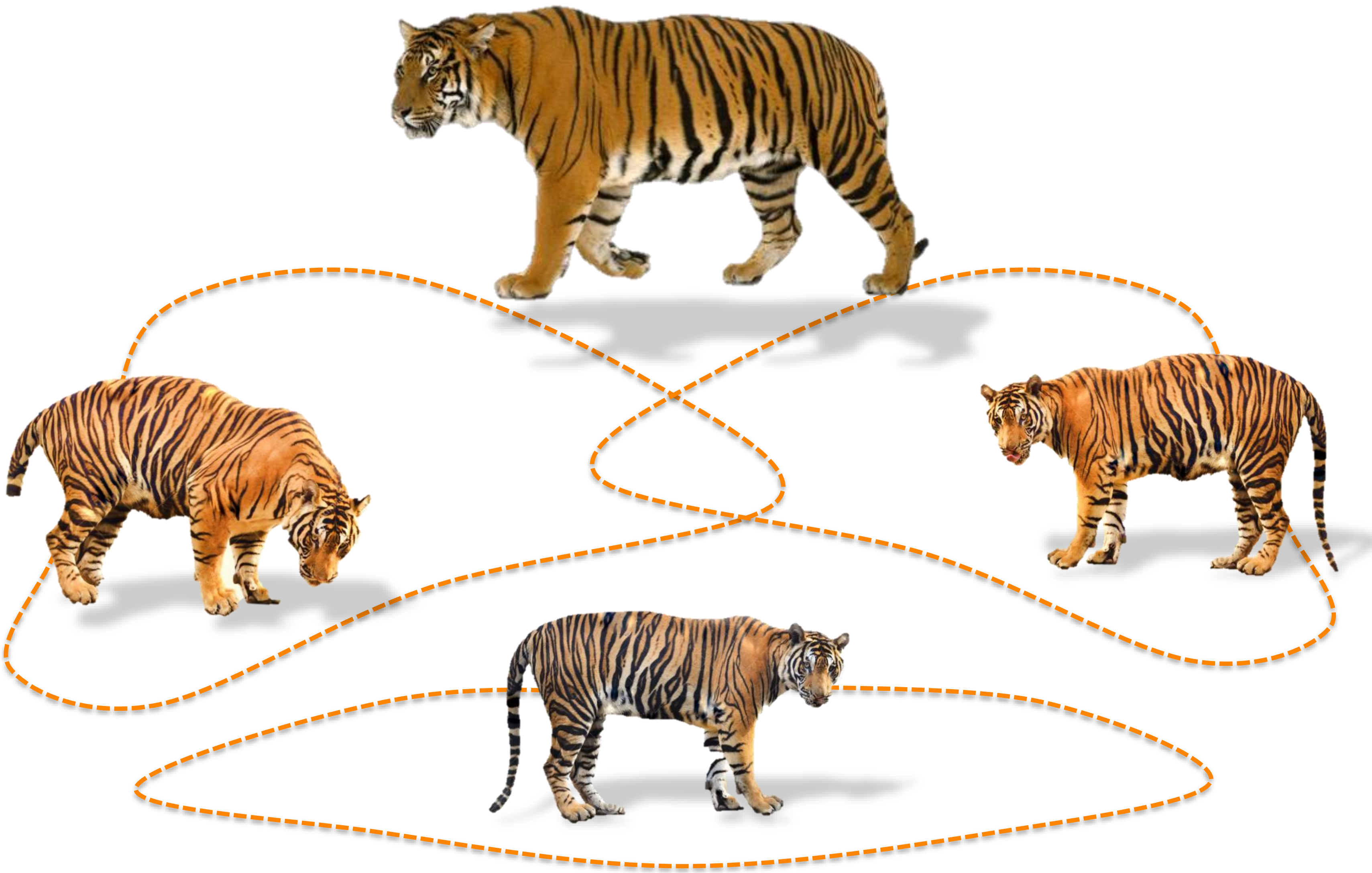
1986-1992: TIGER ECOLOGY AND BEHAVIOR

Time-Activity

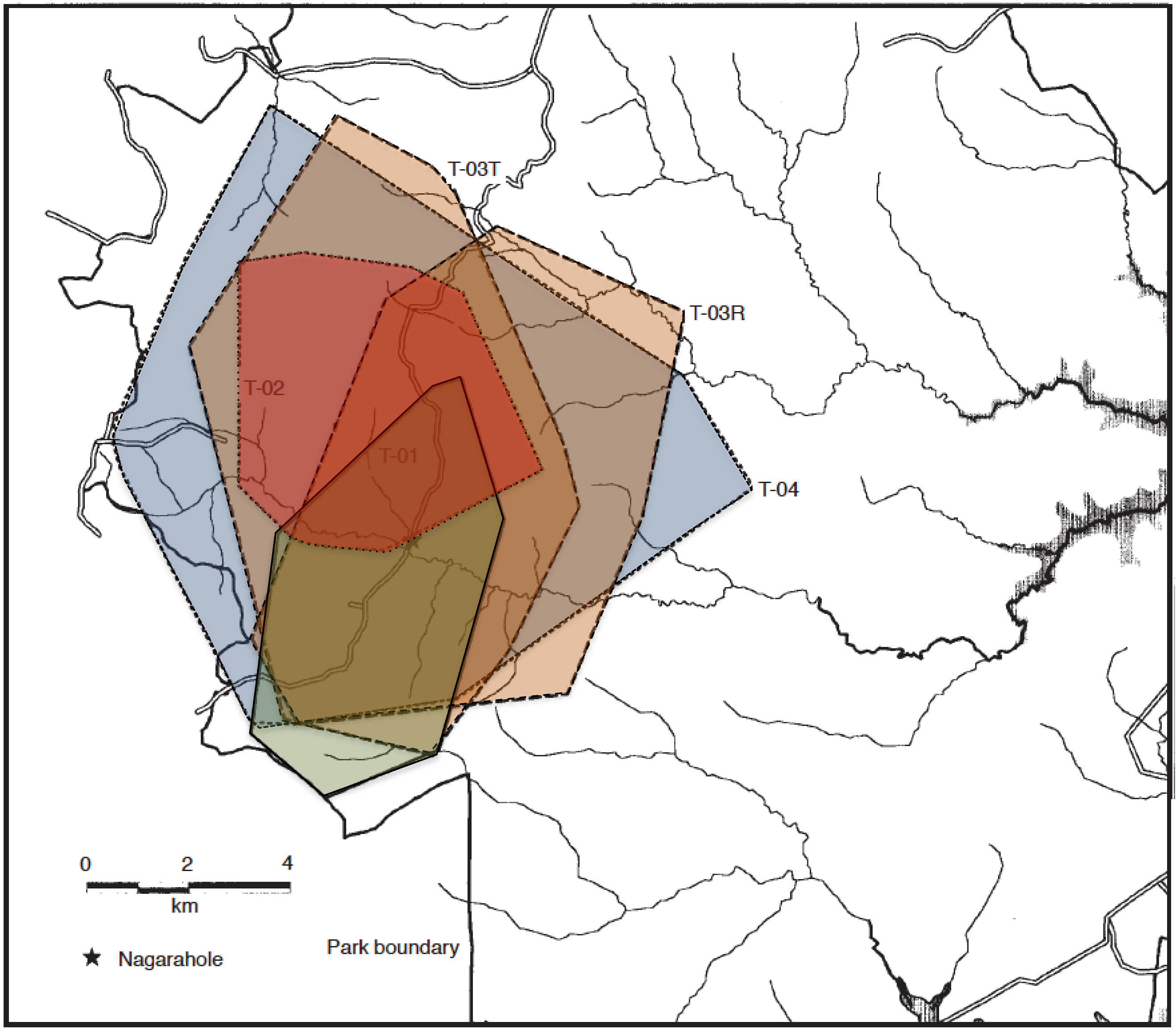


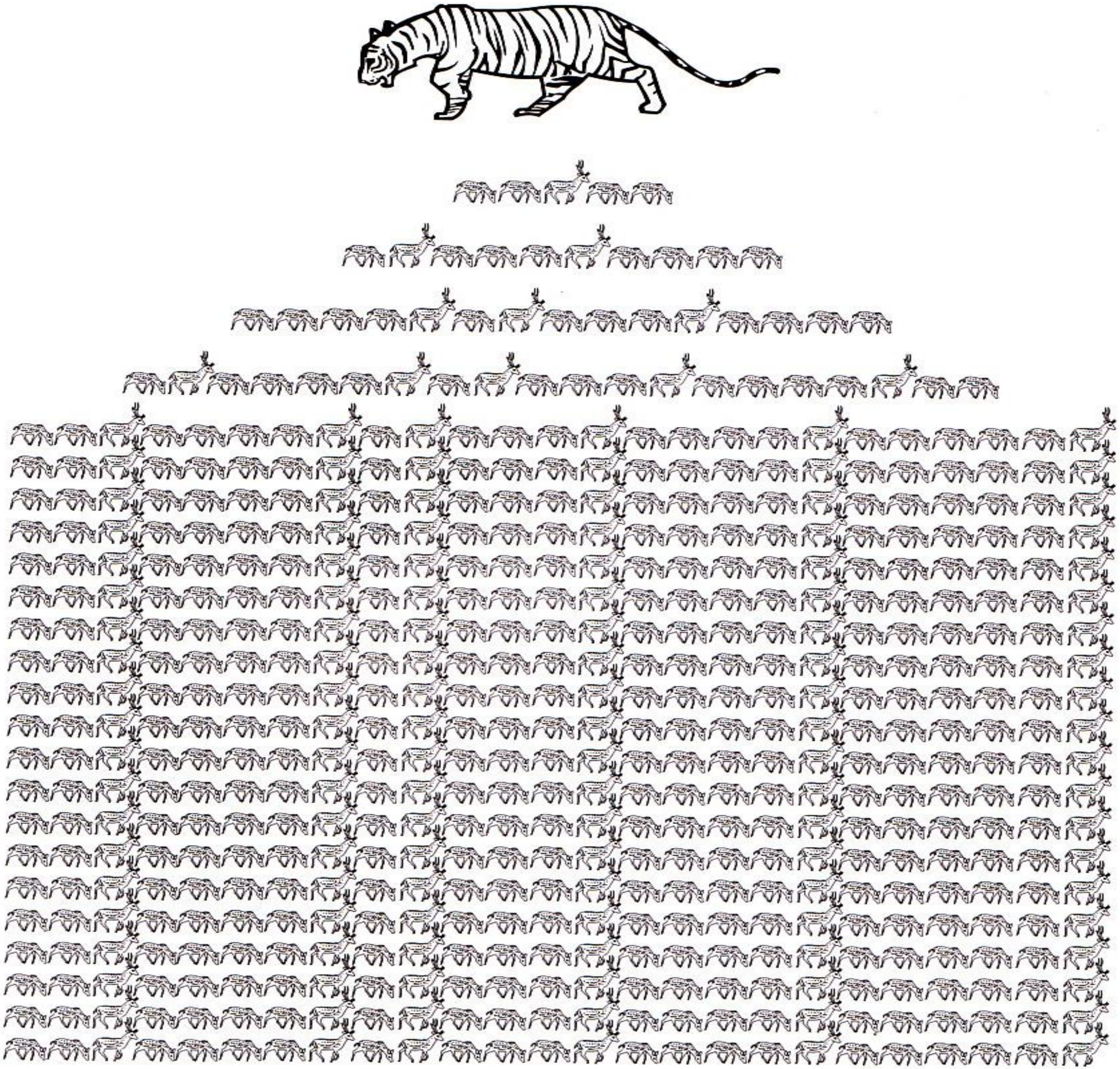


TIGER SOCIAL ORGANIZATION AND LAND TENURE PATTERNS



TIGER HOME RANGES





DE

1990s EMERGENCE OF TIGER

Animal Population Estimation: Problem of Imperfect Detection

The count obtained is a proportion of individuals actually present in the area of interest

$$\hat{N} = \frac{C}{\hat{p}\alpha}$$

Where $\hat{N}$ **is the estimated abundance in the area of interest,**

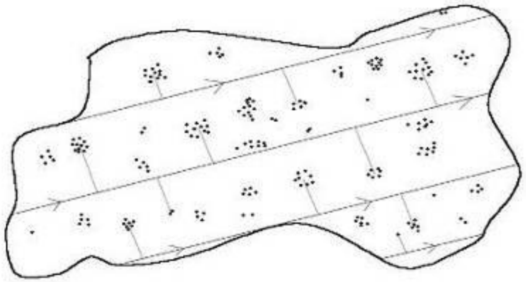
C **is the count obtained during the survey (number of animals captured),**

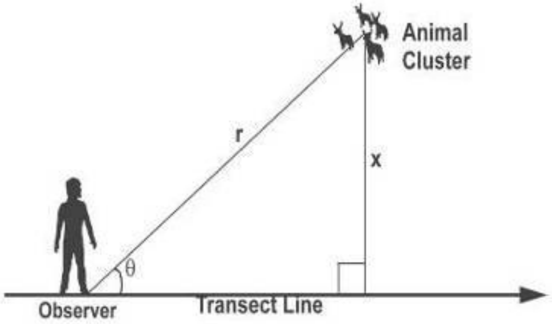
α **is the proportion of area surveyed and**

$\hat{p}$ **is the detection probability**

Prey Species: Distance sampling

- Can be used for species that we can see, count and measure distances to…
- Detection probability is modeled and estimated from these distance detection data



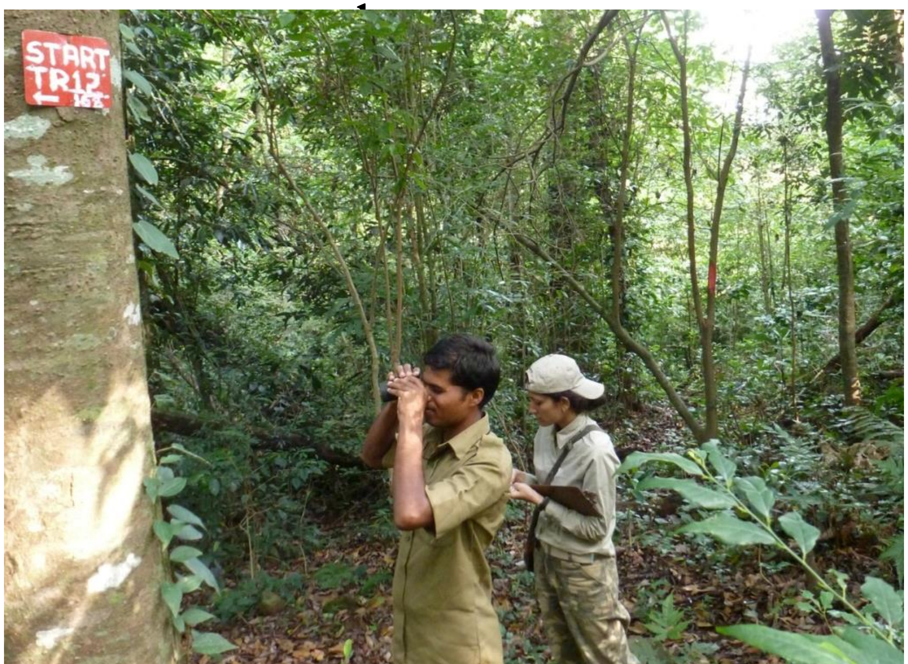


Prey Species: Distance sampling

- Estimating prey numbers in large landscapes

- Determining key determinants of ungulate abundance

- Estimating 'how many tigers can potentially be



- HOW TO COUNT TIGERS
- THE 'PUGMARK CENSUS'
- THE PROBLEMS WITH IT

Pugmark Census to Photographic Sampling


NHT
130

1995: Photographic Capture–recapture Sampling

- Unique individual identifications

- **Closed capture-recapture sampling** in a short period each year

- Multiple years of such sampling using **open capture-recapture** models

- Density, numbers, changes over time, survival and recruitment rates: Population dyamics


BPT-221


NHT-261

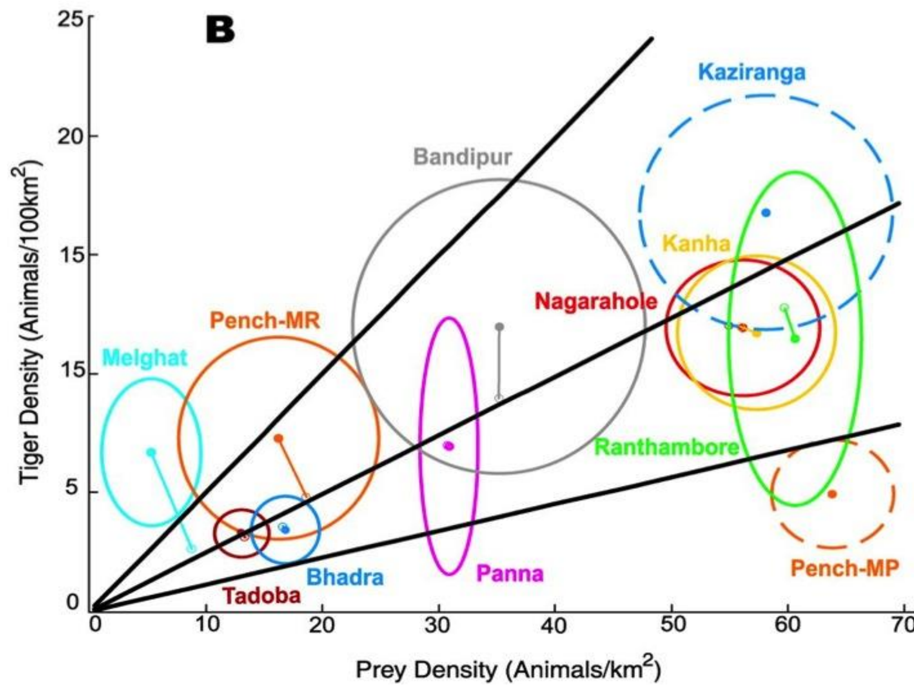

BPT-184


BPT-166


BPT-188


NHT-239

Tiger-Prey Relationships



Tigers and their prey: Predicting carnivore densities from prey abundance

K. Ullas Karanth*†, James D. Nichols‡, N. Samba Kumar*, William A. Link‡, and James E. Hines‡

*Wildlife Conservation Society, India Program, 26-2, Aga Abbas Ali Road, Apartment 403, Bangalore, Karnataka 560042, India; and ‡U.S. Geological Survey, Patuxent Wildlife Research Center, Laurel, MD 20708

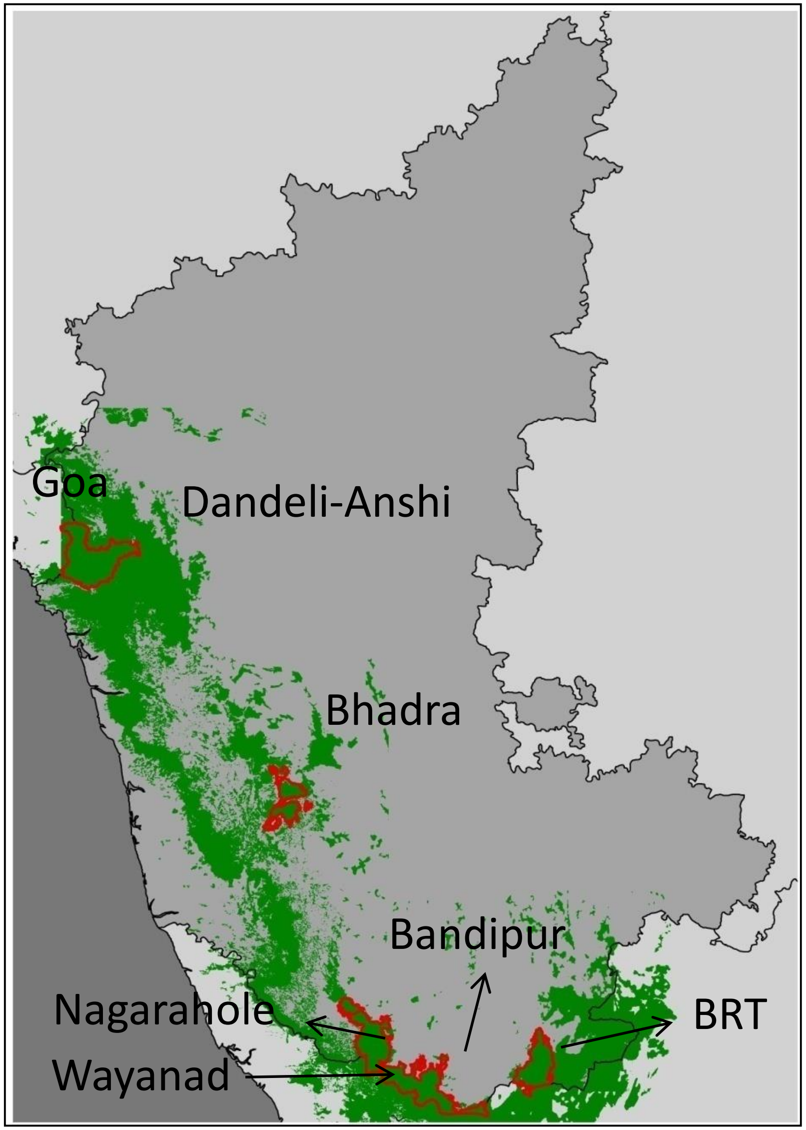
Edited by Gordon H. Orians, University of Washington, Seattle, WA, and approved January 21, 2004 (received for review September 25, 2003)

The goal of ecology is to understand interactions that determine the distribution and abundance of organisms. In principle, ecologists should be able to identify a small number of limiting resources for a species of interest, estimate densities of these resources at different locations across the landscape, and then use these estimates to predict the density of the focal species at these locations. In practice, however, development of functional relationships between abundances of species and their resources has proven extremely difficult, and examples of such predictive ability are very rare. Ecological studies of prey requirements of tigers *Panthera tigris* led us to develop a simple mechanistic model for predicting tiger density as a function of prey density. We tested our model using data from a landscape-scale long-term (1995–2003) field study that estimated tiger and prey densities in 11 ecologically diverse sites across India. We used field techniques and analytical

analyses are often weak and unreliable. The detection and nondetection of patterns may have more to do with spatial variation in detectability of animals and selection of sample locations than with true ecological variations.

The study reported here represents an effort to avoid the above weaknesses associated with many macroecological investigations. This effort focuses on two key aspects (11) of such investigations: (*i*) modeling and prediction and (*ii*) sampling and estimation. With respect to modeling and prediction, instead of looking for macroecological patterns and then treating such patterns as phenomenological models to be tested, we emphasize a more mechanistic approach based on the ecological concept of "limiting factors," factors that are determinants of equilibrium population size or, more generally, of the stationary probability distribution of population densities (12–14). Changes in limiting

Malenad Tiger Landscape: Monitoring Scale



Number of PA sites: 7

Area sampled: 6000 km^2

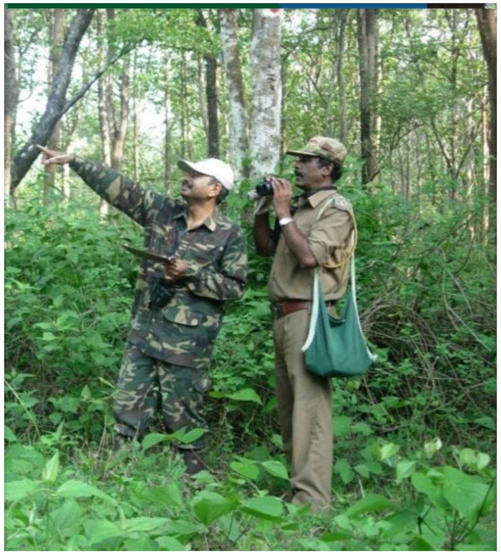
Total number of trap nights (in 7 sites): 23,350

Total number of trap locations (in 7 sites): 727

Total number of line transects (in 5 sites): 234

Total line transect walk effort (in 5 sites): 5,676 km

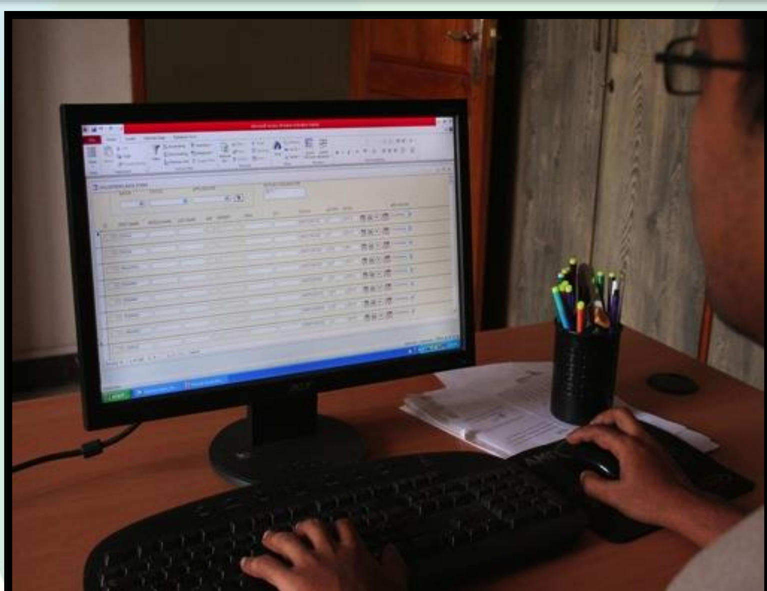
Training and Capacity-building



WCS-INDIA: Animal Monitoring Infrastructure

- Research and Analysis Centre: Bangalore
- Field Training Centre at Hulikanu, Bhad
- Field camps : 05
- 4 X 4 field vehicles :20
- Camera traps: 600+
- Camera trap shells (600)
- GPS units (84)
- Laser rangefinders (62)
- Compasses (80)

Personnel







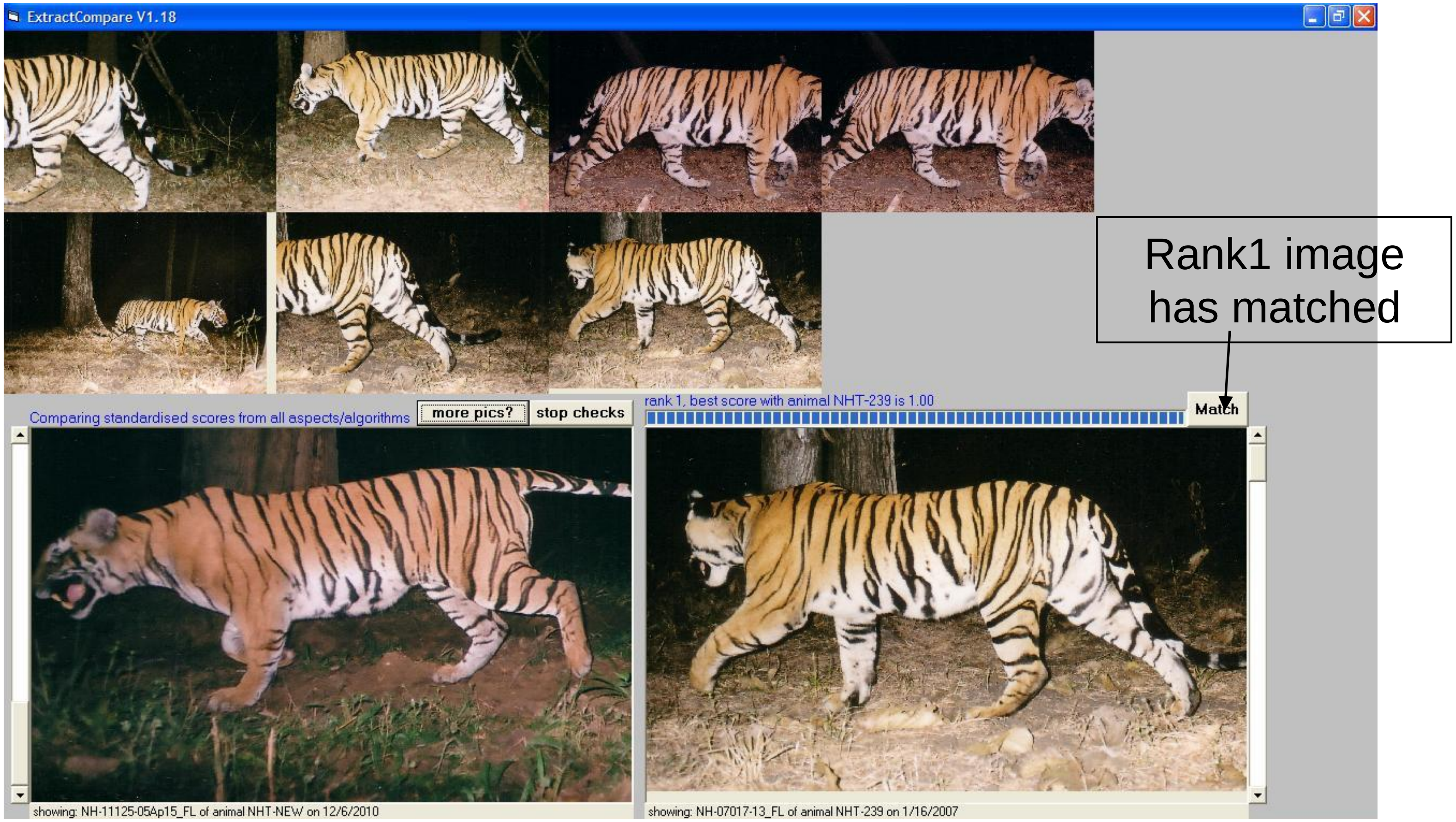





TRAILMASTER

Program *ExtractCompare*

- Pattern is compared with previous images
- High similarity scores
- Visual identification for final verification



Program *ExtractCompare*

- Speedy, accurate identification
- Matching of seized tiger skins of identified individuals
- Long-distance movement of tigers across sites

biology letters

Biol. Lett. (2009) 5, 383–386
doi:10.1098/rsbl.2009.0028
Published online 11 March 2009

Population ecology

A tiger cannot change its stripes: using a three-dimensional model to match images of living tigers and tiger skins

Lex Hiby[1,*], Phil Lovell[2], Narendra Patil[3], N. Samba Kumar[3], Arjun M. Gopalaswamy[3] and K. Ullas Karanth[3]

[1]*Conservation Research Ltd, 110 Hinton Way, Great Shelford, Cambridge CB22 5AL, UK*
[2]*Sea Mammal Research Unit, Gatty Marine Laboratory, University of St Andrews, St Andrews, Fife KY16 8LB, UK*
[3]*Wildlife Conservation Society—India Programme, Centre for Wildlife Studies, 1669, 31st Cross, 16th Main, Banashankari 2nd Stage, Bangalore 560 070, India*
**Author for correspondence* (lexhiby@gmail.com).

The tiger is one of many species in which individuals can be identified by surface patterns. Camera traps can be used to record individual tigers moving over an array of locations and provide data for monitoring and studying populations and devising conservation strategies. We suggest using a combination of algorithms to calculate similarity scores between pattern samples scanned from the images to automate the search for a match to a new image. We show how using a three-dimensional surface model of a tiger to scan the pattern samples allows comparison of images that differ widely in camera angles and body posture. The software, which is free to download, considerably reduces the effort required to maintain an image catalogue and we suggest it could be used to trace the origin of a tiger skin by searching a central database of living tigers' images for matches to an image of the skin

and when each was photographed. But as the photo-id catalogue grows with population turnover and immigration from adjacent sites, the effort required to search the entire catalogue for matches to each new image becomes excessive. The number of visual comparisons required can be reduced substantially by calculating similarity scores between each new image and the images by which existing individuals are represented in the catalogue. Visual comparisons can then be restricted to those individuals for which the maximum score exceeds a threshold value, as exemplified by the work of Kelly (2001) for cheetahs and Karlsson *et al.* (2005) for grey seals.

Camera trap images of tigers are characterized by a wide range of camera angles and body posture. To allow similarity scores to be calculated between such images, we developed a three-dimensional surface model of a tiger. The software, first developed for matching images of grey seals (Hiby & Lovell 1990), fits the model to each new image and scans the stripe pattern from the region of the image lying beneath a predefined region of the model, so that the resulting pattern sample is largely unaffected by camera angle and body posture. A pattern comparison algorithm then calculates similarity scores between the new and existing pattern samples. Scanning the pattern via a three-dimensional model, in effect, unwraps it from the curved surface of the tiger's flank and thus also allows a camera trap image of a living tiger to match an image of its skin laid out flat.

Using camera trap images from the Nagarhole and Bandipur tiger reserves in Karnataka, India, we demonstrate the resulting reduction in effort required to generate capture histories from a large database of camera trap images. We also suggest that the software could be used as a forensic tool to trace the origin of tiger skins.

2. MATERIAL AND METHODS

The surface model of the tiger, stored as a text file of three-dimensional coordinates, extends from the shoulders to the base of the tail, undercutting the fore and hind limbs. Figure 1 shows the

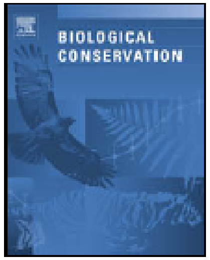
Advances: Genetic Captures of Tigers

Individual identification of tigers using DNA extracted non-invasively field-collected scats

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon



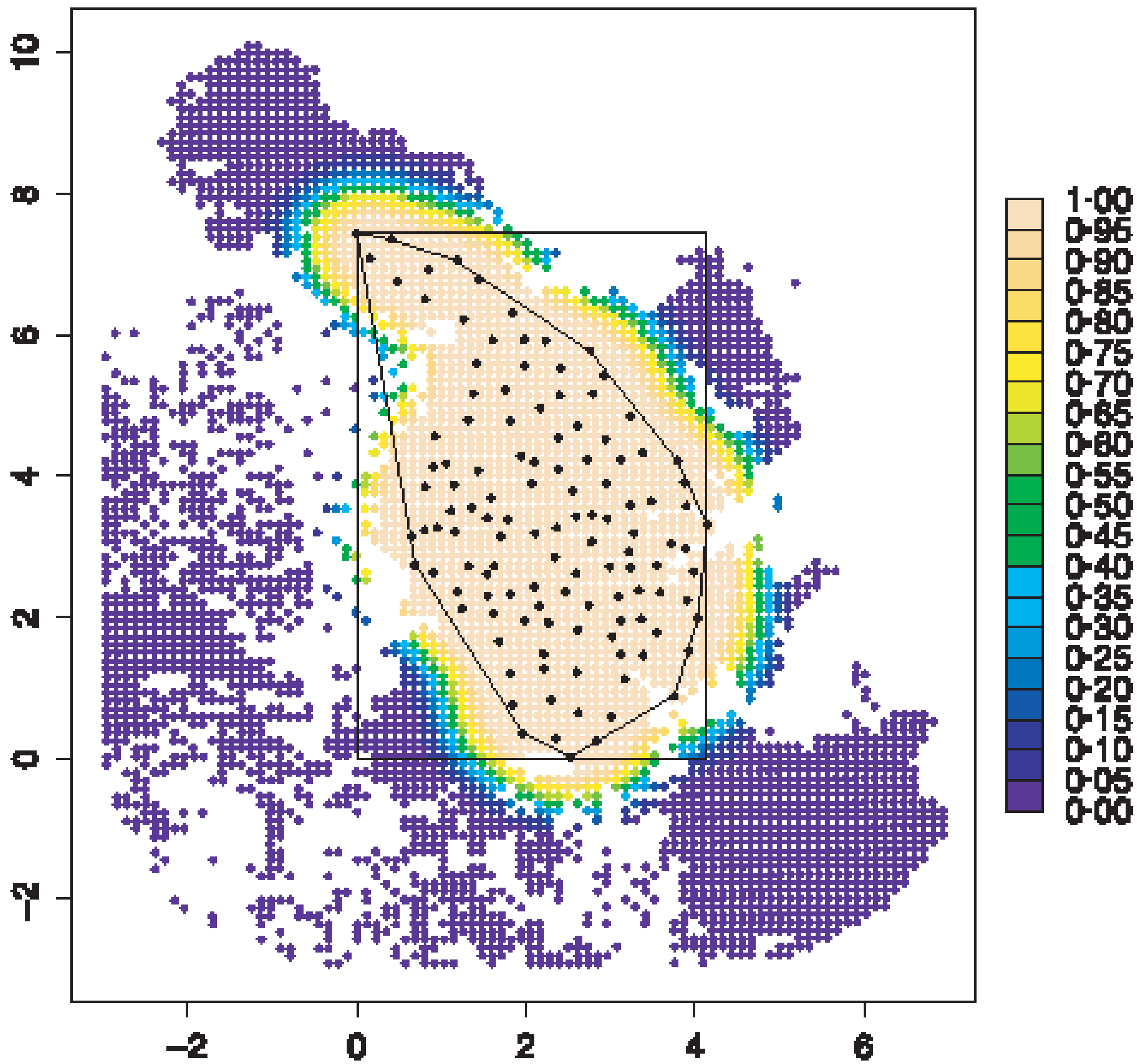
ELSEVIER

Evaluation of non-invasive genetic sampling methods for estimating tiger population size

Samrat Mondol [a], K. Ullas Karanth [b,c], N. Samba Kumar [b,c], Arjun M. Gopalaswamy [b,c], Anish Andheria [d], Uma Ramakrishnan [a,*]

Advances: Spatial Capture-Recapture Models

- Estimating how capture probability varies across a study area



Spatial Capture Recapture: Extensions

- Extensions to the model generalize it to apply to a wide range of scenarios:
  - Multiple captures within sampling occasions
  - Heterogeneity, covariate modeling, variable effort, behavior

Ecology, 90(11), 2009, pp. 3233–3244

Bayesian inference in camera trapping studies for a class of spatial capture–recapture models

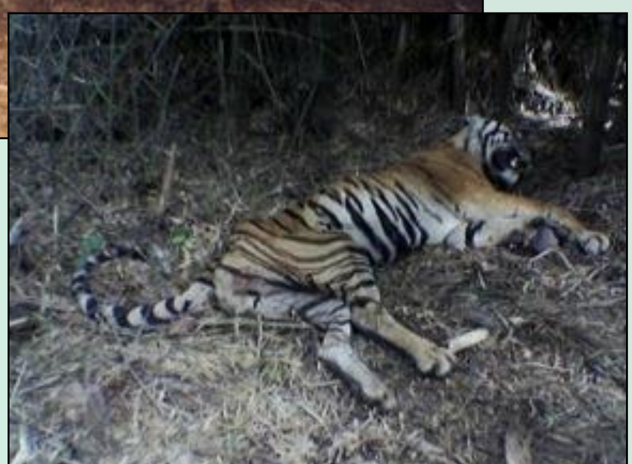
J. Andrew Royle,[1,3] K. Ullas Karanth,[2] Arjun M. Gopalaswamy,[2] and N. Samba Kumar[2]

[1]*U.S. Geological Survey, Patuxent Wildlife Research Center, Laurel, Maryland 20708 USA*
[2]*Wildlife Conservation Society-India Program, Centre for Wildlife Studies, Bangalore, Karnataka-560042, India*

Tracking fate of individuals over time…and space

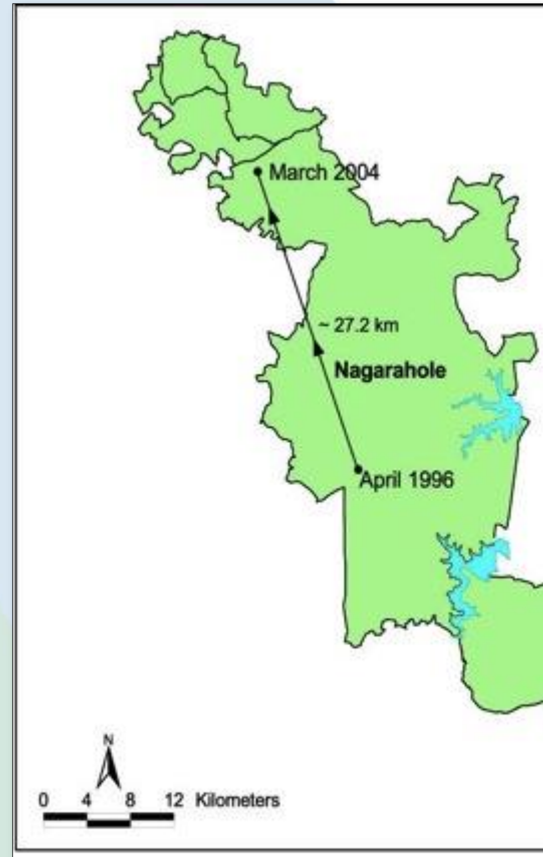
1996

2004



2006

NHT-132



Tracking individuals over time…and space

NHT-267

Dec 2008: **Nagarahole**

Feb-Apr 2009: **Cicada Resorts**

Jun 2009: **Captured, released in Bhadra**

Jul 2009: **Found dead**

Tracking individuals over time...and space

BPT-159 (FEMALE)

- First captured: 12 April-2004
- Last captured: 3 Dec 2005
- Captured in 2004 and 2005, on Chowdapura Kere Road and Marigudi Road
- Skin seized by the Karnataka Forest Department on 19-Sep-2007 near Doddabargi village in Bandipur

Cumulative Number of Individual Tigers Photo-captured in Malenad

Year	No. of Unique Individual Tigers
1990 - 2003	110
2004	180
2005	240
2006	279
2007	313
2008	343
2009	387
2010	426
2011	512
2012	634
2013	746
2014	788
2015	888

Tiger Population Dynamics: Open Model Capture–recapture

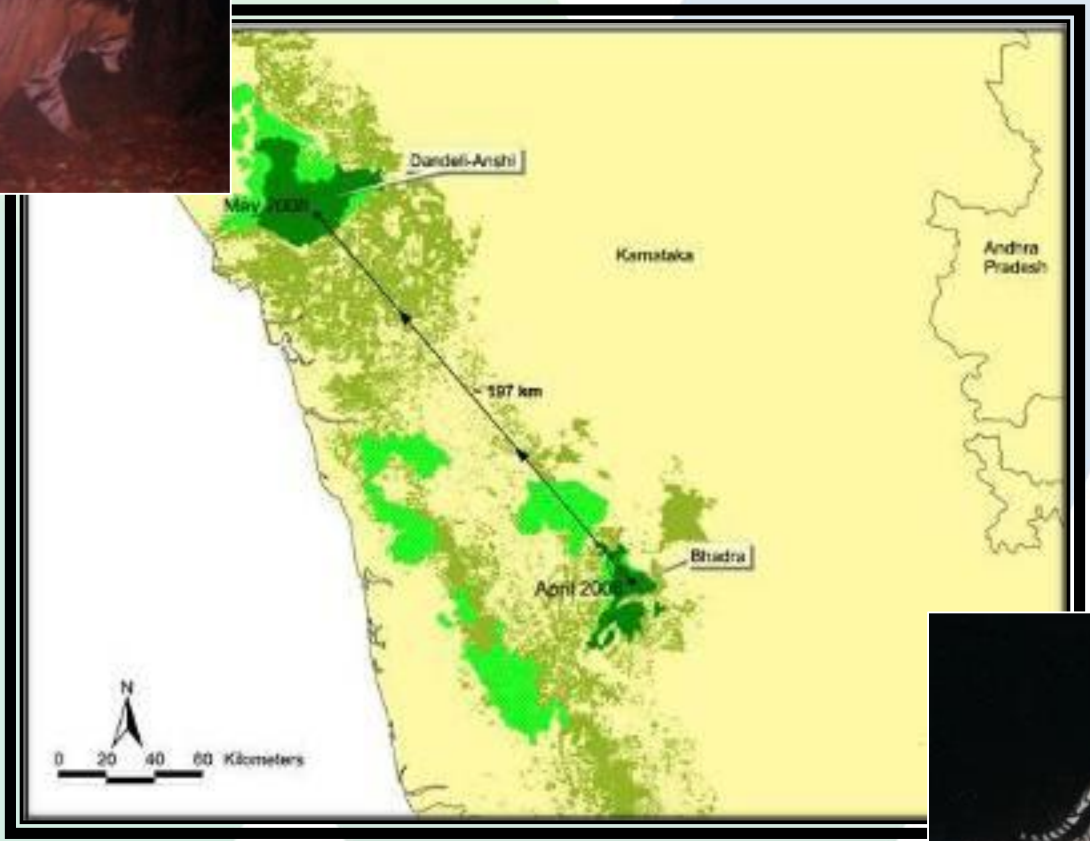
- Study in Nagarahole with 10 'primary' samples (1991-2000)
- Multiple 'secondary' samples in each primary sample
- Integrated approach to modeling closed and open population data
- Total of 5,725 trap-nights of effort
- 74 individual tigers (> 2 years age) photo-captured

Assessing Tiger Population Dynamics: Open Model Capture–recapture

RESULTS

- Annual survival rate estimate: 0.77 (0.051)
- Tiger densities/100 km^2: 7.33 (0.8) to 21.73 (1.7)
- Mean rate of annual population change: 1.03 (0.02)
- Annual recruitment: 0 (3.0) to 14 (2.9) tigers
- Temporary random emigration: 0.10 (0.069)
- Probability that a newly-caught individual is transient: 0.18 (0.11)

Monitoring Tiger Dispersal

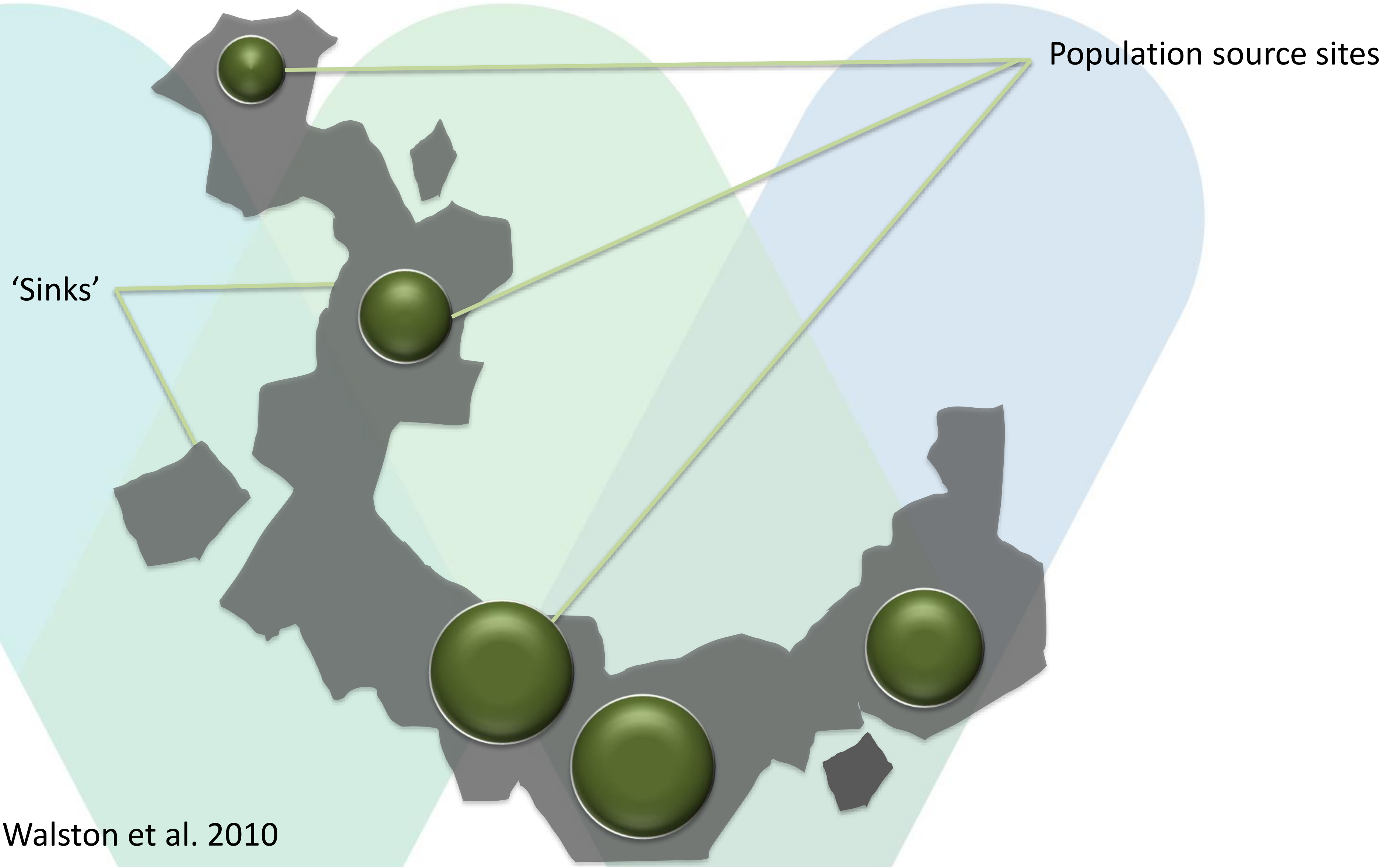


BDT-130: 197 Km

Monitoring Tiger Dispersal

BPT-241: 280 Km

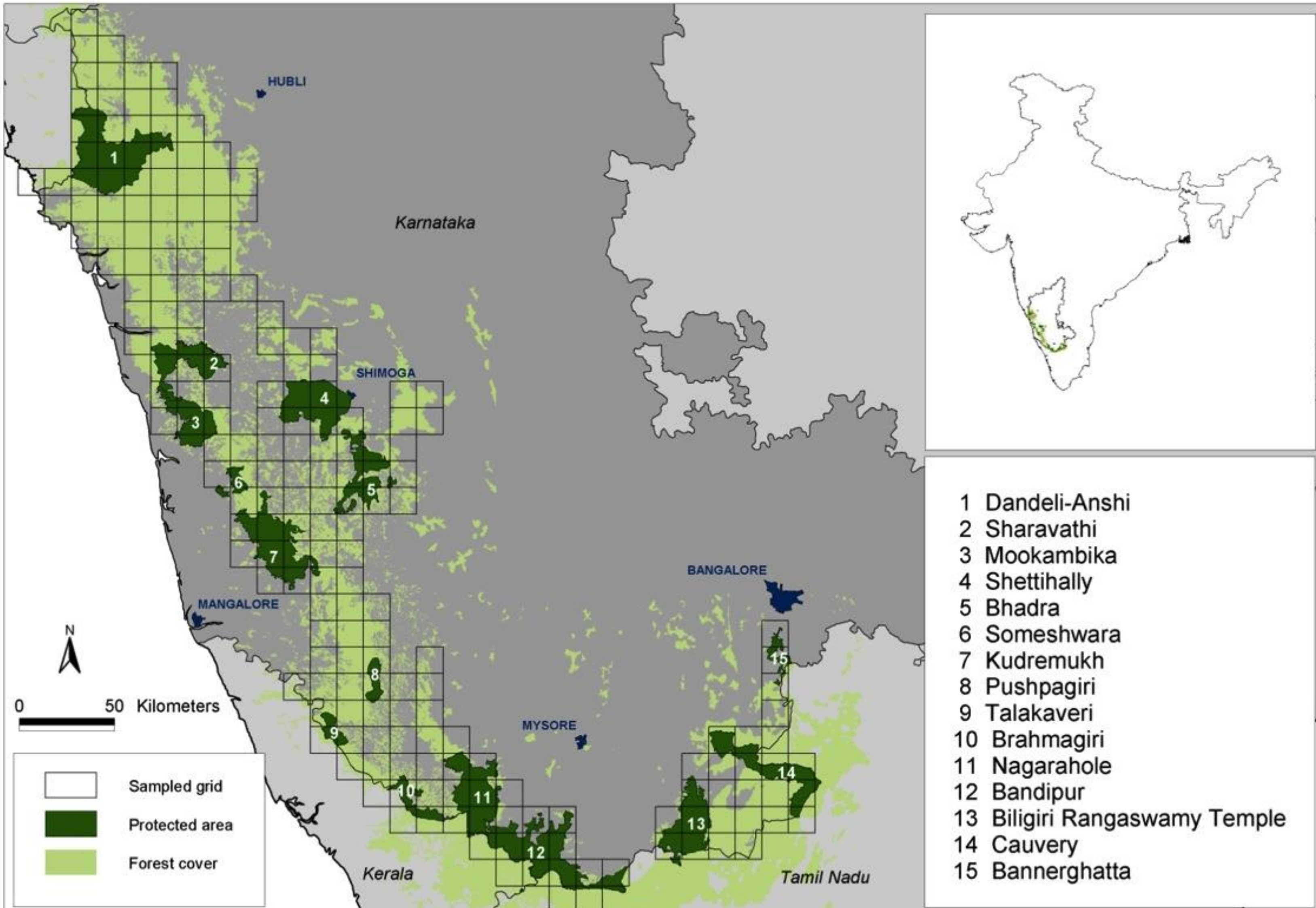
Tiger Population: Sources & Sinks



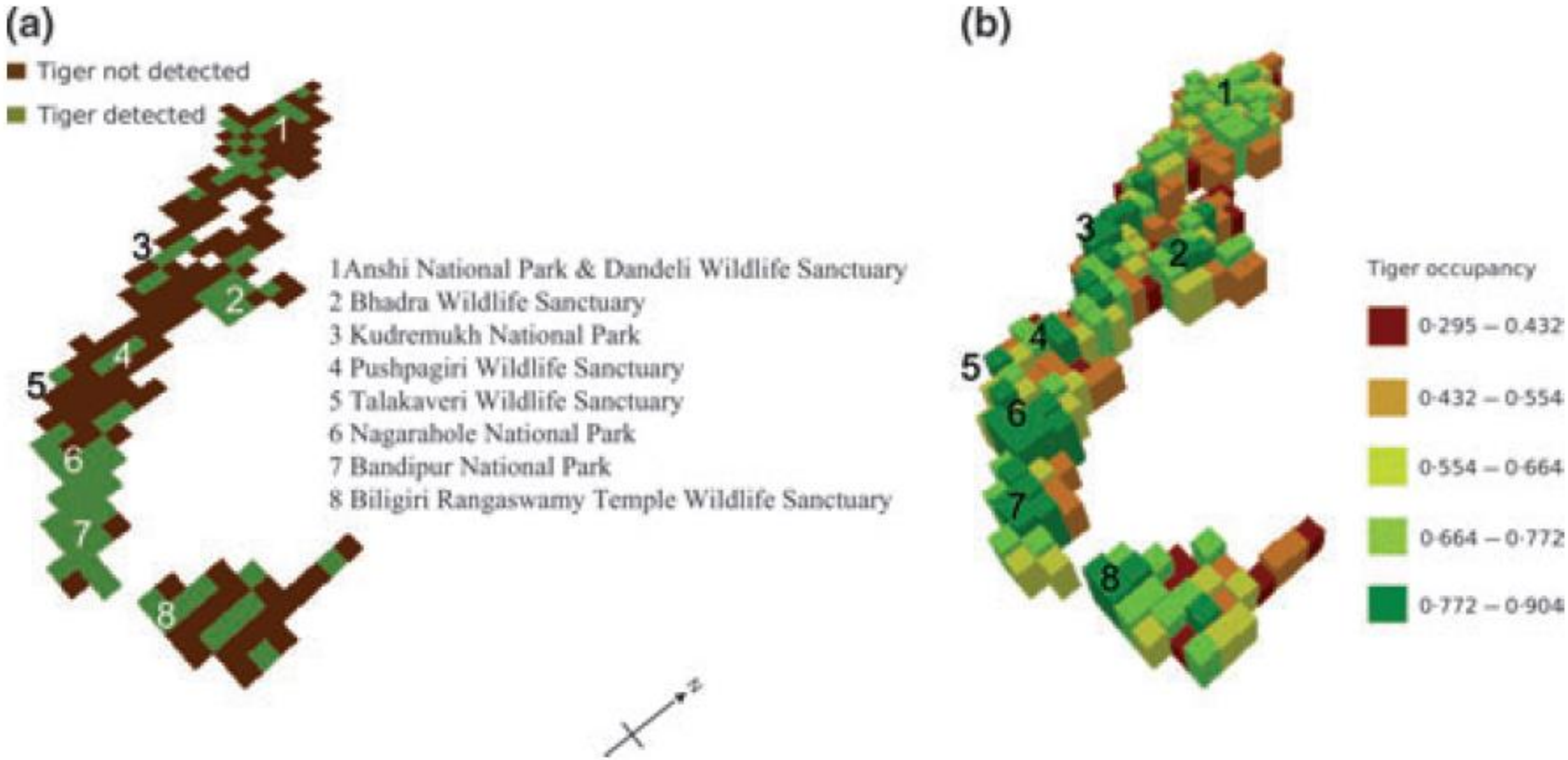
Walston et al. 2010

Large Landscapes: Surveys of tiger and prey signs

Tiger Occupancy Sampling In Malenad



Tiger Occupancy In Malenad



Modeling Tiger Occupancy in Malenad

Ecological Applications, 20(5), 2010, pp. 1456–1466

Tigers on trails: occupancy modeling for cluster sampling

J. E. Hines,[1,4] J. D. Nichols,[1] J. A. Royle,[1] D. I. MacKenzie,[2] A. M. Gopalaswamy,[3] N. Samba Kumar,[3] and K. U. Karanth[3]

[1]*United States Geological Survey, Patuxent Wildlife Research Center, Laurel, Maryland 20708 USA*
[2]*Proteus Wildlife Research Consultants, P.O. Box 5193, Dunedin, New Zealand*
[3]*Wildlife Conservation Society—India Program, Centre for Wildlife Studies, Bangalore, Karnataka-560042 India*

Journal of Applied Ecology

British Ecological Society

Journal of Applied Ecology 2011, **48**, 1048–1056 doi: 10.1111/j.1365-2664.2011.02002.x

Monitoring carnivore populations at the landscape scale: occupancy modelling of tigers from sign surveys

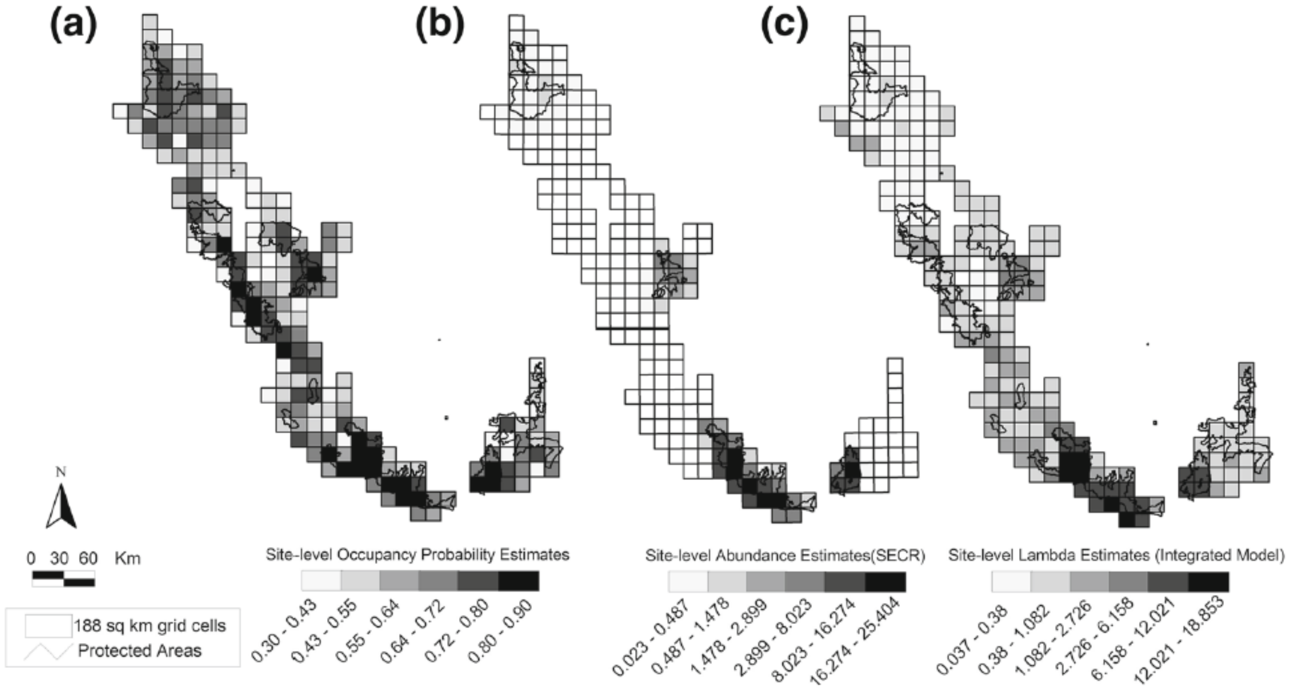
Kota Ullas Karanth[1,2*], Arjun M. Gopalaswamy[2,3,4], Narayanarao Samba Kumar[2,3], Srinivas Vaidyanathan[3,5], James D. Nichols[6] and Darryl I. MacKenzie[7]

[1]*Wildlife Conservation Society – Global Conservation Program, 2300 Southern Boulevard, Bronx, NY 10460, USA;* [2]*Centre for Wildlife Studies, 26-2, Aga Abbas Ali Road (Apt: 403), Bengaluru 560 042, India;* [3]*Wildlife Conservation Society – India Program, 1669, 31st Cross, 16th Main, Banashankari 2nd Stage, Bengaluru 560 070, India;* [4]*Wildlife Conservation Research Unit (WildCRU), The Recanati-Kaplan Centre, Department of Zoology, Tubney House, University of Oxford, Abingdon Road, Tubney, Abingdon OX13 5QL, UK;* [5]*Foundation for Ecological Research, Advocacy and Learning, No 27, 2nd Cross Appavounagar, Vazhakulam, Pondicherry 605 012, India;* [6]*United States Geological Survey, Patuxent Wildlife Research Center, Laurel, MD 20708, USA; and* [7]*Proteus Wildlife Research Consultants, PO Box 5193, Dunedin, New Zealand*

stimating Tiger Abundance at Large Spatial Scales from Multiple Data Sources

- Tiger population dynamics at macro-ecological scales
- Need to formally integrate:
  - 'Expensive' but reliable data from smaller spatial scales (SCR from reserve-level camera trap data)
  - 'Cheap' but less reliable data at larger spatial scales (occupancy from landscape-level sign survey data)
- Hierarchical models under a Bayesian Approach

Tiger Abundance at Macro Spatial Scales: Multiple Data Sources



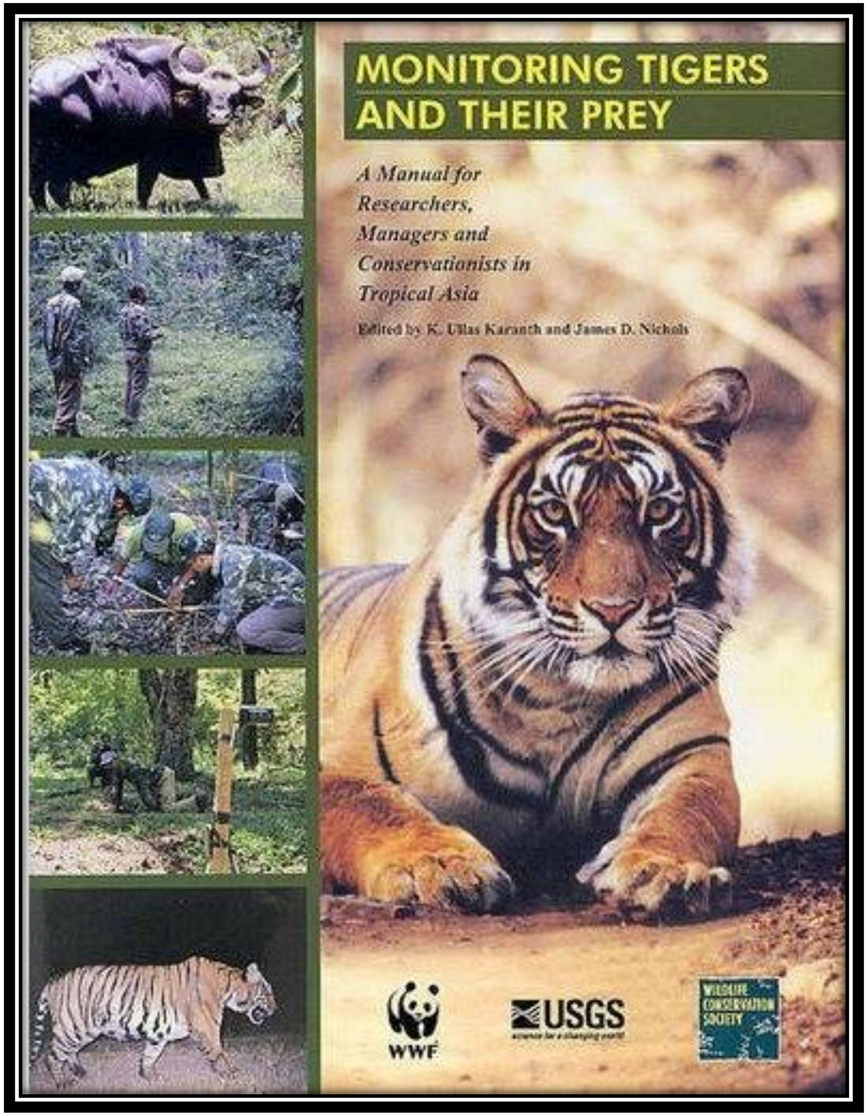
Spatial Capture-recapture Estimates of tiger density in in reserves (30 cells)

Tiger sign encounter surveys in all 205 cells.

Integrated modeling of data at two scales estimated 391 ($\pm 56_{SE}$) tigers in the Malenad Landscape

WCS-WII
International Workshop
Analysis and Management of Animal Populations
15-22 January 2013
Wildlife Institute of India, Dehradun
Wildlife Conservation Society – India | Wildlife Institute of India | Centre for Wildlife Studies
Workshop leaders
Resource Persons
WILDLIFE CONSERVATION SOCIETY
भारतीय वन्यजीव संस्थान
Wildlife Institute of India
James D. Nichols
P.R. Sinha
K. Ullas Karanth
V.B. Mathur

Sharing The Science



CHAPTER 9

STATISTICAL CONCEPTS: ESTIMATING ABSOLUTE DENSITIES OF PREY SPECIES USING LINE TRANSECT SAMPLING

Len Thomas[1] and K. Ullas Karanth[2]

[1]Centre for Research into Ecological and Environmental Modelling (CREEM)
Mathematical Institute, University of St. Andrews, St. Andrews Fife, Scotland KY 16 9SS, UK.
Email: <len@mcs.st-and.ac.uk>

[2]Wildlife Conservation Society (International Programs), Bronx, New York, NY-10460-1099, USA.
Email: <ukaranth@wcs.org>

CHAPTER 10

FIELD SURVEYS: ESTIMATING ABSOLUTE DENSITIES OF PREY SPECIES USING LINE TRANSECT SAMPLING

K. Ullas Karanth[1], Len Thomas[2] and N. Samba Kumar[3]

[1]Wildlife Conservation Society (International Programs), Bronx, New York, NY-10460-1099, USA.
Email: <ukaranth@wcs.org>

[2]Centre for Research into Ecological and Environmental Modelling (CREEM)
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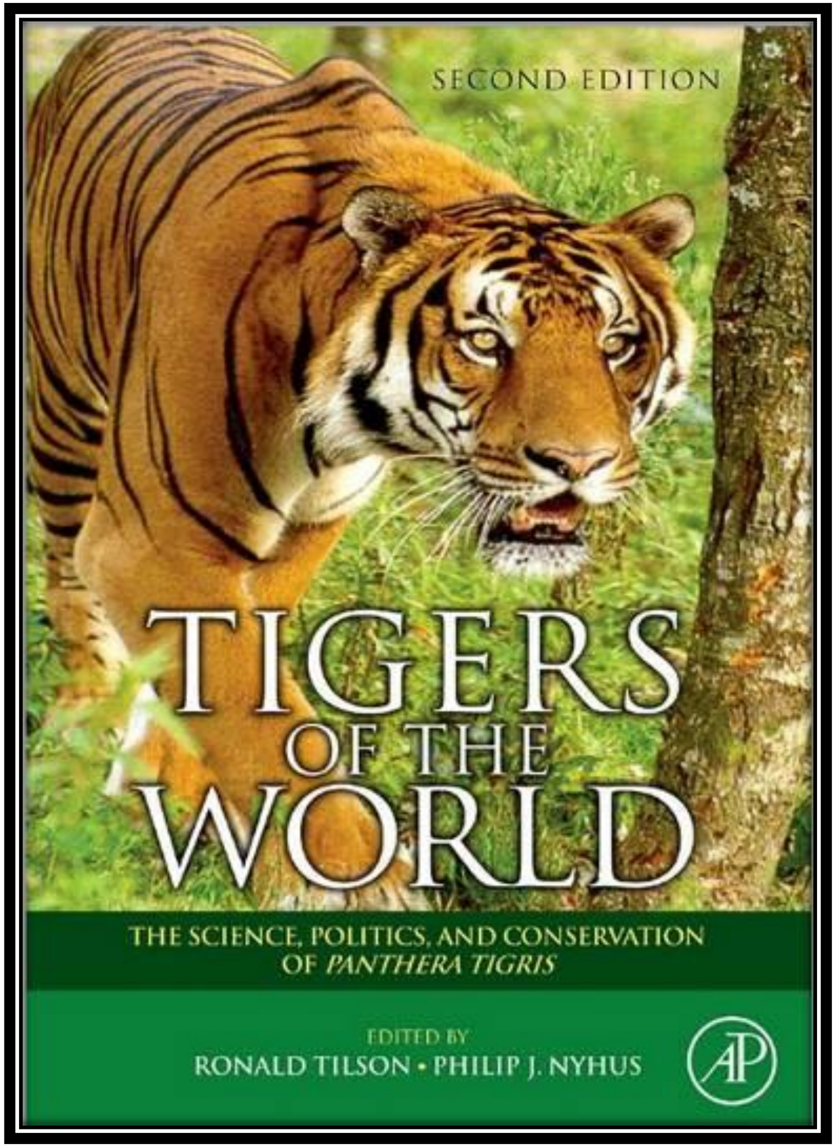
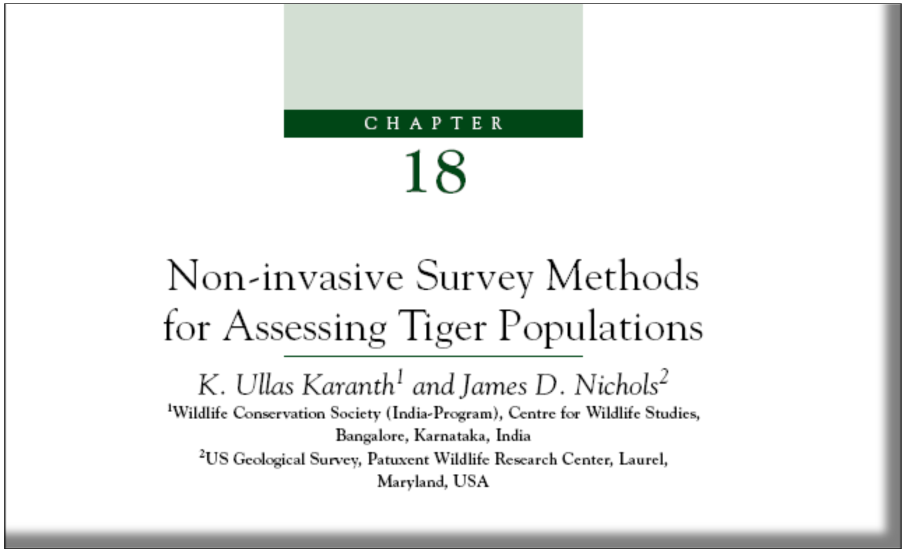
Email: <len@mcs.st-and.ac.uk>

[3]Centre for Wildlife Studies, 26-2 Aga Abbas Ali road (Apt. 403), Bangalore, Karnataka-560 042, India.
Email: <wcsind@bgl.vsnl.net.in>

UPDATING KNOWLEDGE



Methods developed under the project now widely-used globally for monitoring tigers world-wide


CHAPTER 18

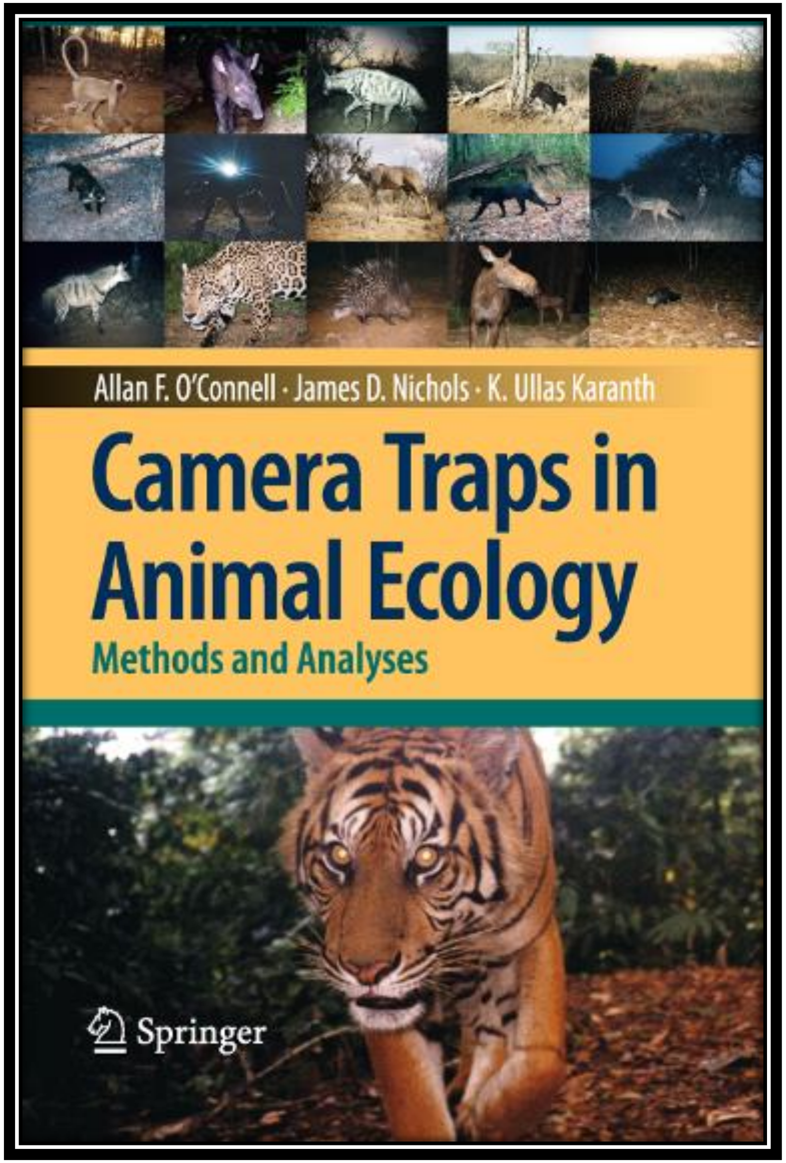
Non-invasive Survey Methods for Assessing Tiger Populations

K. Ullas Karanth[1] and James D. Nichols[2]

[1]Wildlife Conservation Society (India-Program), Centre for Wildlife Studies, Bangalore, Karnataka, India

[2]US Geological Survey, Patuxent Wildlife Research Center, Laurel, Maryland, USA

Camera-trapping: Tigers And Beyond



Methods developed under the project now widely-used globally for monitoring of many secretive species

India: Challenges of Science-Deficiency in Conservation Practice

- Government monopoly on wildlife science
- Natural Laboratories: Restriction of access
- Disregard for peer-reviewed science
- Substandard Science and manipulation of data
- Conflict of interest between science and 'management'
- Lack of specialization and professionalism

- SOLUTION? Legislation to promote conservation science independent of management


THANK YOU
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