Capacity building for Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES)

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NINA Report

Final report

Indo- Norwegian pilot project on capacity building in biodiversity informatics for enhanced decision making, improved nature conservation and sustainable development.

Frank Hanssen (editor), Vinod B. Mathur, Vidya Athreya, Vijay Barve, Rupa Bhardwaj, Louis Boumans, Mandy Cadman, Vishwas Chavan, Mousumi Ghosh, Arild Lindgaard, Øystein Lofthus, Fridtjof Mehlum, Bivash Pandav, Girish Arjun Punjabi, Alberto González Talaván, Gautam Talukdar, Nils Valland, Roald Vang

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Indo- Norwegian pilot project on capacity building in biodiversity informatics for enhanced decision making, improved nature conservation and sustainable development.

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Abstract

This pilot project has been coordinated by The Norwegian Institute of Nature Research (NINA) in close collaboration with the Wildlife Institute of India (WII), the Norwegian Biodiversity Information Centre (NBIC), The Nature History Museum at the University of Oslo (NHM), the Wildlife Conservation Society- India Program (WCS) and the Centre for Wildlife Studies (CWF) in India. The Norwegian Government has funded the project with support from the Indian Government.

The project has collaborated with the Global Biodiversity Information Facility (GBIF) and has implemented several of the capacity building tools, standards and services offered by GBIF. In addition, WII and NHM host the national GBIF- nodes of India and Norway. Furthermore, the project is closely linked to the Indian and international strategies on biodiversity infrastructure development.

The project has focused on national user needs, camera trapping techniques, data management, open access and barriers towards open access. Six case studies demonstrate how biodiversity informatics, camera trapping, data mobilization and access policies can contribute to improved decision making. This has led to a better understanding of camera trapping techniques, occupancy modelling, DNA-analysis, species distribution, human-wildlife conflicts, human disturbance effects on wild mammals, habitat recovery, tiger population management needs and investigation of tiger poaching. The project has conducted a minor data repatriation exercise at Norwegian natural history museums. The capacity-building component of this towards international legacy collections is in the description of how to mobilize data through GBIF.

WII has developed a national database and a web-portal for mobilizing camera trap data. These developments are important steps towards a national, open biodiversity data management system for camera trap images and their axillary metadata. The project has developed a Best Practice Guide (BPG) for publishing of biodiversity data derived from camera trapping. This BPG will be maintained by GBIF in the future.

This capacity-building pilot project has clearly proved relevance in addressing the capacity building needs identified by IPBES. As the project results show, there are many international synergies in capacity-building of biodiversity informatics, camera trapping, data mobilization, data repatriation, data management and data sharing policy improvement. Finalizing the pilot project, the project partners have decided to look for new possibilities for collaboration under the IPBES.

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Sammendrag

Dette pilotprosjektet har vært koordinert av Norsk Institutt for Naturforskning (NINA) i nært samarbeid med Wildlife Insitutute of India (WII), Artsdatabanken, Naturhistorisk Museum ved Universitetet i Oslo, Wildlife Conservation Society- India Program (WCS) og Centre for Wildlife Studies (CWF) i India. Prosjektet er finansiert av den Norske Regjering med støtte fra den og India.

Prosjektet har samarbeidet med Global Biodiversity Information Facility (GBIF) og har implementert flere av deres kapasitetsbyggende verktøy, standarder og tjenester. I tillegg er WII og Naturhistorisk Museum nasjonale GBIF- noder. Prosjektet er nært knyttet til indiske og internasjonale strategier for utvikling av biodiversitetsinfrastruktur.

Prosjektet har fokusert på nasjonale brukerbehov, viltkamerametodikk, dataforvaltning, åpen datadeling og barrierer for åpen datadeling. Seks casestudier har vist hvordan biodiversitets-informatikk, bruk av viltkamera, datamobilisering og strategier for deling av data kan bidra til forbedrede beslutningsprosesser. Dette har ført til en bedre forståelse for bruk av viltkamera, occupancy-modellering, DNA-analyser, artsutbredelse, rovvilt/samfunn konflikter, effekter av menneskelig aktivitet på ville dyr, habitatrestaurering, behov knyttet til forvaltning av tigre, samt etterforskning av ulovlig jakt på tiger.

Prosjektet har gjennomført en mindre datarepatrieringsøvelse ved de norske naturhistoriske museene. Kapasitetsbyggingskomponenten i dette arbeidet overfor internasjonale museumssamlinger ligger primært i beskrivelsen av hvordan repatrierte data kan mobiliseres gjennom GBIF.

WII har utviklet en nasjonal database og en webportal for mobilisering av viltkameradata. Dette utviklingsarbeidet er et viktig skritt i retning av å utvikle et nasjonalt åpent system for forvaltning av viltkamerabilder og tilhørende metadata. Prosjektet har også utviklet en Best Practice Guide (BPG) for publisering av biodiversitetsdata avledet fra viltkamerabilder. Denne guiden vil bli vedlikeholdt av GBIF i fremtiden.

Dette prosjektet har vist høy relevans i forhold til de kapasitetsbyggingsbehov som er identifisert av IPBES. Som prosjektet viser er det store internasjonale synergier innen kapasitetsbygging knyttet til biodiversitetsinformatikk, bruk av viltkamera, datamobilisering, datarepatriering, dataforvaltning og forbedrede strategier for datadeling. I avslutningsfasen av dette pilotprosjektet har prosjektpartnerne bestemt seg for å se etter nye samarbeidsmuligheter under IPBES.

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Contents

Foreword

The project consortium is characterized by the very good collaboration between the project partners and the large degree of mandatory support from the Norwegian and Indian Governments. The project partners have willingly exchanged their expertise and knowledge in camera trapping and biodiversity informatics.

Capacity building has been identified as an essential component of the IPBES. We are confident that all project outcomes described in the following chapters demonstrate synergies and prove relevance for future regional/national capacity building developments under the IPBES. The project partners and the Governments of both countries now seek for new collaborative opportunities under the IPBES umbrella.

When setting up the IPBES, the participating Governments emphasized the importance of collaboration with existing initiatives. This project has from the beginning collaborated with the Global Biodiversity Information Facility (GBIF) about the implementation of open data sharing, international standards, common services and user adapted tools as requested by IPBES. The national GBIF nodes (India and Norway) and the global GBIF- Secretariat in Copenhagen (Denmark) has been very important for the outcomes of this project. GBIF operates at the data-science interface and represents as such an important support for IPBES operating at the science-policy interface.

This project highly emphasize the importance of citizen science in capacity building. Citizen scientists have been collaborating with professional scientists in several case studies throughout the entire project period. Mobilization of georeferenced biodiversity data from citizen science project is a very important task for future scientific achievements. Our project address this task with facilitated online user interfaces for data sharing. Many citizen scientists use social networking sites to share data. In this report, we describe how biodiversity occurrence records can be mobilized from social networking sites.

All project partners are actively involved in several capacity building initiatives both at national and international scales (ecological research, scientific training programs, strategy development, research infrastructure, biodiversity informatics and the development of standards, infrastructures, services and tools). In addition to GBIF, this pool of knowledge and networks represent an important asset to the set up and further development of the IPBES Technical Support Units.

Many people have been involved in this work. We would like to thank everyone for his or her valuable inputs, contributions and comments. A special thanks to Vishwas Chavan, Mousumi Ghosh, Mandy Cadman and Alberto Gonzàlez Talavàn for their support and great efforts in compiling the Best Practice Guide (BPG). We would also like to thank the Norwegian Government for the funding of this project.

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1 Introduction

Capacity building has been identified as an essential component of the Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES)[1]. The Norwegian Government acknowledges the need for capacity building and has developed and initiated several projects addressing capacity-building needs in partner countries. The goal of this pilot project was to build capacity and share knowledge and experiences within the field of Biodiversity Informatics in India. The pilot project is initiated and funded by the Norwegian Ministry for Foreign affairs[2], the Norwegian Ministry of Climate and Environment[3] and the Norwegian Environmental Agency[4]. The pilot project is highly welcomed and explicitly supported by the Government of India.

India was early identified as an ideal partner country for the realization of a capacity building pilot project because of the rich biodiversity in the country and the current national initiations towards the Indian Biodiversity Information Facility (InBIF). InBIF is currently a proposal concept, which has not yet been materialized. The Indian node of the Global Biodiversity Information Facility (GBIF)[5] led by the Wildlife Institute of India (WII)[6] is responsible for national coordination and linkage with the international GBIF community. In the context of GBIF India, WII has the national mandate from the Indian Ministry of Environment, Forests and Climate Change (MoEFCC)[7] to build capacity for effective biodiversity information management, including collection, collation, analysis and dissemination of biodiversity-related data.

The project partners started to develop an application for funding in 2011. The application was finally approved by the Indian and Norwegian Government`s in June 2011. The project was kicked off in October 2011 and has been coordinated and executed by the Norwegian Institute for Nature Research (NINA)[8] and WII, who also has been responsible for the implementation and progress of the project nationally within India.

NINA has provided its expertise in managing camera trap projects, and together with the Norwegian Biodiversity Information Centre (NBIC)[9] and the Natural History Museum at the University of Oslo (NHM)[10], provided the expertise acquired from building the Norwegian biodiversity infrastructure in terms of the NBIC- infrastructure and the Norwegian node in the Global Biodiversity Information Facility (GBIF)[11] at NHM in Oslo. In addition, the Wildlife Conservation Society- India Program (WCS)[12] and Centre for Wildlife Studies (CWF)[13] [14] has contributed a lot to the project within the fields of capacity building and citizen science.

This project had a specific focus on the use of camera trap data in decision making and displaying the benefits of data sharing adapted to various users including decision makers, researchers and civil society. The general idea is to build capacity to enable free sharing, access and dissemination of the biodiversity data in India to be more used in policymaking and evidence-based decision-making.

[1] http://www.ipbes.net/
[2] http://www.regjeringen.no/en/dep/ud.html?id=833
[3] http://www.regjeringen.no/en/dep/kld.html?id=668
[4] http://www.miljodirektoratet.no/english/
[5] http://www.gbif.org
[6] http://www.wii.gov.in/
[7] http://envfor.nic.in/
[8] http://www.nina.no/ninaenglish/Start.aspx
[9] http://www.biodiversity.no/frontpage.aspx?m=23
[10] http://www.nhm.uio.no/english/
[11] http://www.gbif.no/
[12] http://wcsindia.org/home/
[13] http://cwsindia.org/
[14] www.mumbaikarsforsgnp.com

2 Project background, objectives and national/international context

The main objective of this pilot project was to enhance the capacity of India to take evidence-based policy decisions about its own biodiversity management and conservation issues. To achieve this objective, the following necessary actions were proposed, enabled through the global standards and existing infrastructure offered by GBIF:

- A data repatriation exercise of Indian data held in the legacy collections of Norwegian Natural History Museums. In addition to the data itself, it is expected that the experiences from this repatriation exercise will have great synergies for similar exercises in other legacy collections.
- Capacity building exercises where Indian scientists and technicians learn routines for better data digitation and publishing of biodiversity data captured by the Indian network of camera traps deployed over the country, and how to use them for evidence-based decision making.
- Data mobilization from camera trapping projects recorded, based on relevant international data exchange standards.
- Case studies that will operationalize the mobilized biodiversity data for use in environmental conservation and management policy.
- A web- portal interface that provides access to mobilized camera trap images and standardized metadata.

Camera trapping refers to the use of remotely triggered cameras that automatically take images of whatever moves in front of them. It utilizes fixed digital cameras to capture images or videos of animals in wild, with as little human interference as possible, travelling in front of the camera's infrared sensors (Rovero et al., 2010). It provides photographs that serve as objective records of an animal's presence at a location, and information on activity patterns (from the date and time contained in the image), behavior, and pelage characteristics that enable individual identification of some species (Rovero et al., 2007).

WII, WCS and CWS have over many years evolved advanced techniques and great experience in camera trapping from India and neighboring countries both in protected nature reserves and in rural settlements. On a minor scale, NINA has also established experience on camera trapping from different projects in India, Myanmar and Norway.

The main focus and core responsibilities of the project partners were data sharing and exchange of camera trap data, technology and knowledge. The unique feature of this mutual capacity building collaboration is to device workflows, standards and infrastructure for mobilizing camera trap data into GBIF.

In October 2012 India established a National Biodiversity Information Outlook (NBIO)[15] in order to establish a consensus roadmap for the establishment of a national biodiversity information infrastructure (Chavan et. al, 2012). The goal of the NBIO roadmap is to:

- Assess the state-of-the-art of Indian biodiversity information
- Identify barriers to facilitate and encourage processes in biodiversity informatics
- Assist prioritizing acquisition, discovery, and publishing of biodiversity information by relevant stakeholders
- Communicate progress and advocate needs to decision makers in the form of a National Biodiversity Informatics Roadmap

[15] http://www.gbif.org/resources/2307

Users of the NBIO are stakeholders that produce and/or use biodiversity information. This includes researchers, conservationists, natural resources managers, land use planners, policy makers and the society in general. In addition to assess the progress of national biodiversity informatics, the NBIO will also provide an opportunity to make prioritized and demand-driven investment in biodiversity science itself. Further, as illustrated in Figure 1 below, NBIO will aim to establish a link between the biodiversity and ecosystem researchers, stakeholders, policy makers and information managers. NBIO will emphasize the need for efficient and cost-effective management of biodiversity data through the National Biodiversity GRID (NBG) and its implementing body, the InBIF.

Figure 1: NBIO will influence free and open access to biodiversity data through institutionalization of NBG and InBIF, which will enrich the National Biodiversity Strategy and Action Plan (NBSAP)

When NBIO becomes operational and initiates discovery and open access to biodiversity and ecosystems data, it will play an important role in the establishment of a National Biodiversity Strategy and Action Plan (NBSAP)[16]. The NBIO Roadmap will assist in making comprehensive progress in biodiversity informatics ensuring that new investments will be scientifically, ecologically, socially and financially relevant (National Biodiversity Information Outlook, 2012[17]).

The development of the InBIF is an extremely important step to bridge the science-policy interface at the national level in India. The national InBIF- initiative aims to increase the value of nationally collected primary data by making them available through a web- portal for search, access and use. The data portal is not yet realized because of inadequate funding. One of the major challenges identified so far is how to motivate the national data stakeholders to contribute with data into InBIF. Issues such as how to credit contributing data owners and how to secure their intellectual property rights to their data must be addressed in a proper manner.

[16] http://envfor.nic.in/division/national-biodiversity-action-plan-nbap
[17] http://nbaindia.org/blog/532/1/NationalBiodiversity.html

The IPBES- stakeholders have emphasized that IPBES preferably should collaborate with a global existing initiative to avoid duplication of work. GBIF is a key global science organization, which enables free and open access to biodiversity data online to support scientific research and decision-making processes, and includes strong elements of capacity building including access to tools, guidance, data and support. GBIF has over recent years developed consistent institutional networks, tools for data sharing, training programs and methods of capacity building. The GBIF Secretariat in Copenhagen (Denmark) has supported this pilot project with guidance about international data standards, training and capacity building on Biodiversity Informatics. In addition, all the project partners are involved in several national and international eInfrastructure projects focusing on capacity building in biodiversity informatics. The total experiences acquired through the collaboration with GBIF and these initiatives represent important synergies for current and future collaborative initiatives.

This approach is highly recommended in the Global Biodiversity Informatics Outlook (GBIO)[18]. Coordinated funding and improved interaction of initiatives and projects are really needed in order to avoid duplicated efforts and investments. Several important focal areas and action components were identified by GBIO in order to coordinate future efforts and funding and to enable improved interaction of initiatives and projects. Figure 2 below illustrates the focal areas, action components and their current progress.

Figure 2: The GBIO Framework

18 http://www.biodiversityinformatics.org/

The national GBIF nodes at WII and NHM promote, coordinate and facilitate the mobilization and use of biodiversity data among the relevant stakeholders within their domains, primarily to address the stakeholder's information needs with relevant actions. At the national level, this should be within the context of implementing relevant national legislation and institutional mandates. The nodes also serves as communication gateways among the participating institutions and the GBIF secretariat, contributing to and benefitting from the services, infrastructure and capacity brokered and provided by the GBIF secretariat. This approach enables the effective consoled action of GBIF as a truly global, decentralized network of networks.

NINA, NBIC and NHM participates in the development of the European LifeWatch Infrastructure[19], and coordinate the initial establishment of a LifeWatch Infrastructure both at Norwegian and Nordic level. NBIC, NINA and the Natural History Museum in Oslo also participates in the EUBON- project (European Biodiversity Observation Network)[20] in an innovative approach towards integration of biodiversity information systems from on-ground to remote sensing data, for addressing policy and information needs in a timely and customized manner. NBIC also cooperates with the International Union for Conservation of Nature (IUCN)[21] and works with implementation of the Infrastructure for Spatial Information in the European community (INSPIRE)[22] in Norway.

As shown above both WII, NINA, NBIC and NHM have active roles in several national and international initiatives on eInfrastructure development and capacity building. The outcomes of these activities highly support the capacity building intention of this IPBES pilot project.

[19] http://www.lifewatch.eu
[20] http://www.eubon.eu/
[21] http://www.iucn.org/
[22] http://inspire.ec.europa.eu/

3 A short introduction to camera trapping

Camera trapping refers to the use of remotely triggered cameras that automatically take images of whatever moves in front of them (Rovero et al., 2010). This method is most often used to capture images of medium to large sized terrestrial mammals and birds, but has also been used for arboreal mammals (e.g., Oliveira-Santos et al., 2008) and other non-mammalian groups. The use of camera traps in wildlife monitoring, research and management has escalated rapidly in the last ten years and camera trapping methodology has undergone significant and rapid advances over this time (O'Connell et al., 2011; Meek et al., 2012).

Biologists have used camera traps for over 100 years. They have proven to be a useful tool, complementing other methods for determining species richness and diversity. They provide a non-invasive method for detecting rare, shy and cryptic species, as well as for identifying species that cannot easily be distinguished from tracks or other sign. Camera traps can also be used to monitor wildlife use of key resources such as salt licks, ponds, and fruiting trees. When instrumented to operate 24 hours a day, they provide important information on habitat use, behavior and activity patterns. Nevertheless, perhaps the most novel application of camera traps has been to generate information on abundance and population density, in particular applying capture-recapture analytical methods (O'Connell et al. 2011).

3.1 Methodology

Before beginning any research project, investigators should have a clear idea of what information they need to help them address their primary conservation issue or question. Before investing in a photographic recapture survey, researchers should be certain that abundance or density is a quantity that will really be of use to them. To carry out an abundance estimate based upon photograph/re-photograph ratios (hereafter referred to as 'camera trap estimates') the research team must have certain information and equipment.

<u>Minimal requirements</u>:
1. Maps or geographic knowledge of the study area.
2. Access to the study area and a means of traveling throughout the study area.
3. A rudimentary idea as to the topographic features of areas inhabited or sites visited by the study animal and their travel routes.
4. Enough people familiar with the function and maintenance of camera traps to deploy and monitor the traps in a timely fashion.
5. A sufficient number of camera traps to photograph (i.e., "capture") enough individuals of the target species to generate a statistical estimate of abundance. If a rigorous population estimate is the objective, this is a serious requirement for reasons elaborated in following sections.

<u>Additionally, it helps to have</u>:
1. Someone with a high degree of familiarity with the study area.
2. Existing trails or roads to facilitate access to the study area.
3. Extra camera traps to act as replacements in the event of equipment failure.
4. A thumbnail estimate of expected capture rates for the target species.
5. Rough estimates of home range size and life history information.
6. Hand-held GPS units.
7. In a human dominated landscape, to have a dialogue with the local people before camera traps are set in their areas. Field experience show that theft is reduced and that the locals are less suspicious to what an outsider is doing.

3.2 Choosing the right camera trap model

It is essential that the right camera trap type is chosen to ensure that the resulting data is fit for the intended use. With the rapidly growing number of camera trap models available, and rapidly changing technology, choosing the right model can often be difficult.

The criteria that should be included are the trigger mechanism (active or passive), the trigger speed, the type of flash (infrared or incandescent), the camera technology (film or digital, and the mode – still, video, time-lapse), as well as battery life and cost

The trigger mechanism (active and passive sensors)
Most camera traps are triggered by an infrared sensor detecting a moving object that is warmer than the ambient temperature, such as animals, people, or even vehicles passing in front of them.

- Passive infrared sensors detect heat-in-motion; the sensor triggers the image-recording device (henceforth called the 'camera') when something warmer than the ambient temperature passes in front of the sensor. Most commercially available cameras use passive sensors. Whilst well suited to studies of birds and mammals, these camera traps would be less effective at detecting reptiles, because their body temperature is close to the ambient temperature. Because passive sensors respond to heat, these camera traps should not be positioned where there is direct sunlight, as this creates convection waves that could trigger the sensor resulting in empty or 'ghost' images.

- Active infrared sensors are similar to garage door sensors and consist of two components: A transmitter and a receiver. The transmitter emits a beam of light, typically red, that is detected some distance away by a second component referred to as the receiver. When a passing animal breaks the beam of light, the detector unit triggers the camera to take a picture. Active sensors detect objects within a detection zone (or 'opportunity cone'). The apex of the zone starts at the small sensor within the camera trap and expands outward from the camera trap in a circle. The detection zone increases with the distance from the sensor but is still much smaller in area or cross-section than the field of view of the camera. As a consequence, the position of the animal in the photo depends on factors such as: (a) the size of the detection zone (which is influenced by how close the camera is to the animal), (b) the trigger speed (the length of time between the sensor detecting the object and the camera recording a picture), and (c) the speed at which the passing animal is moving (Rovero *et al.,* 2010).

The main advantage of the passive sensor system is that camera traps are designed as a single unit that can be very small and easy to set. Active sensor camera trap systems consist of two or more units and so might be more difficult to position (figure 3 below).

Although active camera traps are employed less frequently than passive camera traps, there are some clear advantages: (1) the beam is typically very narrow so that the subject's position along the beam can be more precisely anticipated; (2) the camera can be placed independently of the sensor and detector allowing for creative photographs (3) Ambient heating is not a problem for active sensor systems because the light beam remains unbroken by convection waves - however, something like a falling leaf can break the beam and cause the camera to record a picture.

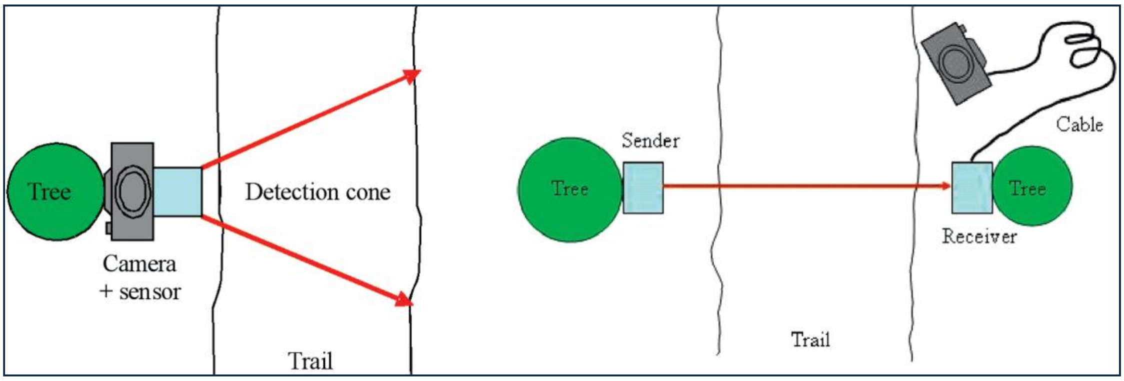

Figure 3: Schematic illustration of Passive sensors (left) and Active sensors (right) camera trap systems (from Rovero, et al., 2010)

Trigger speed
The trigger speed (the time between detection of the animal and shutter-release) must be carefully selected to suit the target animals, the type of study and physical aspects of the camera trap location. Fast trigger speed is usually preferred for faunal inventories because there may be very few chances to record rare or elusive species. Camera traps set along trails require a faster trigger speed, because animals may pass through the frame quickly, whereas camera traps set at locations such as mineral licks, baited stations, by waterholes or under fruit trees can be slower since the animal is likely to stay in the area longer and pause in front of the camera trap. Trigger speed is often slow in less expensive digital cameras, where it can exceed 2 seconds, resulting in many empty photographs.

Sensor system	Advantages	Disadvantages
Passive sensor	➢ Comprises a single unit, so easier to set up ➢ Detects animals of a wide range of sizes	➢ Placing the animal in the centre of the frame may be difficult ➢ Can be triggered falsely by heat from the sun, which makes locating the traps difficult
Active sensor	➢ Positioning the subject is more precise ➢ Not activated by heat from the sun	➢ Made of 2 or 3 units, so is more complex to position and programme ➢ More expensive

Table 1: Main advantages and disadvantages of different sensor systems in camera traps

Types of flash
Cameras with an infrared flash use arrays of LED lights that emit infrared light. Images taken with an infrared flash are often in the grey-scale or may be tinged reddish pink. Infrared flash is less noticeable by passing animals, uses less energy and is usually associated with quicker shutter speeds, but it may be difficult to identify the animal or to detect details of markings in the images, due to the lack of color and lack of sharpness in the images.

Incandescent (or white) flash uses xenon gas technology, which enables taking clear, color images by day or by night. White flash tends to be very bright but brief, uses more energy and is associated with slower shutter speeds. It is well suited to studies where detailed coloration or marking needs to be visible, but has the disadvantage that it might frighten or disturb passing animals, thus influencing their behavior. There are various 'tricks' one can use to minimize the disturbance caused by the flash, without compromising the images taken (see Meek *et al.,* 2012).

Camera trap technology

Film and digital cameras

Cameras that use 35 mm film were the standard tool used by researchers working with camera traps in the previous decade. Over the last few years however, digital cameras have become readily available and widely used, and only a few manufacturers still make film camera traps. Despite this trend, film camera traps might not be replaced altogether and for this reason, they are still referred to in this guide. Earlier digital camera trap models copied the design of film camera traps with a standard digital camera connected to the motion sensor. Modern digital camera traps usually consist of a camera and sensor integrated on a single board.

The biggest advantage of digital over film camera traps is that they can store thousands of images on a memory card. This means that cameras can be left in the field for a much longer period without the need for checking them. In addition, images can be viewed immediately in the field whereas film must first be developed. Data management is more easily achieved with digital photographs that avoid the necessity of scanning film.

Camera trap technology	Advantages	Disadvantages
Film camera	➢ Fast trigger speed (mostly) ➢ Low power requirements	➢ Very few models still available ➢ Must be checked often as film fills up quickly ➢ All photos must be developed before selection can be made, and have to be converted to digital formats for capturing on databases
Digital camera	➢ Can store many images ➢ Easy to delete unwanted or unusable images ➢ Digital images easier to manage	➢ Slower trigger speeds (generally) ➢ High per-day power requirements
Digital camera with infrared flesh	➢ Animals less frightened by flash ➢ Much lower power consumption	➢ Night photos are in black and white only, making identification difficult ➢ Difficult to recognize coat patterns
Digital camera with white flash	➢ Clear, color images by day or night	➢ Uses more power ➢ Animals may be frightened or their behavior affected by bright flash

Table 2: Comparison of camera trap technologies

Still, video and time-lapse capabilities

Other features of the camera trap that might be important are whether it takes still images only, or whether it has video or time-lapse capabilities. A video function can be useful for behavioral studies, although camera traps with a video function usually use more batteries; it may be worth considering if a sequence of still shots would suffice. Some camera traps may also have time-lapse functionality. This allows the operator to determine times at which the camera will be inactive, regardless of animal activity within the detection zone. Some cameras with infrared sensors have a dual functionality and can be set to lime-lapse, but others have no sensors and can be used only as time-lapse devices.

Battery life

Battery life varies greatly among camera trap models - some last a few weeks, but others run for two months or more and can take thousands of photographs. Battery life decreases with the number of photographs taken and cameras with an infrared flash usually have longer battery life than models with a regular flash. Weather conditions (e.g. low temperatures) can also affect the performance of batteries. To conserve power, some digital cameras go into a sleep mode after a certain amount of time, which can greatly increase the time it takes them to take the first picture. It is advisable to test the performance of the camera trap using different batteries in the setting it will be used, before investing in a large number of them.

It is wisest to use the battery type that is recommended by the manufacturer of the camera trap model in use. Most models use either lithium, NiMH (nickel metal anhydride - rechargeable) or alkaline batteries. These have different properties (cost, life and how they are affected by heat or cold) that are compared in detail in Meek *et al.,* 2012. Some camera trap models have an option for connection to an external battery or solar panel.

Cost of camera traps

The cost of camera traps ranges widely from about US$ 120 for a bottom-end model (e.g. a Primos Truth Cam 35), through to about US$ 550 for a mid-range model (e.g. a Reconyx HC500 or Scoutguard SG560) and US$ 1050 for a top-end model (e.g. a PixController Digital Eye) - see Meek *et al.,* 2012, for a detailed comparison of costs. Choice of camera trap models depends on the number of units needed and the total budget. Because performance and characteristics vary between models, cost should not be the only criterion by which to choose camera traps (Meek *et al*., 2012) – the cash savings you make by buying a cheaper model, may carry high costs in terms of poor quality images, or data that is unsuited for the particular study.

It is recommended that five variables are considered to assess cost-effectiveness of camera trap models: (1) the cost of the camera traps (including batteries), (2) the costs of field visits to the camera traps for battery/film replacement, (3) duration of the survey, (4) the number of images taken per unit time, and (5) the resolution and quality of the images captured (Rovero *et al*., 2010). The use of high quality, rechargeable batteries is a cost-saving strategy if the camera trapping survey is intended to run more than a few months, as the higher cost of rechargeable batteries is recovered. Similarly, if visiting the camera traps is expensive, then more expensive camera traps that have longer battery life will minimize the total costs. Less expensive camera trap models almost invariably are ruined sooner by moisture; their slow trigger speed will result in fewer photographs and a greater number of animals missed, and poor resolution results in poor images.

Summary of points to consider in choosing camera traps that best suit the study

Camera traps should be purpose-bought – do not buy any equipment before you have defined a purpose and a rigorous method that can be followed to achieve an empirical outcome. Table 3, below, summarizes the key aspects of a study that should be considered and the camera features that are best suited to them.

Issue or question	**Camera trap features to consider**
Is the study species easy or difficult to differentiate from others in the survey area?	• Color images will help with identification, but infrared flash that results in black and white images will impede identification • Video records of behavior may help with identification

Do you need to identify specific (individual) animals?	• Color images will assist with identification of markings, so use incandescent flash (takes color day and night)
How big or small is the animal?	• Images of small animals may be over-exposed if the camera is set too close • A wide detection zone is best for larger animals (e.g. deer size and up)
Is the animal fast moving or hard to detect (e.g. flying animals)?	• for fast moving (e.g. flying) animals, use camera traps with fast trigger speed, fast recovery time and wide detection zone; this will ensure rapid firing and multiple photos
Is the animal nocturnal or diurnal?	• Flash-type is important • Color images are preferable (especially for nocturnal animals) • High-trigger speed is needed at night • Passive or active infrared needs consideration
Is the animal easily frightened/disturbed?	• Incandescent flash will spook some animals (though infrared is still detectable)
Do you want to study behavior?	• Infrared flash with additional video options are best
Do you want to identify species or make inventories?	• Video facilities are unnecessary
Is the study short or long-term	• Battery life and power-demand of the camera trap are critically important; for longer-term studies use batteries with greater power output and longer life, and check them more often

Table 3: Camera trap features best suited to different types of study (adapted from Meek et al., 2012)

3.3 Setting up camera traps

Inspect the area for optimal camera trap placement
To maximize trapping success, cameras should ideally be placed in areas that maximize the visitation by species of interest. Different species use trails differently (Harmsen et al. 2010[23]). Camera traps are often best set along trails. Knowledge of signs of wildlife presence and spots where the species of interest frequently pass can be of great help when choosing camera trap locations. Prior to placing camera traps, inspect the area selected for monitoring for at least 30 days to identify all locations that show preferential usage by the target animals. Using a GPS unit, record and map the identified locations.

[23] https://www.panthera.org/sites/default/files/differentialuseoftrails_Harmsen_foster_silver_ostro_doncaster_2010.pdf

Choose locations for camera traps
Drawing on information gathered in 3.3.1, select camera trap locations that provide optimal opportunities for recording focal species and that adequately cover the home range of the target animals. It is difficult to provide any general rules of thumb regarding the optimal location of cameras as this will be influenced by the purpose of the study and the type of animal. It is also important to consider the safety of the camera traps – if possible, camera traps should be located where the likelihood of tampering, vandalism or theft is very low and where the behavior of the animals themselves is unlikely to dislodge or damage the instruments. In places of high risk, we suggest locking camera traps to a tree or post. Most models provide cables that can be locked and custom-built metal boxes in which the camera can be secured.

Place camera traps.
Camera traps are usually placed in pairs at each of the locations identified in 3.3.2 - in some studies, depending on the target animals and the nature of the investigation, single cameras at each camera trapping station may suffice. The height at which the camera is set, will depend on what is available, and on the size of the animal being photographed. For general purposes, place camera traps approximately 50 – 100 cm above and parallel to the ground on a tree, rock, or wooden stake — this height can be adjusted depending on the size of the target species (e.g. for small animals like rodents, a height of 20 cm is best, but for larger animals, 100 cm or greater would be appropriate). Set pairs of camera traps to face each other, at a distance of between 4 and 5 m, so that both sides of an individual will be photographed when the trap is triggered — this facilitates identification of individuals (Karanth & Nichols 2002; Trolle & Kéry, 2003). It is common practice to offset the cameras slightly to avoid the flash from one interfering with the other. Do not set the cameras too close to the point of detection (the "aim") - if it is too close to the animal, the images may be blurry or washed out (Meek *et al*., 2012).

Camera traps are usually set perpendicular to the trail to obtain a good side image of the passing animal; however, they can also be placed slightly off perpendicular (i.e. about 60° between camera trap and trail) to increase the path length the subject will take through the frame (Rovero *et al*., 2010). This can be useful on very narrow trails or with camera models that have slower trigger times. Some practitioners (Meek *et al*., 2012) favor setting the cameras at a 45-degree angle to the trail as this increases the chance of detecting the animals and decreases the blind spot that some cameras have in the middle of the lens when the animal approaches directly from the front. We recommend some testing with the camera trap to determine the detection zone. This is especially easy with digital models, but even film models often have a sensor test mode (e.g. a flashing red) that allows testing of the detection zone. Some of the issues relating to placement of camera traps are illustrated in Figure 4 below.

It is important that the location of the camera traps provide optimal opportunities for photographing, without causing undue disturbance to the animal. Some practitioners recommend that the ground in front of the camera trap should be kept clear of debris and tall vegetation, as failure to do so may result in the animal being obscured or the flash might be reflected — this results in over-exposed images or, for some cameras, false triggering of the sensor. In areas that have rapidly growing vegetation or accumulating snow it is necessary to check the site frequently to ensure the camera is not obscured. It should be noted that clearing may result in avoidance of the area by some animals (Pandav, personal comment 2012), and some compromise may have to be sought.

As shown in Figure 3 below, obstacles such as branches can be used to guide the animal's path. A scent or bait lure can be used to attract passing wildlife to the camera trap and to position the subject in the ideal place for a photograph. This allows extra times for the camera trap to obtain a good photograph and many lures have been developed that are especially useful for carnivores (Trolle & Kery, 2005; Long *et al*., 2007).

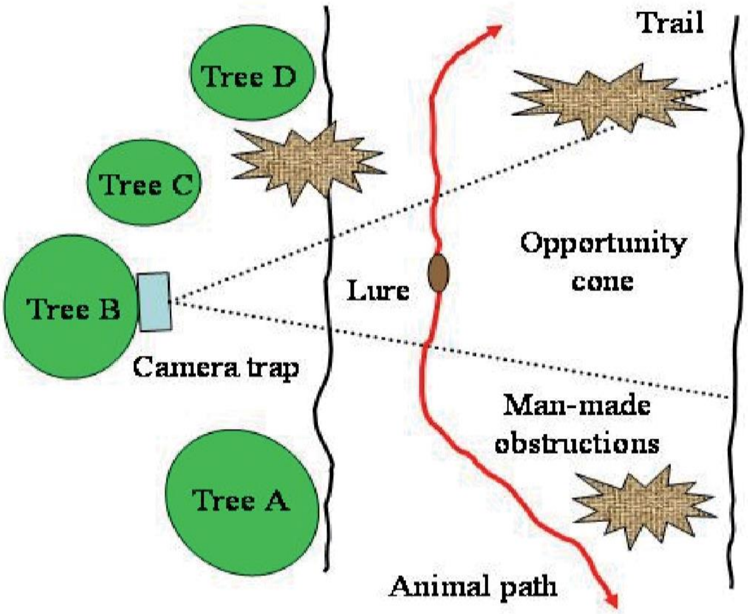

Figure 4: Factors that need to be considered when placing camera traps in the field. In this figure, beside a suspected animal trail are four trees A-D. Trees A and D are too close to the trail for the camera

3.4 Configure camera traps

Configuring the camera traps involves preparing, testing and coding the cameras before deployment; setting the sensors, date, time and time interval; and recording the camera trap data.

Prepare and test cameras
All cameras should be prepared and tested before going to the field so that they simply need to be activated once set up in the field. Make sure you have read the user manual for your camera trap and follow the instructions carefully. Check the proper functioning of the sensor and camera by taking test pictures. Carefully inspect all seals to ensure there are no leaks. Dirt on the seal allows water to enter so camera traps should also be as dust-proof as possible.

Coding
Each camera trap must be uniquely numbered, or coded, for identification purposes. Write the code with a permanent marker on the housing of each camera trap. Some digital camera traps allow printing the code automatically at the bottom of each photograph. If this is not an option then taking a picture of a whiteboard showing the camera trap code with the date and time is a useful technique. For film cameras, this allows identification of rolls of film from the first picture. Write the camera trap code, and start and end date on the outside of the film roll to easily track film from the field to development.

Setting the date and time
Make sure that the date and time are carefully set on each camera, using the 24- hour clock, and re- check the date in the field when installing the camera trap.

Setting the sensor(s)
Sensor sensitivity is a critical setting, especially in some passive-sensor camera traps, in which it is easy to set it too low or too high. We recommend higher sensitivity when working in hot climates and when small species are the targets.

Setting the time interval

For most camera trap models, the *time interval between consecutive* photos must be chosen. For normal use, set camera traps to run continuously with a 1 - 2 minute delay between photos. Please note that the time interval must be adapted for the type of animal being studied. For each pair of camera traps, be careful to ensure that the two cameras do not fire simultaneously (this will cause over-exposure). For some applications, it may be desirable to record sequences of images with shorter delays. For example, if the goal is to detect reproductive events among carnivores, it is likely that the mother will pass by first, followed immediately by the young, thus requiring a minimal time delay between images. Many of the modern digital camera traps allow for this type of setting, and with large SD cards, there is little danger of the memory being over-filled.

Testing camera traps

Once the camera traps are configured, test each pair of camera traps by sitting between them and displaying the location number as the cameras take a picture. This dual purpose test demonstrates that cameras are properly set, and causes the trap location to be recorded, so that there is no question as to the origin of the images.

Recording the camera trap data

The images captured by the camera trap will be useless without supporting site data. For each camera trap (or pair of traps), it is recommended that data are recorded to reflect: Deployment information (camera code, position, time and day of camera trap activation and by whom, any other useful information such as weather conditions); monitoring information (battery type and dates they were changed; film/card type, dates changed and by whom; any notes relating to signs of animal activity, human interference and so on); and site information (the site name, GPS location, camera code, a description of the habitat, distance to the next nearest camera trapping site or proximity to human habitation, signs of animal activity, and so on). To assign a site code, assign each camera trap location its own number and assign letters A and B to the cameras in each pair. Ideally, this information should be recorded on pre-configured datasheets, of the type shown in Table 4 below. You may choose to have different data sheets for the different categories of information (deployment, monitoring and site), or you could combine it all on one sheet, as in the example shown.

Site code:	Date set:	Date retrieved:
Name(s) of recorder (s):	Location:	
Location description		
GPS coordinates	E	N
Other location information	Proximity to next nearest camera trap:	Proximity to human settlement:
General habitat description:		
Habitat types:[customize for location]	Type a:	Type b:
Type c:	Type e:	Type f:
Camera details		
Camera type:	Camera code(s)	Camera direction:
Camera height:	Battery types:	Battery replacement date(s):
Card/film replacement date:	Card/film type:	Number of images:
Lure/Bait		
Yes/no:	Type:	Distance to lure/bait:
Other notes:		

Table 4: Example of a camera trapping data sheet showing the categories of information that should ideally be recorded. This example is adapted from those in other published sources, and is intended to serve as an example that could be customized for a specific project.

4 Management of camera trap data and objects

Camera trapping can, potentially, generate many thousands of images, especially in long- term studies. Sorting, storing and managing the images and their associated data is, therefore, an important issue, but the different approaches used by the different camera trapping projects are varied, with no commonly accepted standards. This makes data archiving, sharing and access difficult (Meek, *et al*., 2012 & Morris *et al.,* 2013). In this section, we recommend best practices that can help overcome this problem. A generic workflow associated with the collection, storage and management of camera trap data is illustrated below in Figure 5 below.

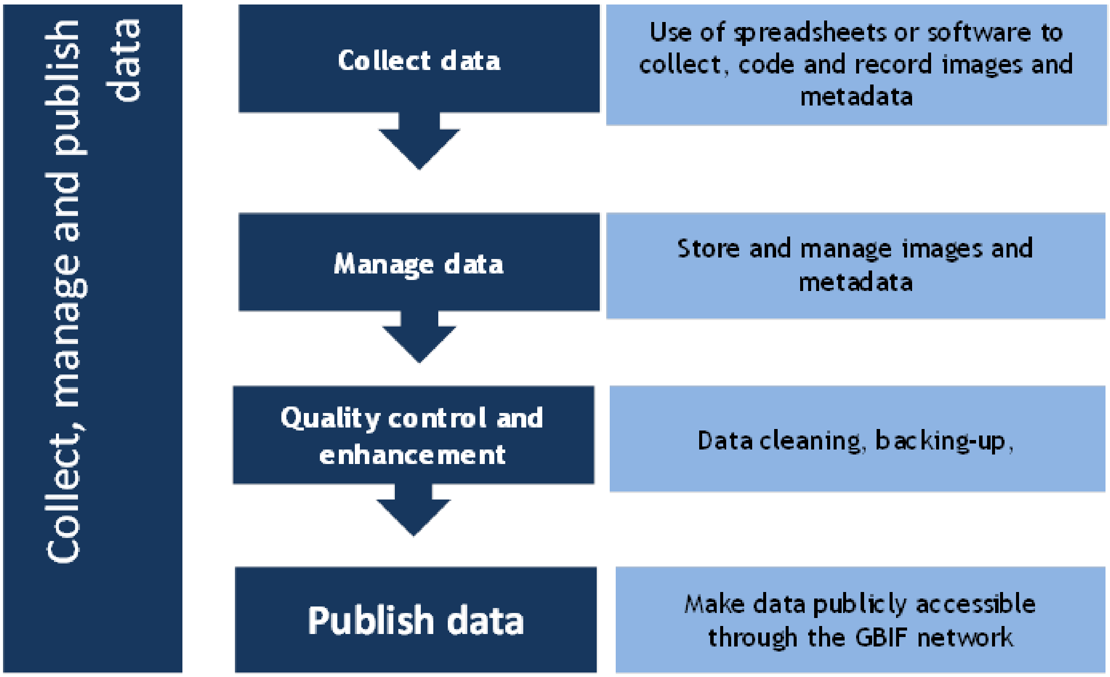

Figure 5: Workflow for collecting, managing and publishing camera trap data

4.1 Generating or collecting data

Once the camera traps have been set-up and configured the next step in the workflow is the collection of the camera trap data (see Figure 4 above) – this includes both the images taken and their associated metadata (information about the images). Data collection or data creation (also called "sampling effort") will differ slightly depending on the type of camera technology in use (analogue or digital).

Working with analogue cameras
Film camera traps may need to be checked as often as every one to two weeks to make sure they do not run out of film. If at least one of the cameras at a camera trap location has taken more than 18 photographs, exchange the film in both of the camera traps at that site at the same time. Otherwise, change film monthly in all cameras to avoid moisture damage. The film will need to be processed and the analogue images digitized. Once the images have been stored electronically, the data management practices will be the same as for working with digital cameras.

Working with digital cameras
Monitor and adjust camera traps regularly during the sampling effort at intervals appropriate to the animals being studied and the nature of the investigation. The time interval at which camera traps are checked also depends on the battery life and storage capacity of the camera trap

model, the expected number of photographs as well as accessibility. If cameras are taking excessive numbers of photographs of the same individuals (as often happens with animals like peccaries or large terrestrial birds), the delay between trigger intervals can be increased.

Digital camera traps can store many more images than film models, but their autonomy depends on the battery life: Most models can run for up to one month and those using an infrared flash can run for up to 2 months and store thousands of images. Camera traps will still need to be checked regularly (at least once every three to four weeks and in some cases even more often) to detect camera traps that have been moved by animals or that have developed problems of some kind. When checking camera traps, the following data should be recorded: Number of photographs, whether film or batteries have to be changed, battery level as well as any observations about the camera (See table 4). This can help estimating average battery life and, in cases in which cameras have stopped working, can be used to work out when the camera failed. If possible, one or two spare camera traps should be taken to replace camera traps that have stopped working. We also recommend checking the date and time setting of each camera trap each time the camera trap is visited. Collect and replace memory cards from digital cameras and download the images onto a suitable image-viewing device (laptop or Cuddeviewer). Be sure to record the day and time each card was retrieved.

4.2 Image coding

Each camera trap can, potentially, capture many hundreds of images. To facilitate quick identification and sorting of images, a file name (or unique identifier) should be assigned using *a consistent format*. The file name, or unique identifier should contain the symbols, numbers or letters to denote the following: Geographic location, Camera trap code, Date and time of collection, Sequential photo number and The object in the image.

Example from Sanderson, 2004: Assign file names to images using the following format: XXXXXIDxNNddmmyyyyhhmm.jpg where “XXXXX” is the field station acronym, “IDx” identifies the camera (ID is the camera trap number; x is A or B, referring to each camera in the pair), NN is the species number on the Excel spreadsheet, “dd” is the day, “mm” is the month, “yyyy” is the year, “hh” is the hour, and “mm” is the minute (see Table 5 below).

Component in file name	**Meaning**
XXXXX	Station acronym
IDx	Identifies the camera, ID is the camera trap camera number, x is A or B referring to each camera in the pair
NN	Species number on the Excel spreadsheet
DD	Day
MM	Month
YYYY	Year
Hh	Hour
Mm	Minute

Table 5: Scheme for naming multimedia objects using the method developed by the TEAM group (from Sanderson, 2004).

Researchers working in India have assigned filenames using a string that serves as a unique identifier. All file name components (e.g. for the file name **CTP050612011001A00049a**) is provided in Table 6 below.

Component in file name	Meaning
CTP	Refers to the definition of the dataset, i.e. camera trap photographs
05	State code, in this case for Uttarakhand from Census of India
061	District code, for Pauri from Census of India
2011	Year in which photograph was captured
001A	Alpha-numeric code for the camera trap ID; the first three digits refer to the trap number, and A/B is added as a suffix since camera traps are often deployed in pairs facing each other at each location
00049	Refers to the sequential photo-capture number (nth capture) obtained at a particular camera
a	The lower case "a" helps distinguish between multiple objects in the same photograph; if there was a second animal in the same photograph, the same photograph needs to be entered again in the data sheet template with the unique identifier **CTP050612011001A00049b**, and so on.

Table 6: Components in file name

4.3 Record the data on the datasheets and enter the data

Two data forms (set up as Excel spreadsheets) should be used - the first is the summary data form for all camera trap locations (table 4 above), and the second is a record of each photograph taken by each camera (table 5 above). Data forms can be generated using readily available and easy-to-use software such as e.g. Microsoft Excel.

The data sheets should essentially include all information that could be extracted from the camera trap image, such as date, time, species, GPS location of the site and other biological information (age-sex classification, number of individuals, reproductive status etc.) depending on the objectives of the study. For instance, in most studies estimating density of species using photographic capture-recapture frameworks, each photograph is assigned an individual identification based on pelage patterns and this could be entered here.

4.4 Image and image data management

It is important that the camera trap data are well organized during all parts of the study to avoid confusion and possible data loss. Data sorting requires that each photograph have at least the following information: (1) date, (2) time, and (3) camera trap site code. While the date and time is usually captured on each image, only some digital camera traps allow imprinting the camera trap code on each photograph. For other camera traps, the camera trap code must be tracked throughout the study. Hence we recommend taking a picture of a whiteboard with the camera code, date, and time when setting up the camera trap, and when changing film or the memory card so that the first and last picture on each roll or memory card contains the proper information. We also recommend writing the code as well as the start and end date on each roll of film.

To manage photographs from film camera traps, several options are available. One option is to print contact sheets with all photographs shown as thumbnails, and then only the photos of interest are printed, digitized and archived. The camera trap code should be entered either as part of the folder name or in a text file in each folder.

Digital images are usually stored in common file formats such as TIFF, JPEG, PSD or, sometimes, RAW files. While the photographs constitute the raw data, the information about them must be organized in a spreadsheet or database for analysis. The minimum data that must be recorded for each photograph is the code of camera trap that took it, the date and time, and the species that appears in the photograph. Additional information that can be useful is the sex and age of the animal, the number of individuals and comments on the behavior shown.

Spreadsheet applications (e.g. Microsoft Excel) are still the most commonly used software for managing camera trap data. While they are simple to use, their main disadvantage is that reorganizing data for different analyses can be time consuming. A more flexible alternative is the use of either relational databases in the form of desktop applications (e.g. Microsoft Access, Filemaker) or database servers (e.g. MySQL, SQL Server). In most cases, the former will be easier to use since they include tools for building forms and queries, but the latter might be useful when data is being used and managed by a group of people and must be stored on a central server. Database systems allow images to be linked to the data and all data to be managed in a single system. Dual-screen computer systems make data entry and management easier and there are many specialist programmes available for working with camera trap images (for example MapView[24], DeskTeam[25]; CameraBase 1.5.1[26] – see Meek *et al*., 2012 for a comprehensive summary). CameraBase is a free software for managing camera trap data. CameraBase is based on Microsoft Access and can manage camera trap data together with the digital images. The software has a wide range of analysis and data-export options built-in, including activity patterns, capture-recapture analysis, occupancy analysis, and species accumulation and richness estimation. It is very important that the image collection is backed-up. Special digital asset management systems (DAM)[27] can also be used for managing images. The cheapest and easiest way to manage images, however, is to use a Microsoft Excel or Access-based database, and for the bulk of users, this will be the most cost-effective method.

4.5 Quality control and quality enhancement

Care should be taken to record all data carefully. The genus, species, date, and time of each photograph must be verifiable if the data are to be analyzed properly - this means that the collection and management of metadata is a critically important part of the survey.

It is important to record the total number of photographs taken, but before data analysis begins, the data can be cleansed by removing those images that are superfluous or of poor quality – this includes those that are taken during camera set-up and retrieval and any images that are of poor resolution, or empty images. Original camera trap images may also be edited or modified in various ways to enhance the quality. These edits may include altering the resolution, brightness, contrast, zooming in, cropping the image to focus on the biodiversity object.

4.6 Management of camera trap objects

Preserving original camera trap objects

The original camera trap image should be renamed using a persistent identifier and stored in a folder containing all images captured in a sampling session. These images can be provided in the desired resolution (high, medium, low) and linked to the thumbnails provided on the data

[24] http://www.reconyx.com/page.php?id=121
[25] http://www.findbestopensource.com/product/deskteam
[26] http://www.atrium-biodiversity.org/tools/camerabase/
[27] http://www.capterra.com/digital-asset-management-software

portal. Management of multiple access points and the capacity to return the image in different forms and resolutions is essential.

Enhancing quality of camera trap objects
If any images have been enhanced or modified by cropping or "retouching", or have been edited in any way, this needs to be described in detail and captured in the Metadata datasheet. It is important that the methodology used as well as how and when it might have been changed or edited is reflected.

Generating "child" objects from "parent" objects
The original camera trap image may be cropped if required to describe sub-parts of the image and "child" objects can be generated in the process. For instance, a camera trap image may include two tigers. So, the image may be cropped so that each tiger can be treated as an individual object with a unique record in the database. This is illustrated in Figure 6 below.

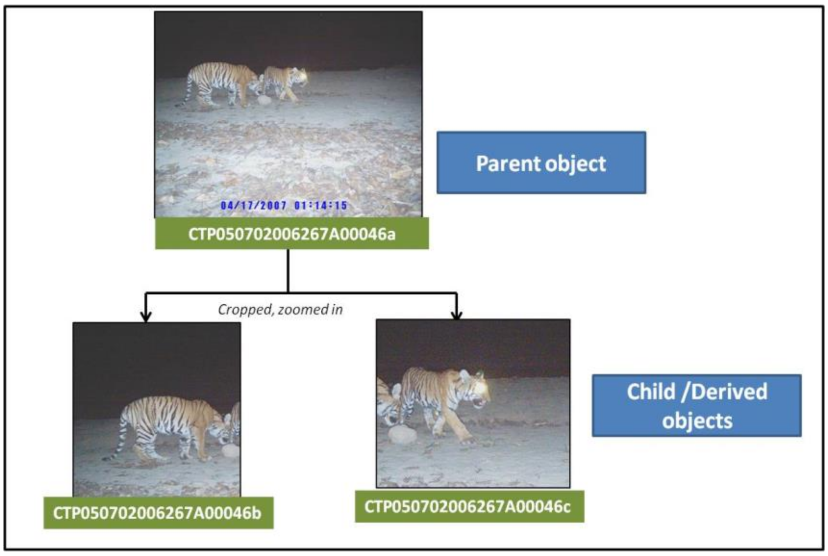

Figure 6: Creating child objects form a parent image

Persistent identifiers and naming conventions for parent, child and derived objects
In cases when a child or derived object is generated to describe sub-parts of the camera- trap image, the object should have a suffix "b"/"c" at the end of the unique identifier against "a" for the parent object.

Establishing links between parent, child and/or derived objects
In cases when a child object is generated to describe sub-parts of the camera trap image, it may be linked to the parent image by following the guidelines given below:

- The parent object should have a suffix "a" at the end of unique "identifier" and the "identifier" of the child/derived object should have a suffix "b"/"c" onwards. Other digits in the unique identifier remain unchanged.
- The parent object must mention the child object under the field "Associated Specimen Reference" in the datasheet and *vice versa*.

Conventions and best practices for data management
In choosing a data management system, it is important to bear the following in mind:
- It is essential to have a well-defined procedure in place from the start so that users end up with data that can be effectively analyzed and managed using the preferred management tools

- The data management system selected should, so far as possible, make use of freeware or cheap, well-established and readily available software, to reduce investment costs and to avoid possible disruptions caused by problems with very specialized software (especially if the IT capacity available to you is relatively low)
- The learning curve for data management and processing should not be too demanding; the ease with which researchers can integrate the requirements of the data management system into their existing ways of working will influence how effectively it is taken up.
- The data should be stored and managed in a way that makes it easily exchangeable with other systems.

Many valuable multimedia resources exist that have no information stored in databases. Some may have a web presence and others not. Even those available online may not be adequately discovered by search engines, or may be lost in the noise of images from unreliable sources. Image repositories are very diverse systems and what is needed is an infrastructure that can: (i) leverage such collections for scientific analysis, (ii) facilitate free and open access to the data, and (iii) assist in better management of these resources (Morris *et al*., 2013).

5 Open access: Barriers and needed actions

Data sharing and open access to publicly funded data is on the political agenda worldwide. The following sections are entirely based on an unpublished international literature review (Hanssen and Heggberget et.al, 2014) made by the Nordic LifeWatch pilot project coordinated by the Norwegian Institute for Nature Research (with support from GBIF) on request from the Nordic Research Council NORDFORSK[28].

5.1 Technology, standards and financial framework

Infrastructure shortcomings, capacity limitations, inadequate competence and lack of funding often represent barriers for making publicly funded data openly accessible. Harmonizing technology and databases towards interoperable data protocols is a practical issue, though highly influenced by the institutional priorities, in-house ICT-competence and financial capacity. Many institutions would like to share data, but lack the ability to prioritize it, and in the longer run, to realize it. Making data available is a very important effort, but to ensure that this work does not depress institutional research activities, national authorities should target specific capacity building programmes towards the institutions.

5.2 Institutional culture and individual researcher attitudes

Conflicting informal agendas both within and between research institutions will always influence the actual data sharing ability. Such agendas represent potential barriers for sharing of publicly funded data. Institutions should therefore be obligated to develop strict data policy strategies in order to prevent such barriers from evolving.

Metadata is crucial for data documentation and data reuse. There are several standards for metadata reporting but these are often too comprehensive and complicated to use, resulting in a very time-consuming metadata mapping. This problem has been reported from several international research projects (Schmidt- Kloiber *et al*. 2013). The reluctance to report metadata could have several explanations. Metadata reporting can be both time- and work consuming, and when such resources are limited, the individual scientist may fear that this work has to be done at the expense of doing real science. One solution to avoid this researcher's dilemma could be to allocate sufficient resources for mandatory metadata reporting in project contracts. In Europe Beniston *et al*. (2012) suggest developing an EU-directive in the form of a best practice guideline for data management, data sharing and open access. Another, non-financial means of compensating for metadata reporting burden could be to urge scientists to use social scientific networks such as Mendeley[29] or ResearchGate[30] to showcase their reported metadata. Some researchers fear that sharing metadata with the public implies losing the intellectual properties to the data itself. It is therefore very important to underline that publishing metadata does not automatically imply making data freely available. Information about intellectual property, criteria for use and contractual arrangements need to be specified in the metadata.

When it comes to licensing and accreditation of data, lack of knowledge can be an obstacle for researchers to share under an open license. While the function of an open license is to make data more widely reusable while maintaining ownership and ensuring due accreditation, it is often

[28] http://www.nordforsk.org/en?set_language=en
[29] http://www.mendeley.com/
[30] http://www.researchgate.net/

felt as “giving something away” rather than sharing. This holds especially true for a license allowing for commercial use, where many may feel that it allows others to profit financially from work that one has shared freely. In reality, it is all but impossible to earn money directly from work under an open license, as the license and owner have to be clearly stated. It does however allow third parties to invest in the usage of the data (e.g. for impact assessments, customised web portals, web services, etc.), adding to its value to such an extent that it is economically viable as a new product. It is important to communicate these aspects well, to safeguard both the influx of data as its usability under the appropriate terms. Bottom line is that the license and the owner of the original data have to be clearly stated.

Some data owners fear that open access could lead to misuse and/or misinterpretation by other scientists. These data owners also fear that they will not be credited if other scientists use their data. Again, these worries could be met by a thorough metadata provenance scheme. Uncertainty and lack of knowledge on the consequences of open access often lead to scepticism among scientists and data owners. As a response to this, in Norway, the Norwegian Agency for Public Management and eGovernment[31] has developed an Open data handbook[32] addressing legal, social and scientific aspects of open data sharing. However, this handbook only addresses open data issues at a general level, and extended documentation for scientific issues are therefore desirable.

5.3 The need for academic accreditation of open data access

Academic accreditation is important for any researcher’s scientific career. Currently, open data sharing does not directly honour researchers the same way as published scientific articles in high-ranking journals. Electronic publishing of scientific literature calls for mechanisms of online reference citations that ensure future recognition and retrieval. Electronic publishing of data represents similar but more complex challenges. Validated data citation standards and best practices have to be implemented to meet these challenges. Several institutions, countries and disciplines have been working on this task for some time. Political and technical approaches have been introduced by the American National Information Standards Organisation (NISO)[33].

Others have been working on the development of Persistent Identifiers (PID) which are live and easily maintainable identifiers referring to digital objects, data files (such as documents, pictures or software installation files) or to physical entities (such as collection specimens). PIDs are not like hyperlinks, as they will remain valid after being moved between clients and organizations. Hyperlinks (HTTP URLs) provide a location service, while PIDs provide a naming service for the entity. Several standards have reached a mature level of development:

- Uniform Resource Name (URN)
- Persistent URL (PURL)
- Digital Object Identifier (DOI)
- National Bibliography Numbers (NBNS)
- Archival Resource Key (ARK)
- Open URL
- Universally Unique Identifier (UUID)

[31] http://www.difi.no/artikkel/2009/11/about-difi
[32] http://data.norge.no/sites/data/files/Veileder-i-tilgjengeliggjoring-av-offentlige-data-V2.pdf
[33] http://www.niso.org/home/

The Digital Object Identifier (DOI)[34] became an ISO-standard (26324)[35] in May 2012, driven by the international non-profit DOI foundation (established in 1998). Delegates from several CODATA-committees (Committee for Data for Science and Technology)[36], the ICSTI (International Council for Scientific and Technical Information)[37] and others have established an international task group on data citation standards and practices[38] to investigate relevant issues, coordinate activities and to suggest common practices and standards for the scientific community. Other important groups are the DataCite initiative[39] and the group composed of SCOR (Scientific Committee on Oceanic Research)[40], IODE (International Oceanographic Data and Information Exchange)[41], and MBLWHOI (Marine Biological Laboratory/Woods Hole Oceanographic Institution Library)[42], meeting annually to discuss data storage, interdisciplinary data publication, and interaction with scientific publishers. In 2012 the group made an online bibliography[43] of institutions focusing on data citation and referencing practices.

In 2012 GBIF and PenSoft Publishers[44] pioneered a workflow between the GBIF Integrated Publishing Toolkit (IPT)[45] and Pensoft journals such as PhytoKeys[46], ZooKeys[47], BioRisk[48], NeoBiota[49] and Nature Conservation[50] to automatically export metadata into the form of a data paper manuscript, based on the Ecological Metadata Language (EML)[51]. Data papers are scholarly journal publications whose primary purpose is to describe a dataset or a group of datasets, rather than to report a research investigation as such, it contains facts about data, not hypotheses and arguments in support of the data, as found in a conventional research article (Chavan and Penew, 2011). Pensoft has recently established a new journal Biodiversity Data Journal[52] dedicated to publishing data papers (Smith *et al*., 2013).

The Nature Publishing Group launched in 2014 a new platform named Scientific Data[53], for open-access, online-only publication of the descriptions of scientific valuable data sets. Scientific data provides formal peer-review for scientific data sets and a solution for citation of data sets in a similar manner as for citation of other scientific works. Scientific Data will build further on more general data repositories such as Dryad[54] and Figshare[55] where the actual data sets to be described in Scientific Data will be uploaded and can thus be accessed. The Dryad data repository

34 http://www.doi.org/
35 http://www.iso.org/iso/catalogue_detail?csnumber=43506
36 http://www.codata.org/
37 http://www.icsti.org/
38 http://www.codata.org/taskgroups/TGdatacitation/index.html
39 http://www.datacite.org/
40 http://www.scor-int.org/
41 http://www.iode.org/
42 http://www.mblwhoilibrary.org/
43 http://www.codata.org/taskgroups/TGdatacitation/Bilbliography_Links.html
44 http://www.pensoft.net/
45 http://code.google.com/p/gbif-providertoolkit/
46 http://www.pensoft.net/journals/phytokeys
47 http://www.pensoft.net/journals/zookeys/
48 http://www.pensoft.net/journals/biorisk/
49 http://www.pensoft.net/journals/neobiota
50 http://www.pensoft.net/journals/natureconservation
51 http://knb.ecoinformatics.org/software/eml/
52 http://biodiversitydatajournal.com/
53 http://www.nature.com/scientificdata/
54 http://datadryad.org/
55 http://figshare.com/

is also open for researchers to share scientific data sets underlying scientific publications accepted by peer-review journals. Figshare provides an even more flexible platform for researchers to share their scientific results in any file format and in a scholarly citable, sharable and discoverable manner. In addition, GBIF (Global Biodiversity Information Facility) will start collaborating with Scientific Data, the collaboration will develop methods for authoring submissions to the new journal using the standard formats for metadata recommended for sharing data through the GBIF network.

5.4 Data management, strategies and contractual arrangements

Making publicly funded data accessible from structured databases is an institutional responsibility that has to be implemented in long-term strategies. Internationally, several scientific funding sources have started to demand data management plans for project funding. Such data management plans should act as a guideline checklist to ensure that data are managed according to all relevant aspects of data management.

The international Data Curation Centre (DCC) in the UK has developed a data management plan template[56]. DCC has also developed an online solution for developing and maintaining such a data management plan. Examples on data management plans are also available from the Australian National Data Service (ANDS)[57].

When it comes to actual strategies regarding development and implementation of data management plans there is substantial variation among international research institutions. GBIF has developed the "Best practice guide for Data Discovery and Publishing Strategy and Action Plans"[58]. Strategies and plans have to outline all aspects related to responsibilities, intellectual property rights, utility value and synergies associated with data sharing.

It is very important that these issues are formalized in contractual arrangements at the start of an inventory project or a research project. The source of funding is responsible for consistently embedding such practices in contracts, and to see to their implementation by the contractor. The contractor is then legally responsible for the collection, maintenance, documentation and sharing of data.

Factual data, also in the form of prosaic text, is not copyrightable (ref https://wiki.creativecommons.org/Data), and thus does not require a license to allow its reuse. There are a number of reasons to apply a license nevertheless. First and foremost, a sufficiently open license ensures the usability of a dataset by covering the anomalous copyrightable data within it, without requiring a check for such data. In addition, a license setting requirement to attribution is psychologically important as it seemingly guarantees data sharers proper scientific accreditation, even though scientific accreditation of data sources is not governed by copyright.

The most common options for scientific data are either licensing under a license requiring attribution, such as Creative Commons Attribution (CC BY)[59], or a waiver such as Creative Commons Zero (CC0)[60] where the dataset is released into the public domain, thus freeing it from possible

56 http://www.dcc.ac.uk/resources/data-management-plans
57 http://ands.org.au/datamanagement/index.html
58 http://www.gbif.org/orc/?doc_id=2755
59 http://opendefinition.org/licenses/cc-by/
60 https://creativecommons.org/publicdomain/zero/1.0/

copyright restrictions. In the latest version of CC BY (4.0)[61] accreditation is flexible enough to remove the need for anyone reusing such data to determine how to properly attribute these. Scientific practice requires scientific attribution, regardless of enforcement by a license, so the more open CC0 guarantees the usability of the data without annulling proper scientific accreditation of the source.

In practice, however, data owners are more reluctant to share even non- copyrightable data without a license demanding attribution. This may lead to data not becoming available, whereas it would have under a license that, where legally applicable at all, does not extend beyond common scientific practice. It can thus be more pragmatic to allow a CC BY license with an added predefined agreement in which attribution is specified in a way that does not hinder use within or outside the scope of a national camera trap WEB-portal. It is essential for reuse of large, compound datasets that both content and licensing are machine-readable: Directly readable and processable by a computer so that it can readily be shared between IT systems.

[61] http://creativecommons.org/licenses/by/4.0/

6 Proposed actions for open access to Indian biodiversity data

Data and Information have gained high significance for developmental planning in knowledge societies. Civil societies seek open access to such data and information generated with public funds for planning developmental processes. On the other hand, sensitivity requirements demand the restriction of access and availability of sensitive data. With growing levels of misuse of technologies by non-state actors, providing free access to data and information is a challenge faced by countries all around the globe.

National Data Sharing and Accessibility Policy (DSAP) published in the Gazette of India on March 17th 2012 by the Ministry of Science and Technology envisages a new data sharing policy (Anonymous, 2012). The current classification of data of sharing is based on the Open Series Data model[62]. In this process, any data not specifically included in the "Open Series Dataset" remains inaccessible for public use.

The Government of India has accorded approval to the changed paradigm of migrating towards a "Negative List" of data rather than definition of an "Open Data Series Model". Such Negative Lists could be based on features rather than nature and type. Data owners and sources will therefore need to define and classify their data based on "features" and "exclusion principle" for preparing a negative list within a defined period. Department of Science and Technology (DST)[63] will serve as a Nodal Point and repository for all kinds of data.

Introduction

Data are recognized at all levels as a valuable resource that should be made publicly available and maintained over time to ensure that their potential value is realized. There has been an increasing demand by the community, that data should be made more readily available to all, to enable a rational debate and better decision making.

Principal 10 of the United Nations Declaration on Environment and Development (Rio de Janeiro, June 1992), stated that: *"………..each individual shall have appropriate access to information concerning the environment that is held by public authorities ……. and the opportunity to participate in the decision making process. States shall facilitate and encourage public awareness and participation by making information widely available (United Nations, 1992)"*

Section 4(2) of the Right to Information Act, 2005 reads *"It shall be a constant endeavor of every public authority to take steps in accordance with the requirements of clause (b) of sub-section (1) to provide as much information suo motu to the public at regular intervals through various means of communication, including internet, so that the public have minimum resort to the use of this Act to obtain information"*

The principles on which data sharing and accessibility are needed include: Openness, Flexibility, Transparency, Legal conformity, Protection of intellectual property, Formal responsibility, Professionalism, Interoperability, Quality, Security, Efficiency, Accountability, Sustainability.

There is large quantum of data generated at the cost of public funds by various organizations and institutions in the country. Most of this data is non-sensitive in nature and can be used by public for scientific, economic and developmental purposes. The Data Sharing and Accessibility Policy (DSAP) is designed to apply to all non-classified data collected using public funds. The policy would help data users and data solicitors get access to data through established procedures and defined norms. NDSAP published in the Gazette of India on March 17.th 2012 by

[62] http://www.opendatamodel.com/

[63] www.data.gov.in

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Objectives
The objectives of the National Data Sharing and Accessibility Policy (DSAP) are to address all issues related to data in terms of the available scope of sharing and accessing spatial and non-spatial data under broad frameworks of standards and interoperability:

- Data Classification
- Technology for sharing and access
- Current legal framework (RTI Act and Privacy Act)

Benefits of the data sharing policy
- Maximizing use: Ready access to governmental data will encourage more extensive use of a valuable public resource for the benefit of the community.
- Avoiding duplication**:** By sharing data, the need for separate bodies to collect the same data will be avoided resulting in significant cost savings in data collection.
- Maximized integration: By adopting common standards for the collection and transfer of data, more integration of individual databases will be possible.
- Ownership**:** The identification of owners for the principal data sets enable users to identify those responsible for implementing prioritized data collection programs and for developing data standards.
- Better decision-making**:** Quality information allows making competent decisions. Avoiding large potential costs. Ready access to existing spatial data is essential for many decision-making tasks such as protecting the environment, development planning, managing assets, improving living conditions, national security and controlling disasters.
- Equity of access**:** A more open data transfer policy ensures better access by all genuine or authenticated users.

Definitions
Data means a representation of information, knowledge, facts, concepts or instructions which are being prepared or have been prepared in a formalized manner, and is intended to be processed, is being processed or has been processed in a computer system or computer network, and may be in any form (including computer printouts magnetic or optical storage media, punched cards, punched tapes) or stored internally in the memory of the computer. It also includes data in conventional form on paper and other media.

Sensitive personal data - Sensitive Personal data or information of a person shall include information collected, received, stored, transmitted or processed by body corporate or in-termediary or any person, consisting of:

[64] http://www.opendatamodel.com/
[65] www.data.gov.in

- Any proceedings for any offence committed or alleged to have been committed by him, the disposal of such proceedings or the sentence of any court in such proceedings.
- Information related to financial information such as Bank account/credit card/debit card/other payment instrument details of the users
- Physiological and mental health condition
- Medical records and history
- Biometric information
- Information received by body corporate for processing, stored or processed under lawful contract or otherwise

Data set means a named collection of logically related features including processed data or information.

Data Archive means a place where machine-readable data are acquired, manipulated, documented, and distributed to others for further analysis and consumption.

Data Acquisition means an Initial acquisition (collection) of data or subsequent addition of data to the same specification, including data quality assurance processes.

Data Enclave means a controlled, secure environment in which, eligible users can perform analyses using restricted data resources.

Metadata is the information that describes the data source and the time, place, and conditions under which the data were created. Metadata informs the user of who, when, what, where, why, and how data were generated. Metadata allows the data to be traced to a known origin and known quality.

Negative list is a list of non-sharable data as identified by the ministries / departments

Raw Data are field observations, contents of project-related data study repositories, survey results, results of laboratory studies and preliminary analysis.

Restricted Data are datasets that cannot be distributed to the public due to confidentiality concerns, security considerations, or other issues.

Standards / Compliant Applications embeds data handling functions (e.g., data collection, management, transfer, integration, publication, etc.) and operates on data in a manner that complies with data format and data syntax specifications produced and maintained by open, standards bodies.

Spatial Data are data representing geographically referenced features that are described by geographic position and attributes. Typically it includes data about natural resources, the environment, land use, demography and socio-economic.

Unique Data are data that cannot be readily replicated.

Non-shareable data (Negative List)

National security and privacy are paramount to the country and individual respectively. In view of this, it is mandated that each government ministries / departments need to prepare a negative list. The negative list is that which includes the data that is not sharable and the same would not be available on the public domain. Sections 8 and 9 of the Right to Information Act (2005), The Information Technology Act (2000)[66] and the right to privacy upheld by the Honorable Supreme Court of India in its various judgments, need to be consulted and taken into consideration while preparing the negative list.

[66] http://rti.gov.in/

Shareable Data

- The other datasets, which have not been included in the negative list, shall be verified and validated by the individual scientists and then shared.
- Appropriate support and incentives for data clean up, documentation, dissemination and storage shall be given by funding agencies (about 15% of the project cost).
- The metadata indicating what data is accessible shall also be ported on the website. The metadata should contain information related to the data sets available, their quality and the data formats.

Data Classification

Departments generate different types of datasets. The types of data produced by a statistical system consist of derived statistics like food habits and databases from census and surveys. The geospatial data however, consists primarily of satellite data, maps, etc. In such a system, it becomes important to maintain standards in respect of metadata, data layout and data access policy. Datasets are to be classified in various types:

- **Open Access data**. Open access to research data from public funding should be easy, timely, user- friendly and Internet-based. Data should be made openly available as soon as possible but no later than 1 year after the data was collected.
- **Registered Access**. The users are required to register their names through the web and then download the information needed using the user name and password provided to them at the time of registration.
- **Restricted Access**. Access to the following categories of information, in case these are not already in public domain – are restricted:
    - Exact coordinates of strategic locations
    - Information about persons in terms of protection of data privacy
    - Protection of intellectual property rights

The data users who are accessing / using this data for research should clearly acknowledge the source

Technology for data sharing and open access

A state-of-the-art data warehouse with online analytical processing (OLAP) capabilities, which includes providing, a multi-dimensional and subject oriented view of the database needs to be created. This integrated repository will hold data of current and historical nature and this repository will over a period encompass data generated by WII. The main features of the data warehouse need to include:

- User friendly interface
- Dynamic / pull down menus
- Search based Report
- Secured web access
- Bulletin board
- Complete Metadata
- Parametric and Dynamic report in exportable format

Current legal framework

Data access arrangements needs to respect the legal rights and legitimate interests of all concerned stakeholders. Access to, and use of, certain data will necessarily be limited by various types of legal requirements, which may include restrictions for reasons of:

- National Security: Data pertaining to intelligence, military activities, or political decision-making may be classified non-shareable data.
- Privacy and confidentiality: Data on human subjects and other personal data are subject to restricted access under national laws and policies to protect confidentiality and privacy.
- Trade secrets and intellectual property rights: Data access arrangements should consider the applicability of copyright or of other intellectual property laws that may be relevant to publicly funded databases.
- Protection of rare, threatened or endangered species: In certain instances, there may be legitimate reasons to restrict access to data on the location of biological resources for the sake of conservation sites etc.
- Legal process: Data under consideration in legal actions (sub judice) may not be accessible. Subscribing to professional codes of conduct may facilitate meeting legal requirements.

Metadata
Metadata documenting archived/online data sets of all types needs to be made available when or before, the dataset itself are released according to the terms above.

All metadata will follow standards and will minimally contain adequate information on proper citation, access, contact information, and discovery. Complete information including methods, structure, semantics, and quality control/assurance is expected.

Responsibilities of database owners, generators and controllers
The data owners /generators/controllers shall:

- Extend authorization to database managers for access to information
- Authorize access to secondary users in written form

Database managers shall:

- Provide the day-to-day controls of the data
- Provide secondary users of how to access/visualize the data

The database owner shall validate data before the same is made accessible to the users.

- The data owners, managers and all authorized secondary users shall take all reasonable precautions against unauthorized access, willful or not, to screens and/or reports containing sensitive data.

- The IT, Remote Sensing and GIS cell shall install security procedures to reasonably prevent unauthorized access to systems and data by any other unauthorized person.

Infrastructure provisions
While policies provide official mandate, facilitation of optimum accessibility and usability of data by the implementers pre-suppose a trajectory of proper organization of data, with access services and analysis tools that provide the researchers with added value. For data to be reused, it needs to be adequately described and linked to services that disseminate the data to other researchers and stakeholders. The current methods of storing data are as diverse as the disciplines that generate it. It is necessary to develop institutional repositories, data centers on domain and national levels that all methods of storing and sharing have to exist within the specific infrastructure to enable all users to access and use it.

Data sharing advantages and barriers

Advantages:

- Re-analysis of data helps authenticate results as well as the data itself, which is a key part of the scientific process
- Different interpretations or approaches to existing data contribute to scientific progress – especially in an interdisciplinary setting
- Well-managed, long-term preservation helps retain data integrity
- When data is available, (re-)collection of data is minimized; thus, use of resources is optimized
- Data availability provides safeguards against misconduct related to data fabrication and falsification; replication studies serve as training tools for new generations of researchers

Barriers:

- Governance– Reluctance to share if the data is not requested by relevant administrative level
- Misinterpretation of Policy so as to create importance for self
- Lack of dialogue between data providers and users
- Economic Issues - Cost of sharing the data, mistrust regarding Incentivizing / crediting mechanism
- Licenses and legal frameworks – lack of knowledge regarding licenses and IPR
- Data characteristics - Poor accuracy / authenticity of the data, Sensitivity of data, formats (analog / digital, etc.)
- Poor documentation or lacking metadata
- Poor reporting mechanism as to who is using data
- Lack of capacity and time required to share data and not knowing where to deposit the data

Discussion and conclusion

Data and Information have gained high significance for developmental planning in knowledge societies. Civil societies seek open access to such data and information generated with public funds for planning developmental processes. On the other hand, sensitivity requirements demand the restriction of access and availability of sensitive data. With growing levels of misuse of technologies by non-state actors, providing free access to data and information is a challenge faced by countries all around the globe. The NDSAP is now available at national level in India (top down approach), however for the policy to be implemented a bottom up approach has to be adopted. Under the RTI Act Government of India, the Government has asked all public funded organization to prepare its own data sharing and access policy as well as processes taking into consideration the advantages and the barriers for its implementation.

7 Project implementation and outcomes

The pilot project was formally kicked off at a high-level segment meeting organized by WII at the India International Conference Center in New Delhi the 28th of October 2011. In addition to the project participants, delegates from the Indian Ministry of Environment, Forests and Climate Change (MoEFCC)[67], the National Tiger Conservation Authority[68], the Wildlife Conservation Society - India[69], the Norwegian Environment Agency[70] and the Royal Norwegian Embassy[71] in New Delhi attended the meeting. The meeting confirmed the Indo- Norwegian governmental support of the project, and highlighted its strategic role in the context of the priorities of the Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES)[72]. The high-level segment meeting was followed by a project workshop in Dehradun October 29-30.th 2011 in order to design the content and plan the progress of the project. The 2011- meetings was followed up with a new high-level segment meeting in New Delhi (August 21, 2012) and a second project workshop in Dehradun (August 22-24, 2012) in order to consolidate the project status and to plan and secure further progress. Outside all meetings and workshops, frequent Skype and teleconferences have been the main communication channels. The project partners met again in Trondheim (May 20-26, 2014) in order to plan the finalization of the project and to identify potential interfaces of future collaboration both within the IPBES context and the general scientific context. The final report and the project outcomes will be show- cased at a High Level Segment meeting at the Norwegian Embassy in New Delhi September 19th 2014.

7.1 Field excursion in the Rajaji National Park

In connection with the Dehradun meetings, WII invited the project core team to a one-day field excursion in the Rajaji National Park the 30th of October 2011 (see map in figure 7 below).

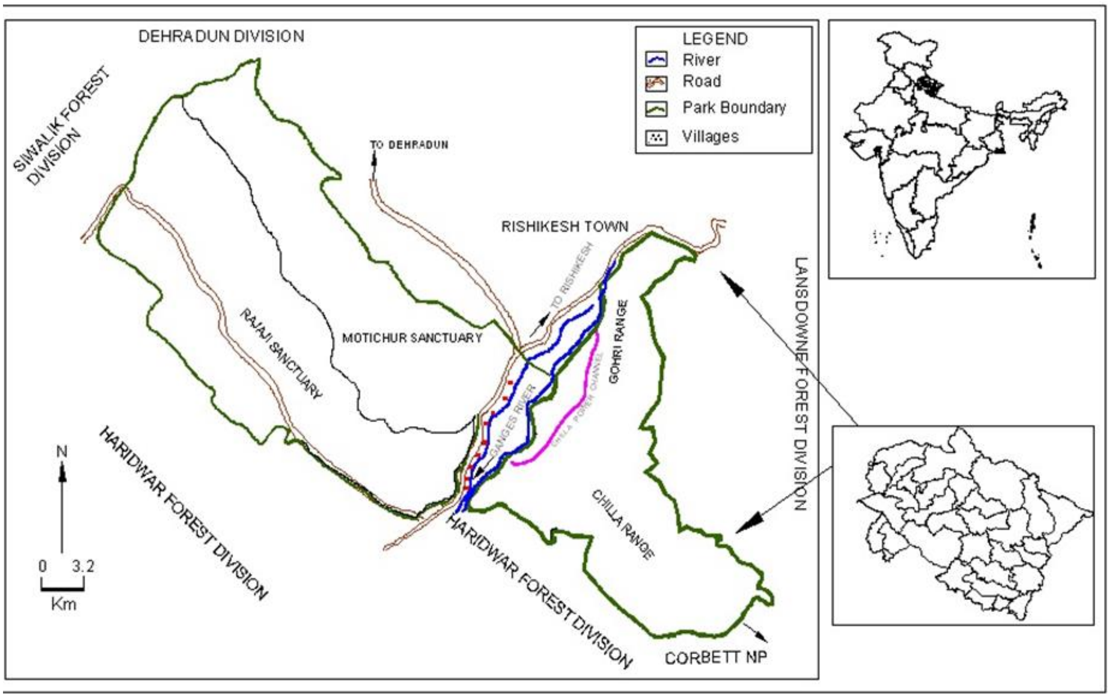


Figure 7: Location of the Rajaji National Park in India showing study area.

67 http://envfor.nic.in/
68 http://projecttiger.nic.in/
69 http://cwsindia.org/
70 http://www.xn--miljdirektoratet-oxb.no/english/
71 http://www.norwayemb.org.in/
72 http://www.ipbes.net/

The purpose of this field excursion was for WII to demonstrate the use of camera traps in Rajaji, and for the Norwegian partners to learn about the ongoing research activities conducted by WII inside the park. Dr. Karthikeyan Vasuedevan from WII led the excursion. Dr. Vasuedevan gave a very thoroughly and interesting insight into the ecology and wildlife of the park.

Figure 8: Dr. Karthikean Vasuedevan (to the left) and the local Park Officers demonstrating the use and implementation of wild camera traps in the WII research activities in the park.

The Rajaji National Park (RNP) is approximately 820 km^2 and forms the northwestern population limit of tigers in India. RNP is bisected into a western part (600 km^2) and an eastern part (220 km^2) by the river Ganges. The park was created in 1983 by amalgamation of three sanctuaries: The Rajaji sanctuary (established in 1948), the Motichur sanctuary (established in 1964) and the Chilla sanctuary (established in 1977) after the name of the renowned statesman and freedom fighter Sri C. Rajgopalachariya - the first and last Governor General of independent India popularly known as "Rajaji". RNP has the largest area representing Shiwalik Ecosystem. The Shivalik trail is 10 million year old and very rich in fossils. Its fossils faunal remains include about 50 species of elephant; one of them is present today

Rajaji National Park has a small population of tigers (large carnivores) which needs large areas for ranging and adequate prey base of ungulate species. Given that vast tracts of forests that had tigers, have now been lost to human habitations, obtaining reliable quantitative information on existing populations, opportunities for dispersal and connectivity between populations could aid metapopulation management thus lowering the risk of local extinction.

7.2 Mapping of national user needs

A considerably amount of Indian camera trap data on threatened fauna have been captured across India, but very few data are at the moment freely available. There are many challenges and constraints due to data management and logistics that have to be solved in order to make the data stakeholders willing to share their camera trap data in a national data management system.

To increase the relevance of camera trap data there is a great need of data quality enhancement. This could be achieved through a central database for systematic storage and easy retrieval of data. This demands an improved logistic which could be solved by improved funding, an improved access and permission regime and improved low-cost camera trap technology. The project has addressed several added values of such a data regime towards the needs of scientists and decision makers. These added values will be described in Chapter 9. Important here is to illuminate how new scientific questions can be raised and answered with the help of a standardized data management system.

The National Biodiversity Information Outlook (NBIO) underline the fact that a national strategy for capacity building in biodiversity informatics has to be based on specific national needs and adapted to the existing international standards for biodiversity data publishing. In order to map the user needs of camera trap data in India and Nepal, WII organized a questionnaire-based survey in the period from April 27 to May 31, 2012 (see figures 9, 10 and 11 below). The questionnaire sought to identify:

- The types of multimedia data used
- Details of creation of the camera trap data
- The major species studied
- The size of data-holdings
- The main applications to which the data is put
- Data sharing practices
- Whether data is being used adequately for decision-making
- The need for a national infrastructure for managing camera trap data.

Based on 38 responses, it was observed that:
- A large volume of high-quality, camera trap images of threatened fauna exists, with 96.4 % of the respondents possessing digital images (stills) from 41 sites (protected and non-protected areas) spread over 20 Indian States and Nepal
- The majority of the users (71%) own their data
- Common Leopard, Tiger and Black Bear were the three major species studied.

Despite the existence of a large body of camera trap data, the survey also established that:

- Very few (13%) of the respondents make image data freely available to others and data sharing policies and guidelines are required
- Incentives are needed to encourage data owners to contribute and exchange data
- Easy-to-follow data management and publishing protocols are currently lacking
- There is general endorsement of the need for a national infrastructure for storing and managing camera trap data, particularly to make data gathered using public funds available

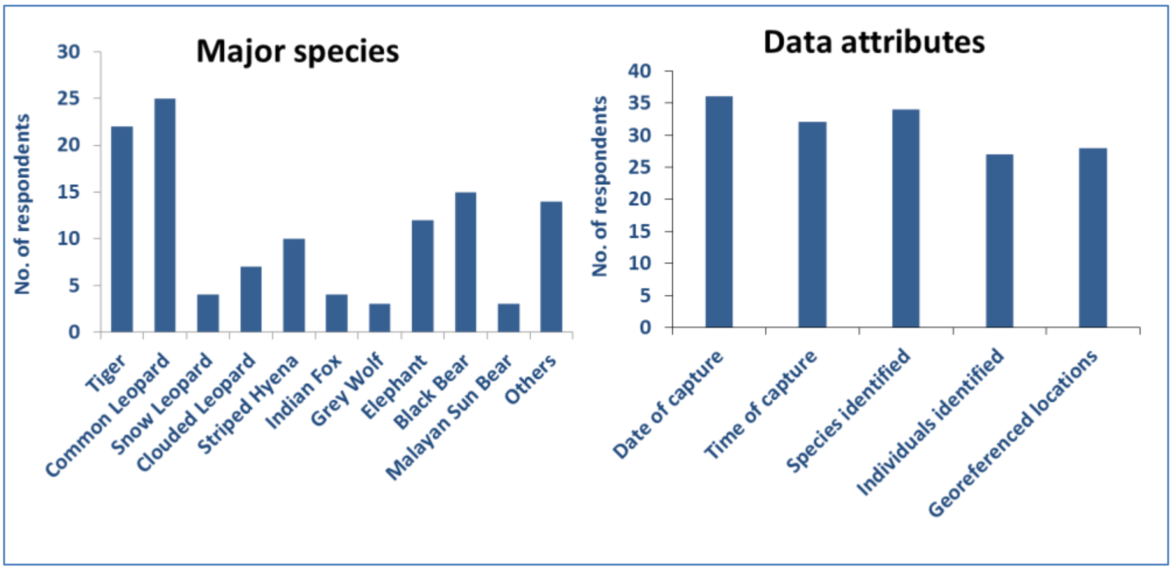


Figure 9: Image repositories and data attributes

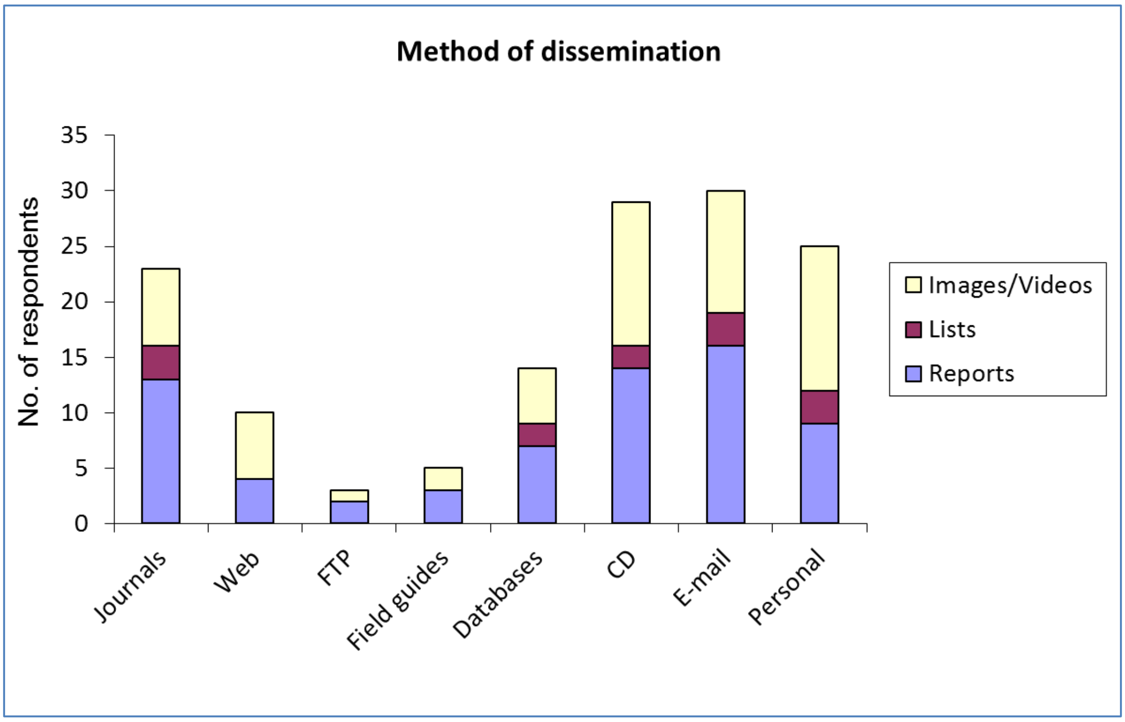


Figure 10: Methods of dissemination of camera trap data

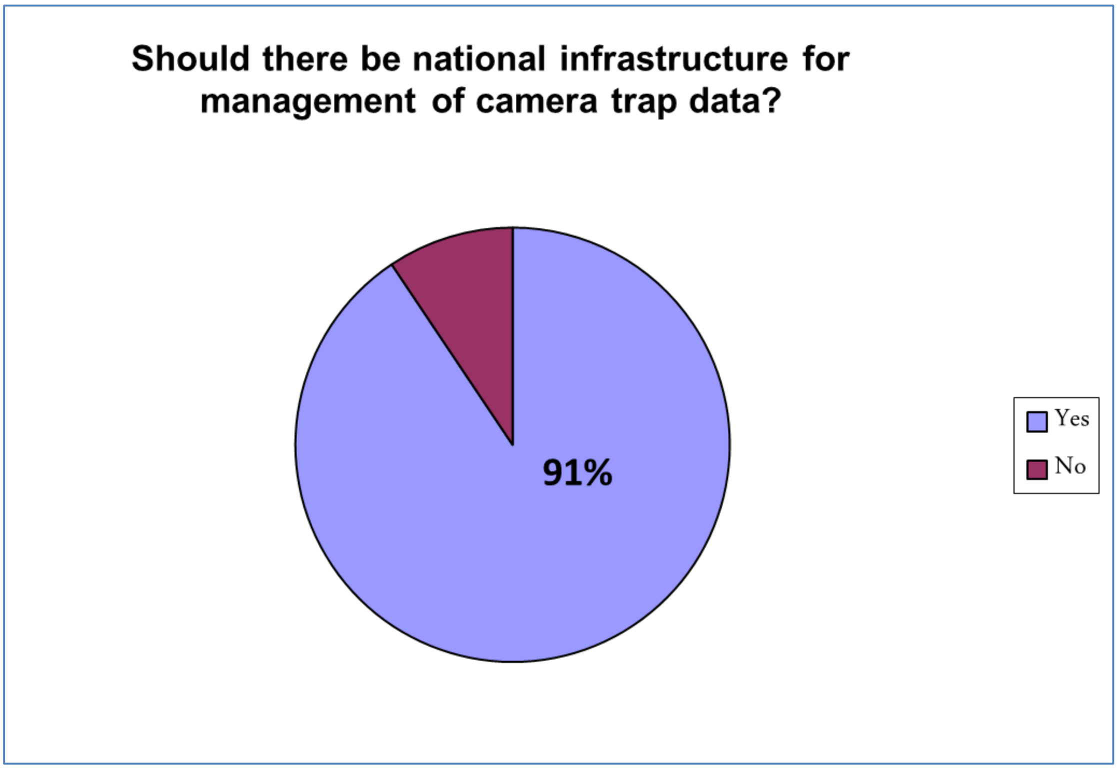


Figure 11: Respondents interest in having a national infrastructure for management of camera trap data

The findings from this mapping exercise highly illuminate the need for a national infrastructure for camera trap data in India. The establishment of such an Infrastructure has to be implemented in the context of the NBIO Roadmap in order to ensure that the identified needs will be addressed in a proper way.

7.3 Case studies

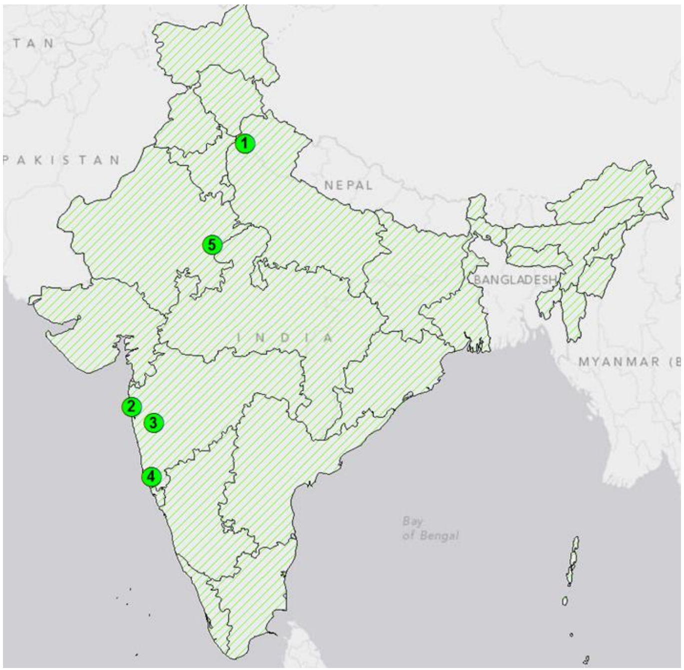


Figure 12: In order to demonstrate the relevance of camera trapping data in a science-policy interface case studies has been performed in Rajaji National Park (1), Sanjay Gandhi National Park (2), the Pune District in Maharashtra (3), the Sindhudurg district in Maharashtra (4), along the Khanduli River (5) and outside protected areas across India.

7.3.1 Population density estimate of Tigers in the Rajaji National park

Dr. Bivash Pandav (WII), Abhishek Harihar (WII) and the Field Director from the National Tiger Conservation Association (NTCA) have carried out and reported this case study on population density estimate of Tigers in the Rajaji National park.

Introduction
WII has been conducting camera trapping in Rajaji National Park since 2004, hence it was selected as a case study in the current pilot project to demonstrate camera trap data mobilization, data access, policy and decision-making.

Conserving large mammals in a human dominated landscape requires reliable quantitative information on existing populations, opportunities for dispersal and connectivity between populations. Using which, the effectiveness of management practices can be assessed and goals set for the future. In India conservation efforts such as Project Tiger 2005[73] have, since 1973, been attempting to save the nations declining populations of tiger, their prey and habitats, yet about 26% of their range has been lost in the recent past (Qureshi et al. 2006). With about 69% of India's protected areas being inhabited by people (Saloni, 1996) and the recent crisis of vanishing tiger populations (Project Tiger 2005), the fact that most reserves are faced with severe anthropogenic pressures is increasingly becoming a cause of concern. While the ultimate threats to species survival are anthropogenic, intrinsic ecological and life history traits determine how well populations are able to recover (Cardillo et al. 2004).

Tigers (Panthera Tigris) are highly endangered large carnivores, whose extinction risk is compounded by their need for large ranging areas and their dependence on prey species (Carbone and Gittleman 2002, Karanth et al. 2004) that may themselves be threatened. Despite thirty

[73] http://en.wikipedia.org/wiki/Project_Tiger#Goals_and_objectives

years of continued conservation efforts, an expanding human population has caused considerable decline in the tiger's habitat, prey and the tiger itself in India (Seidensticker et al. 1999). Though illegal killing of tigers for body parts has contributed greatly to the extinction of local populations (Project Tiger 2005), vast tracts of forested landscape that once housed the tiger have now been lost to human habitation. This has caused a sharp decline in the ungulate populations and confined many of the remaining tiger populations to small, isolated patches of forests (Smith et al. 1998).

One such landscape, the Terai arc landscape, encompassing the Shivalik hills and the Terai flood plains running parallel to the outer Himalayas from Jammu through Nepal to Assam are considered one of the most threatened and fragile ecosystems in the Indian subcontinent (Harihar et al. 2007).

Rajaji National Park along with Corbett Tiger Reserve and its adjoining forests are one of the largest contiguous patches of forest (ca. 4,000 km^2) and forms the north western limit of the tiger and elephant distribution in India (Johnsingh and Negi 2003). Known as the Rajaji- Corbett Tiger Conservation Unit, it is a level I Tiger Conservation Unit (TCU I, Wikramanayake et al. 1998) identified for the long-term persistence of the species. River Ganga bisects the 820.42 km^2 Rajaji National Park in to eastern part comprising of Chilla and Gorhri ranges (ca. 250 km^2) and the western part comprising of Motichur, Kansrau, Ramgarh, Chilawali, Dholkhand, Beribada and Haridwar ranges (ca. 570 km^2.). Both these parts of Rajaji National Park are connected by Chilla-Motichur corridor (Johnsingh et al. 1990). However, eastern part of Rajaji National Park continues to maintain a strong connectivity with the Corbett Tiger Reserve through Laldhang and Kotdwar ranges of Lansdowne Forest Division.

Rajaji National Park is a true representative of Shivalik formation, is characterized by rugged hills ranging from 400m to 800m in altitude with steep southern slopes, and is drained by rivers and streams running north to south, most of which remain dry in late winter and summer. Broadly, the forests of this region are categorized as Northern Indian moist deciduous forest and Northern tropical dry deciduous forest (Champion and Seth 1968). The park supports a healthy assemblage of wild ungulates such as spotted deer, sambar, barking deer, nilgai, wild pig and goral. Besides tiger, the park supports a healthy population of leopard. Other carnivores present in the park are sloth bear, Asiatic black bear, hyena, jackal, jungle cat, leopard cat and rusty spotted cat.

Until recently, the Park was reeling under severe anthropogenic pressure, owing to the presence of large number of nomadic pastoralists (Gujjar's) within its limit. A voluntary relocation of Gujjar settlements was initiated by the then Government of Uttar Pradesh, and after the creation of the state, the process was actively pursued in 2003. As a result, more than 1200 families of Gujjar's have so far been relocated from RNP and six ranges out of 9 ranges are completely free from Gujjar habitation. This has resulted in creation of an inviolate space of approximately 520 km^2 (Figure 12 below).

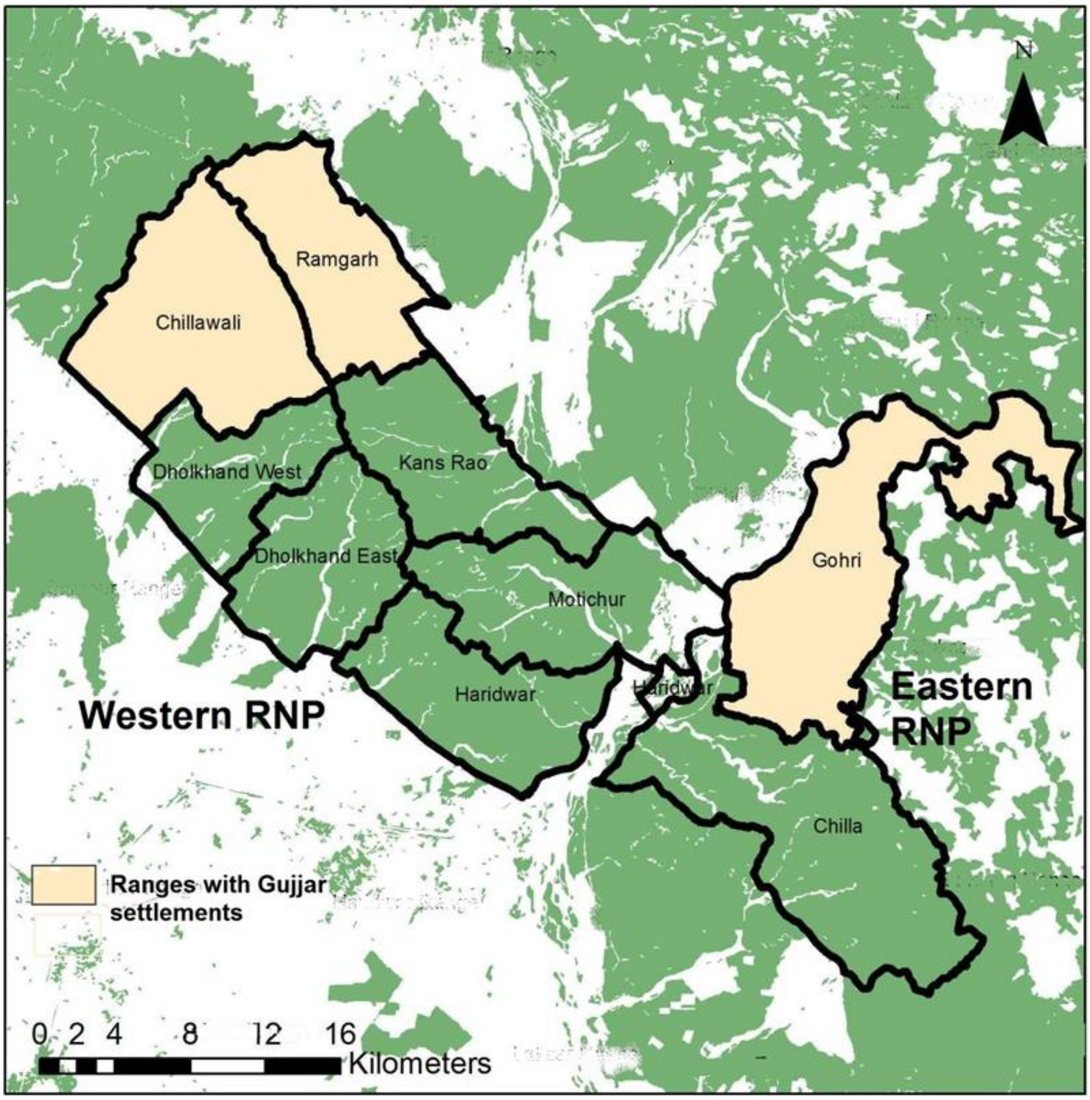


Figure 13: Map of Rajaji National Park (RNP) indicating the western and eastern sectors. Six out of nine ranges in the park are currently free of human settlements. With adequate prey base these six ranges provide inviolate space for tiger conservation.

Following the resettlement of 193 Gujjar (pastoralists with large buffalo holdings) families from Chilla Range of Rajaji National Park, WII monitored a recovering population of tiger across nine consecutive years from 2004-05 to 2012-13. Distance sampling method is used to estimate density of wild ungulate prey and camera traps to estimate tiger density.

Camera trapping methodology

In order to estimate the population density of adult tigers in the study WII used photographic capture-recapture analysis (Karanth 1995, Karanth and Nichols 1998). At least thirty camera trapping stations were maintained through the study period in the Chilla range of RNP (Harihar 2009). These trapping stations were selected to maximize the capture probabilities of tigers (Karanth 1995). In order to systematically sample the area, sampling blocks (spatially separated) were identified within the intensive study area and the cameras were deployed in a phased manner. Sampling along the east of Ganges (Chilla and parts of Gorhri ranges) was carried out during winter of each survey year in 4 blocks and on the west of the Ganges (Dholkhand West and Dholkhand East ranges) in 2 blocks during summer of each year. Each block consisted of 10 trap sites run for 15 consecutive days/occasions. Thus, each sampling occasion combined captures from 1 day drawn from each block. One trap-night was a 14-hour period (1700-0700 hours) during which a camera was functional. Owing to a good network of roads all the 10 trapping sites in a block was checked on a daily basis. Figure 13 below depicts the location of camera traps in Eastern Part of Rajaji National Park.

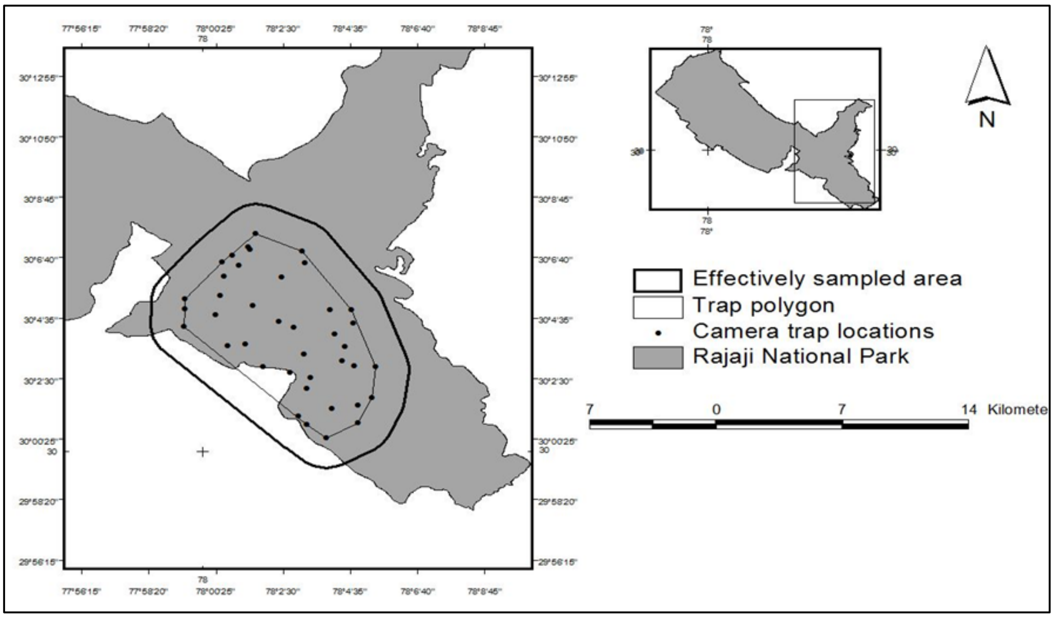


Figure 14: Location of the camera traps, camera trap polygon and the effective sampled area in east Rajaji National Park

All photographs were downloaded at the trap site using a laptop. Every tiger captured was given a unique identification number (e.g., RT-002) after examining the stripe pattern on the flanks, limbs and forequarters (Schaller 1967, McDougal 1977, Karanth 1995). Following the identification of tigers, capture histories (X matrix) were developed and analyzed using program CAPTURE (Otis et al. 1978, White et al. 1982, Rexstad and Burnham 1991).

Based on photographic capture-recapture estimates, WII documented an increase in the density (D) of tigers from 3.1 in 2004-05 to 7.1 tigers/100km^2 in 2011-12 (Harihar et al. 2011; Harihar & Pandav 2012). It was concluded that this increase in tiger density is most probably due to immigrating tigers from nearby Corbett Tiger Reserve. A high turnover of individual tigers were observed during the study. 40 individual tigers were photographed, including five cubs, during the nine-year period. With photographic evidence of breeding tigers in Chilla range, it is believed that this area could serve as a potential source site from where tigers can colonize adjoining forests across River Ganga.

Recovery of habitat, wild prey and tiger following relocation of human settlements
While creation of inviolate space has been widely recognized as a conservation tool to recover wild tiger population across its range, studies carried out by WII in RNP provides empirical evidence for this important conservation intervention. A systematic monitoring program over nine years has clearly documented a successful recovery of habitat, wild ungulate and tiger in parts of RNP, the area that was once subjected to intensive human interference.

The immediate response to this voluntary relocation was noticed in terms of revival of the grasslands in the valley habitats of Rajaji. The valleys that were left degraded for years due to livestock grazing gave rise to luxuriant growth of grass species viz. Saccharum spontaneum, Imperata cylindrica and Vetiveria zizaniodes (see figures 14 and 15 below) within six months of relocation. This was followed by a recovery of wild ungulate and tiger population of the area.

Figure 15: Immediately after relocation

Figure 16: Within six months after relocation

The WII monitoring program documented an increase in spotted deer (*Axis axis*) population in terms of increased population performance. The fawn to female ratio of spotted deer increased from 6.86 ± 3.1/100 females in 2004-05 to 69.2 ± 3.1/100 females in 2010- 2011 (see figure 16 below). Consequently, the tiger population of the area responded positively. The tiger density of the relocated habitat doubled in a span of five years. Immediately after the relocation of human settlements, we documented a tiger density of 2.9 ± 0.62/100km2. Today, after nine years of relocation, Chilla Range of Rajaji NP supports a tiger density of 6.9 ± 0.52/100 km^2 (see figure 17 below). Evidences of breeding were clearly evident from the photograph of cubs obtained over past nine years. Over the past nine years, WII's monitoring program has documented 40 individual tigers using the Chilla and Gohri ranges of eastern Rajaji. Recent monitoring in April 2013 has revealed the presence of nine individuals (four males and five females) in Chilla and Gohri ranges of Eastern RNP. In addition, confirmed records for 3 breeding females were found.

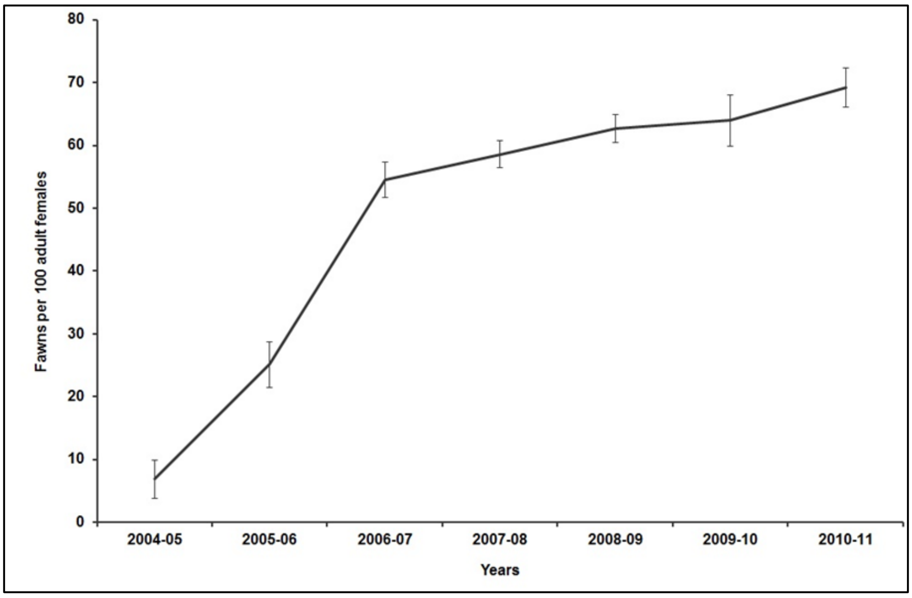


Figure 17: Population performance (number of fawns per 100 adult females) and associated 95% bootstrap confidence interval of spotted deer (*Axis axis*) across seven survey years (2004-2011).

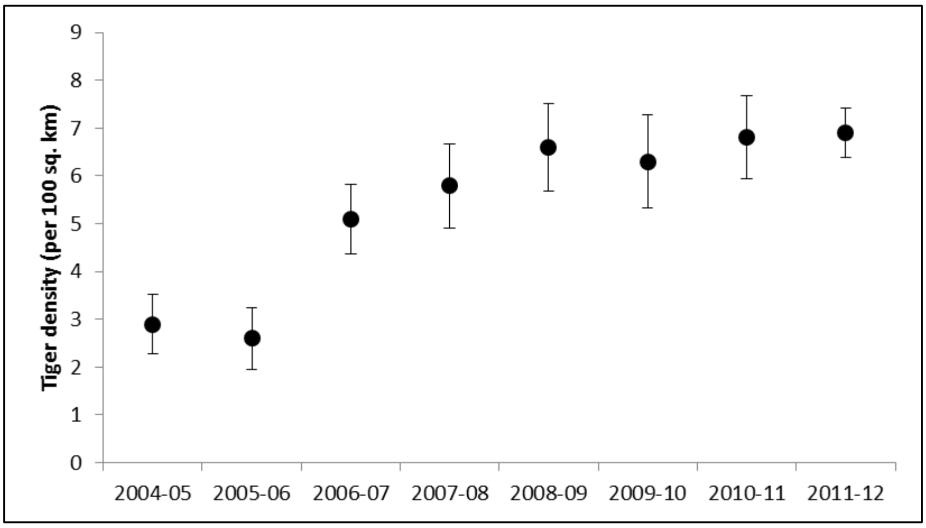


Figure 18: Density of tiger (number of individuals per 100 sq. km) and associated confidence interval across seven survey years (2004-2012).

Potential for recovery

While the recovery in eastern part of RNP has been largely possible due to strong connectivity of eastern RNP with Corbett Tiger Reserve (CTR) through the Lansdowne Forest Division (FD), the scenario in the western part of RNP has not shown similar recovery of its tiger population. Five out of the seven ranges of western RNP (570 km^2) are presently devoid of human settlements since 2005 (figure 18 below). WII's monitoring program indicates a high density of wild ungulate prey (110.01 individuals per km^2) within this inviolate space in western RNP, which is capable of supporting up to 40 tigers. Despite the presence of such high prey densities, systematic camera trapping carried out in January and February 2013 over an area of 400 km^2 in western RNP has revealed the presence of only two tigresses. Besides the results of the camera trapping studies, sign surveys in western RNP by WII have not revealed the presence of any male in the area. Lack of evidences of breeding among tigers is of serious concern to the long-term persistence of tigers not only in western RNP but also in the entire forested tract (approximately 2000 km^2) between the rivers Ganga and Yamuna. While the tiger population in eastern RNP is still recovering, colonization of western RNP by tigers has so far not been possible due to lack of functional connectivity (Chilla-Motichur corridor) across the river Ganga.

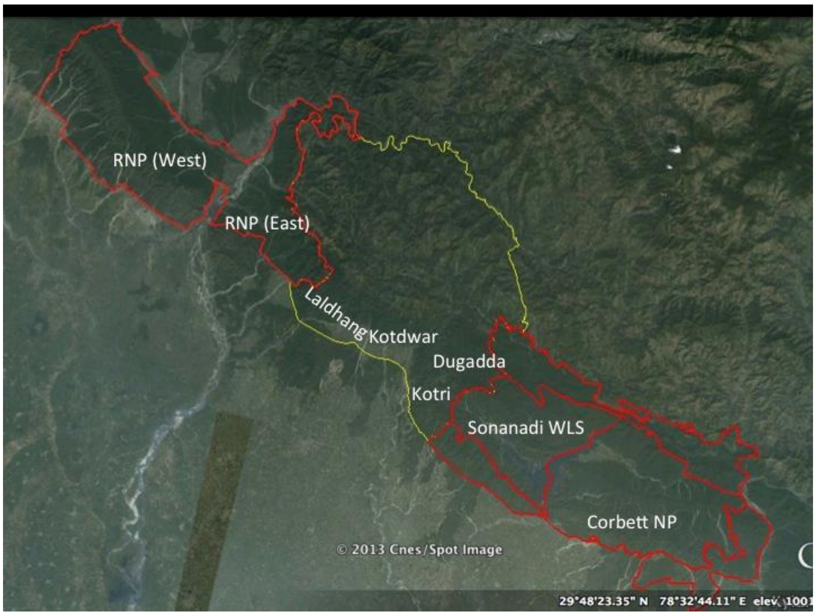


Figure 19: Rajaji- Corbett Tiger Conservation Unit

With the help of scientists from WII involved in monitoring in RNP, an attempt has been made to evaluate possible management interventions that will enable tigers to recover in western RNP. Using Population Viability Analysis the relative performance of three possible management scenarios against isolation, which is presently the situation prevailing in western RNP, has been assessed. These are:

- Population supplemented by introducing individuals
- Natural connectivity restored to adjoining source population
- Supplementation carried out for 10 years with habitat restoration to connect the population to the source.

The results support the scenarios with initial supplementation for the first ten years during which connectivity is also being restored emerged to ensure long-term persistence of tigers (figure 19 below). This is considered as the most pragmatic option to ensure long-term persistence of tigers in the forested tract west of River Ganga. Thereby, restoring Chilla-Motichur connectivity should remain the foremost priority for securing the future of tigers in this landscape; while supplementation should be initiated immediately to avoid local extinction, which is otherwise imminent.

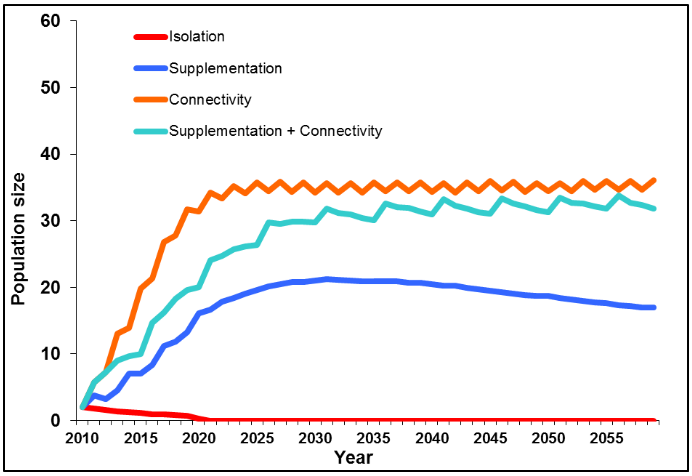


Figure 20: Population sizes over 50 years, under the seven different scenarios modelled on the tiger population from western Rajaji National Park.

Need for a Rajaji Tiger Reserve
A multitude of factors such as availability of inviolate space, a healthy prey biomass, a small breeding population provides excellent opportunity for tiger conservation in RNP. However, as stated above, recovery of tiger population across the park requires active management intervention, focused attention and sustained funding.

The decade long monitoring has highlighted the critical importance of RNP as a potential source site and recovery site for tigers at its northwestern range limit, which has prompted the National Tiger Conservation Authority to endorse it as a Tiger Reserve in 2013. This move would strengthen the existing park management infrastructure with inflow of additional funds and should help ensure the persistence and recovery of the tiger population in this reserve.

7.3.2 Distribution and abundance of herbivores in Sanjay Gandhi National Park

This occupancy survey case study has been performed and reported by research student Mr. Girish Arjun Punjabi with great support from of Principal Investigator Dr. Vidya Athreya (Wildlife Conservation Society – India Centre for Wildlife Studies, Bangalore). Others contributors have been the Mumbaikars SGNP project; The Maharashtra State Forest Department; Chief Conservator of Forests/Field Director of Sanjay Gandhi National Park Mr. Sunil Limaye; Range Officer Mr. Prashant Masurkar; Range Officer Mr. Kiran Dabholkar and a number of private individuals.

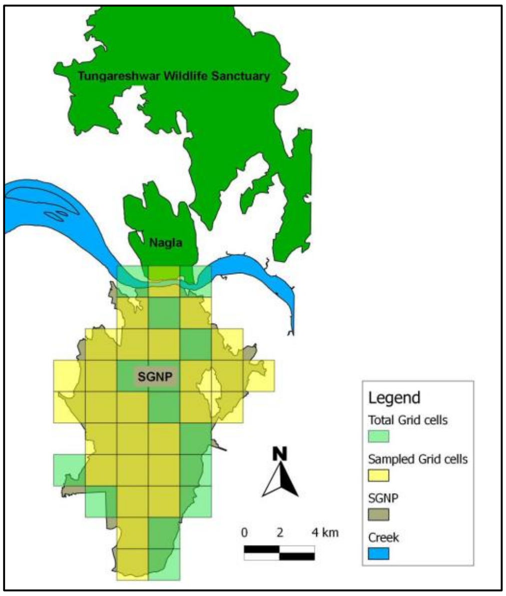
Introduction
Occupancy is a state variable examining the proportion of sites occupied by an animal (MacKenzie et al., 2002). Generally, when examining occupancy the focus shifts from actually counting animals to examining proportion of sampling units (for example, grid cells) occupied by the animal. The occupancy technique has become increasingly popular in species distribution and occurrence modeling, due to its ability to tease apart true absence from non-detection.

Moreover, recent advances in the occupancy technique have also introduced models to estimate abundance using repeated counts (Royle and Nichols, 2003). There have also been recent developments to accommodate spatial dependence in survey replicates used for sampling (Hines et al., 2010). Using a combination of these developments and based on one earlier study (Rayar, 2010), we designed an occupancy survey to understand distribution and abundance of herbivores in Sanjay Gandhi National Park. The herbivore species known to occur in the park were spotted deer (*Axis axis*), sambar (*Rusa unicolour*), muntjac (*Muntiacus muntjac*), wild boar (*Sus scrofa*), four-horned antelope (*Tetracerus quadricornis*), and chevrotain (*Mosciola indica*).

Grid cells, each measuring 3.25 km^2 were overlaid on a map of the study area. The grid size was based on examining literature on known home range sizes of herbivore species (Rayar, 2010). 40 grid cells covered the park entirely, however on further examining the areas we ascertained 32 grid cells could be sampled given low percentage forest cover or steep terrain and two logistical constraints in the remaining eight grids. However, at the end of the study we managed to survey 27 grid cells given problems of accessibility and steep terrain. Of the 27 sampled grid cells, we detected enough signs of only spotted deer and sambar to perform the occupancy and abundance modelling. Overall detections for other species were too low (< 10 detections) to perform any modelling using the data. The study perhaps is the first of its kind to give baseline estimates of spotted deer and sambar cluster abundances (herd/ group abundances) in the Sanjay Gandhi National Park.

Study area
Sanjay Gandhi National Park is situated in suburban Mumbai, and measures 103 km^2 in area. The topography of the park is hilly and vegetation is mainly characterized by Southern Moist deciduous forest (Champion & Seth, 1968). More details on the study area can be found in an unpublished report by Edgaonkar and Chellam (1998).

The intensive study area covered a large portion of the Sanjay Gandhi National Park (about 80% by area of SGNP). We covered most portions of the park except for the central portion (encompassed by three grid cells) and a portion towards the East, near Mulund (2 grid cells). These areas were not sampled due to access issues, steep terrain and logistical constraints. The entire area of Nagla block was not a part of the proposed study area, however we did sample the southern end of Nagla block, just above the creek. Please refer to figure 20 below for map of total and sampled grids.



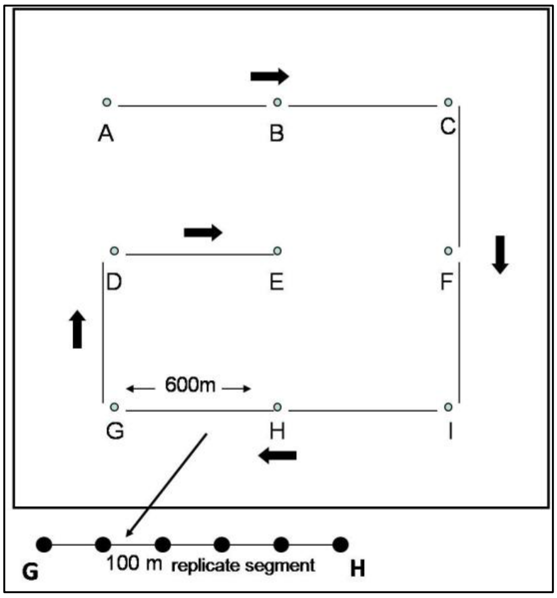


Figure 21 (left): Map showing sampled versus total grids overlaid on Sanjay Gandhi National. Figure 22 (right): Field sampling GRID Cell.

Field sampling

Each grid cell had 9 points and the design used for the survey has been shown in figure 21 above. Distance between each set of points (A to B to C to F to I to H to G to D to E) was 600 meters and the total walk effort in each cell was a maximum of 4.83 km. Each set of points was further divided into 100-meter replicate segments and data on presence/absence of herbivores (spotted deer, sambar, muntjac, wild boar and four-horned antelope) was collected on these replicates. We also collected data on human disturbance on the same replicate segments to be used as a covariate in the analysis.

Data compilation

Data was entered into spreadsheets as capture histories. Capture histories are dummy codes in the form of 1's and 0's indicating presence and absence respectively of the species sign or disturbance. Since we only detected spotted deer and sambar signs in the study area adequately (more than 50 detections), we used them in the distribution and abundance modeling further. Detection of other herbivores or their signs were very low (less than 10), therefore we could not model them to understand their distribution and abundance. However, we plotted them on maps of the study area, to understand where these detections occurred spatially.

Covariates

Primarily habitat and disturbance factors were considered to be important determinants of large herbivore distribution. For measuring human disturbance, we calculated a cumulative disturbance index, which was used as a covariate during modeling, by adding all detections of human disturbance in a grid cell divided by the walk effort in the respective grid cell. Habitat factors were ascertained by creating two indices- terrain/slope index and percentage forest cover. We calculated terrain/slope index by counting the number of contour lines in each grid cell, since the number of contour lines in each cell would appropriately index the terrain/slope in each sampling unit. The denser or more number of contour lines in a grid cell, the steeper the slope and vice versa. Percentage forest cover though calculated, was not used as a covariate since it was negatively correlated with cumulative disturbance index (Pearson's r > -0.6). We expected human disturbance to negatively influence spotted deer and sambar abundance (Ceballos and Lascurain, 1996), while terrain/slope index was hypothesized to negatively affect spotted deer abundance (Schaller, 1967; Duckworth et al. 2008) and positively affect sambar abundance (Timmins et al. 2008). We used covariates to examine their effect on occupancy as well, but they were not used to examine their effect on detection probability for any of the models.

Analysis

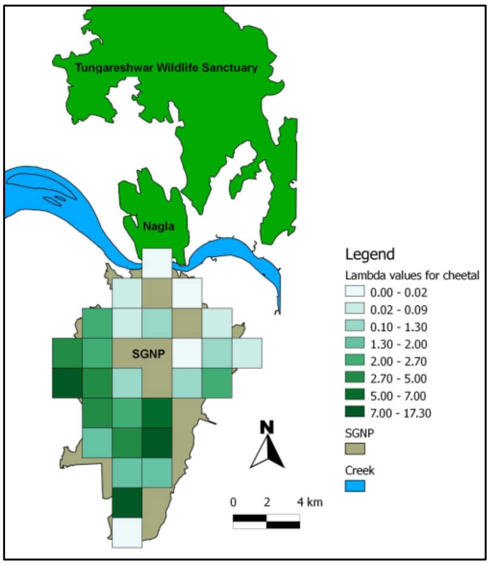
The analysis for spotted deer and sambar was done using data structured as per three replicate lengths each – 100 meters, 300 meters and 600 meters. Three kinds of models were used at each replicate length for each species- the Mackenzie et al. model (2002); the Royle and Nichols model (2003) and the Hines et al. model (2010). The Royle and Nichols model (2003) was the model that furnished values of r (where r = animal specific detection probability) and λ (lambda = grid cell specific cluster abundance). The selection of the appropriate replicate length to explain cluster abundance for spotted deer and sambar was chosen based on values of θ and θ' from the Hines et al. (2010) model at each of these lengths, where θ = probability of species presence on replicate, given absence on previous replicate and θ' = probability of species presence on a replicate given presence on previous replicate. As replicate lengths become independent, the difference between θ and θ' becomes lower. For more details on the technicalities of analysis, please refer to Rayar, 2010. All analysis was performed using the software PRESENCE2 (Hines, 2006).

Results

For spotted deer, the 100 meters replicate scale seemed the best choice, given the low difference in values of θ and θ', as well as overall values of r (animal specific detection probability) and λ (grid cell specific cluster abundance). Both cumulative disturbance index and Terrain/slope index were important variables in explaining λ (see table 7 below). The negative sign of the estimate indicates a negative effect. The value for r (overall animal specific detection probability) at the 100 meters replicate length for spotted deer was as low as 0.03. The values for lambda across the sampled grid cells have been shown in figure 21 below.

Covariate	Parameter estimate (SE)
Cumulative disturbance index	-0.449 (0.150)
Terrain/slope index	-0.119 (0.0363)

Table 7: Parameter estimates for the model examining the effect of covariates (cumulative disturbance index and terrain/slope index) on lambda of spotted deer.



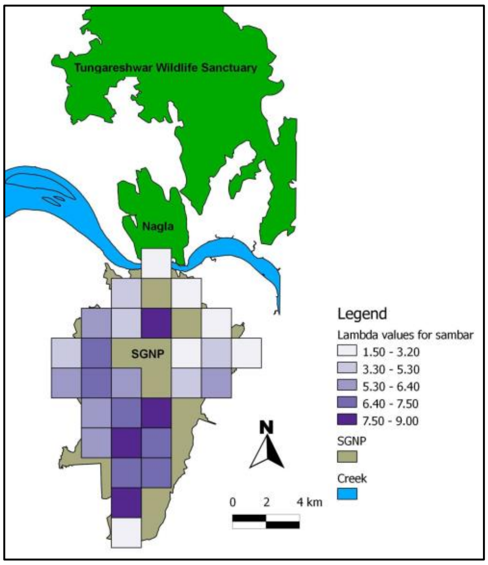


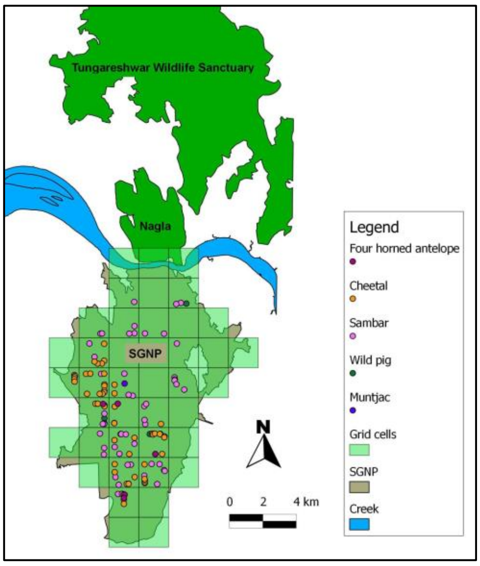
Figure 23 (left): Map showing spotted deer cluster abundance in Sanjay Gandhi National. Figure 24 (right): Map showing sambar cluster abundance in Sanjay Gandhi.

For sambar, the 600 meters replicate scale seemed the best choice, given the values of r (animal specific detection probability) and λ (grid cell specific cluster abundance). Cumulative disturbance index was an important effect, but terrain index did not have any effect due to weak Parameter estimates (see table 8 below). The value of the standard error for terrain index was high; therefore, the variable was not influential. The value for r (overall animal specific detection probability) at the 100 meters replicate length for sambar was as low as 0.07. The values for lambda across the sampled grid cells have been shown in figure 22 above.

Covariate	Parameter estimate (SE)
Cumulative disturbance index	-0.154 (0.073)
Terrain/slope index	0.0313 (0.030)

Table 8: Parameter estimates for the model examining the effect of covariates (cumulative

For all other species, namely nuntjac, four-horned antelope and wild boar, the number of detections overall were too low to perform the analysis meaningfully, therefore we have only plotted their occurrence on maps. These have been shown in figure 24 below. Lastly, we have also plotted on a map (figure 25 below) the prominent kinds of human disturbance we noticed.



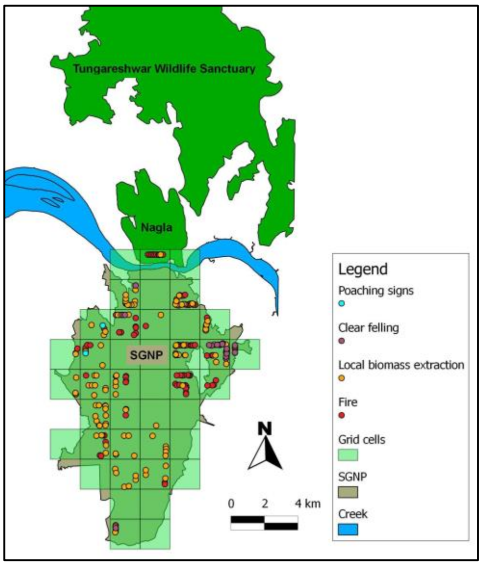


Figure 25 (left): Locations of herbivore signs recorded in Sanjay Gandhi National Park for examining herbivore occupancy and abundance from February to March 2012. Figure 26 (right): Map showing locations of disturbance signs recorded in Sanjay Gandhi National Park for examining herbivore occupancy and abundance from February to March, 2012.

Discussion

1. This study suggests that both spotted deer and sambar cluster (herd) abundance in the park are negatively influenced by human disturbance (cumulative disturbance index), indicated by the -ve sign of the parameter estimates of the Royle and Nichols (2003) model, shown in the tables 7 & 8.
2. Spotted deer cluster abundance is also influenced negatively by steep terrain (terrain/slope index), therefore areas with steeper terrain do not seem to support higher cluster abundances of spotted deer.
3. Overall, both spotted deer and sambar seem to be most abundant in the Central, Southern and Western parts of the park. For spotted deer, the best areas seem to be near the tourist zone, Malad trench line, Shilonda trail and areas around Tulsi and Vihar Lake. For sambar, the best areas seem to be areas around Tulsi and Vihar Lake, Chenna, areas around lion and tiger safari, highest point, Gaimukh and Air force station, Yeur (see figure 25 below).
4. The Northern and Eastern parts of the park both seem to have very low cluster abundance of spotted deer and sambar. These areas include Manpada, Ovala, Nagla (south side) and Yeur East (see figure 27 below).

5. Wild pig, four-horned antelope and muntjac sign detections were very low overall (7, 5 and 1 detection respectively) indicating that they likely occur in very low densities throughout the park (figure 23 above).
6. Occurrence of fire, followed by local biomass extraction seemed to be the most common forms of human disturbance and therefore management may need to address these threats first, since cumulative disturbance index was seen to negatively influence spotted deer and sambar cluster occurrence/ abundance in the park.
7. Areas around Yeur seem to be heavily disturbed given the low detection of herbivore signs and high detection of signs of human disturbance (figure 26 above).

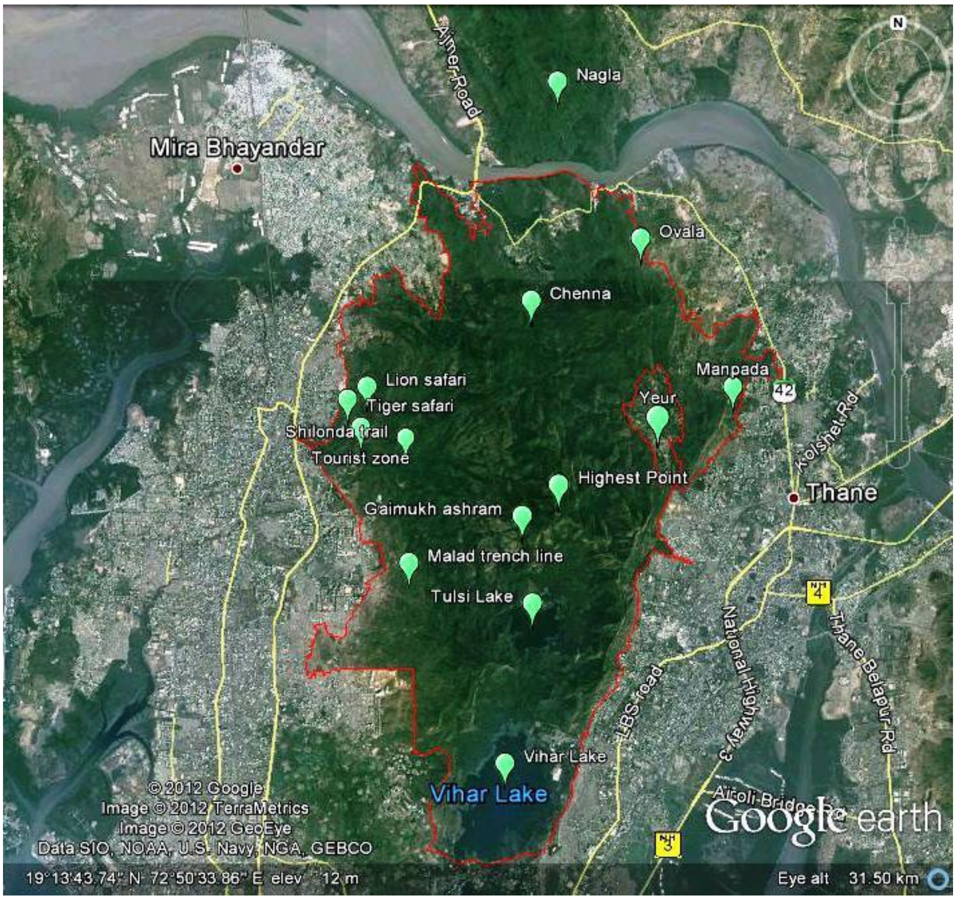


Figure 27: Map showing important locations in Sanjay Gandhi National Park for examining Herbivore occupancy and abundance from February to March 2012

7.3.3 Wild mammal biodiversity in the Pune District (Maharashtra)

This assessment case study has been performed and reported by Nikit Surve (Athreya and Surve, 2012) under the supervision of Dr. Vidya Athreya (Wildlife Conservation Society - India, Centre for Wildlife Studies, Bangalore). Other contributors have been the Forest Department of Junnar Division; CCF Pune district Mr. Nitin Kakodkar; DCF Junnar Mr. A.D. Bhosle; Range forest officers of Shirur and Narayangaon ranges (Mr. Sanjay Kadu, Mr. Jadhav, Mr. Bulbule); Forest Guard-Shirur Mr. Datta Phaphale and a number of local farmers..

Introduction

Camera traps are a valuable tool to understand the presence and status of wildlife. A camera trapping survey was conducted in the Ambegaon and Junnar talukas of Pune district to examine the presence of wildlife in an agricultural landscape. Different species of wildlife also use human-use areas and this recent branch of ecology is termed as urban ecology (Gehrt et al. 2010). Rural India has characteristics that fit into the definition of urban ecology in terms of a high degree of modification of the natural habitat as well as a very high density of humans. Although not well studied, many species of wildlife occur outside Protected Areas in India, in rural landscapes. This survey was carried out to document the wildlife present in a human-dominated landscape of Pune district, Maharashtra, India.

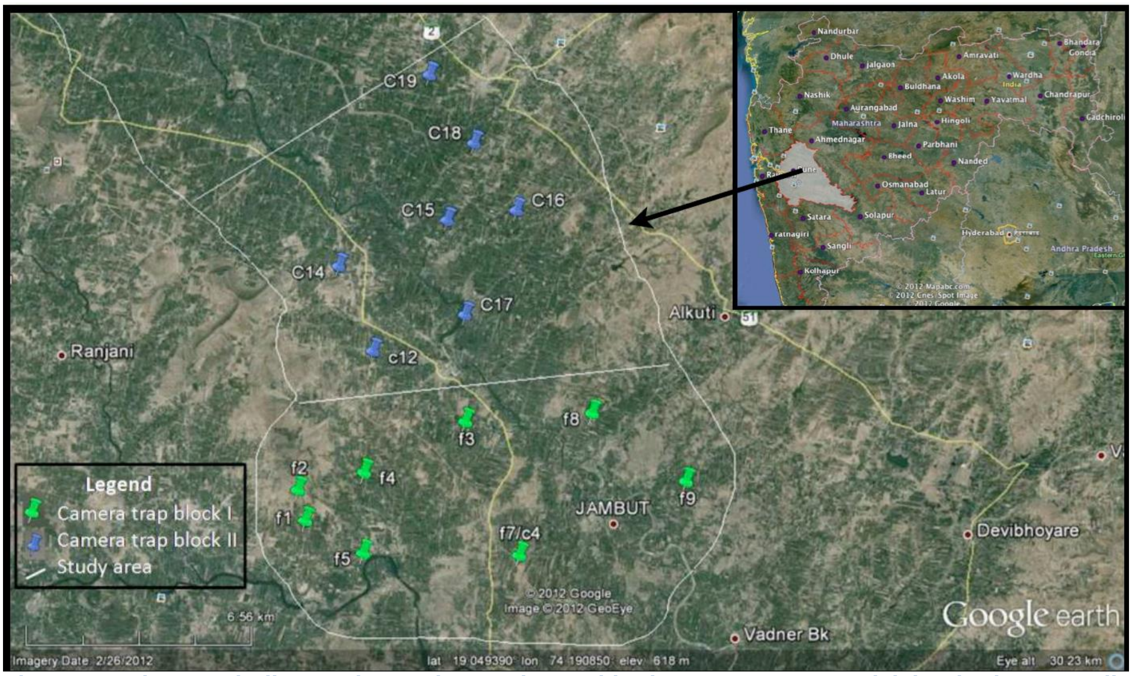


Figure 28: The map indicates the study area located in the Junnar Forest Division in the Pune district. The two blocks with camera trap points located in the agricultural landscape in Block I and II are highlighted in blue and green respectively.

The study area

The Junnar Forest Division (FD, 18°36’46.77” - 19°25’17.18”N and 73°29’08.78” - 74°20’34.02”E) is situated in the northwestern corner of Pune district. The area is administered by the territorial wing of the Maharashtra State Forest Department. The density of people is around 200 per km^2. The study area was divided into two blocks (henceforth, Block I and II) based on potential camera trap points, ease of logistics and known village boundaries in the Ambegaon and Junnar talukas (see figure 27 above). Only a small portion of Ambegaon taluka was covered, while the Junnar taluka formed a major portion of the study area. Block I consisted of the Shirur range falling under the Maharashtra Forest department and consisted of the following villages - Pimparkhed, Kathapur khurd, Jambut, Chombhut, Shirapur and Pargaon. The village Paragon was at the northern portion of Block I and served as a border between the two blocks. Block II was under Narayangaon range and was situated south of Narayangaon town and north of Pargaon village. It consisted of the following villages - Pargaon, Mangrul, Belhe, Nimgaon sawa and Sakori. The topography in both the blocks was flat, dissected by rivers and interspersed by few rocky hillocks.

Methodology

Camera traps were deployed in the study area from 3rd June to 22nd June 2012. Eight locations were sampled in Block I and seven in Block II where a pair of camera traps was placed on both sides of potential paths. These points were selected a priori by observing paths trails, intersections, dry streams, and rivulets on a satellite image of the study area (Google Earth Version 6.1.0.5001, Copyright 2011 Google Inc.).

The camera traps used in this project work on the principle of heat sensing. Each camera being a film roll camera trap had an attached heat sensor connected with the circuit. The sensor detects any object with a temperature higher than the surrounding temperature and triggers the circuit that then sends a signal to the camera to click with a flash.

While setting the camera traps a few guidelines were followed, such that a pair of cameras was set at approximately 50 to 60 cm above ground level, facing each other at a distance of eight to ten feet on opposite sides. Cameras were set on both sides of a selected point, such a trail or a dry streambed to get images of both flanks of the animals. The cameras were active only from the early evening to early morning because this is the period when wild animals are usually active in a human-use landscape. A total effort of 230 trapping nights (120 and 110 in Block I and II, respectively) was invested in Block I and Block II.

Results: The wild animals captured on camera traps were as follows:

- Indian hare (*Lepus nigricollis*)
- Common palm civet (*Paradoxurus hermaphroditus*)
- Small Indian civet (*Viverricula indica*)
- Golden jackal (*Canis aureus*)
- Jungle cat (*Felis chaus*)
- Striped hyena (*Hyaena hyaena*)
- Leopard (*Panthera pardus*)
- Wolf (*Canis lupus*)

Leopards were captured at two different points at F2 and C17 in Block I and II respectively. We also captured images of golden jackal and Indian hare in Block I. A jungle cat was captured by the cameras at two places (C16 and C19) in Block II. A striped hyena was captured in one of the cameras in Block II. See figure 26 for location of camera trap points within the study area.

Discussion

The surveys obtain evidence of eight wild mammal species in the agrarian landscape of the study area of which seven were carnivores (including the probable image of a wolf). It is often thought that wild animals are restricted to forests and protected areas but the local people were aware of the presence of these species in their environments.

7.3.4 Occupancy of large-felids in the Sindhudurg district (Maharashtra)

This occupancy case study has been performed and reported by research student Girish Punjabi and Principal Investigator Dr. Vidya Athreya (Wildlife Conservation Society - India, Centre for Wildlife Studies, Bangalore). Other contributors have been the Maharashtra State Forest Department and a number of private individuals.

Introduction

Large carnivores have suffered massive range contractions in the last century (Cardillo et al. 2004; Schipper et al. 2008). The tiger (*Panthera tigris*) and leopard (*Panthera pardus*) are listed as endangered and threatened large carnivores respectively, and their distribution in India is restricted and patchy (IUCN 2010; Karanth et al. 2009). The Western Ghats has been recognized as a priority site for large carnivore conservation in India (Das et al. 2006), and very recently, it was inscribed on the World Heritage list (UNESCO 2012). The northwestern Ghats and adjoining forests in the Konkan region of the state of Maharashtra are heavily human-modified and there is a constant threat of large-scale land-use modification from infrastructural, industrial and irrigation projects. The Sindhudurg district in Maharashtra is the southernmost district in the state and has forest connectivity to Protected Areas (PAs) further south in Karnataka and Goa states. An earlier study found a high probability of occupancy for tigers (more than 0.7) and leopards (more than 0.9) in a portion of the proposed study area (Punjabi and Edgaonkar, 2012 report submitted to Maharashtra Forest Department). The current study aimed to assess a) Large felid habitat use and occupancy (MacKenzie et al. 2002) in a larger landscape (approximately 1500 km^2) and b) Density of large felids in the forest and human-use areas (approximately 300 km^2) of the district using camera trapping and DNA sampling.

Study area

The study area comprised of reserve forest areas in the Sindhudurg district (in Kudal, Sawantwadi and Dodamarg tehsils) under the jurisdiction of the Maharashtra State Forest Department. The study area also comprised of a number of community and private forests, private plantations of cashew (*Anacardium occidentale*), areca nut (*Areca catechu*), mango (*Mangifera indica*), and many rubber estates. The total area covered was approximately 1410 km^2, spread across three tehsils covering areas with natural and modified vegetation (see figure 28 below). Permissions for the study were obtained from the Chief Wildlife Warden`s office vide letter no. Desk-22(8)/Research/3660/2012-13 dated 19-12-2012.

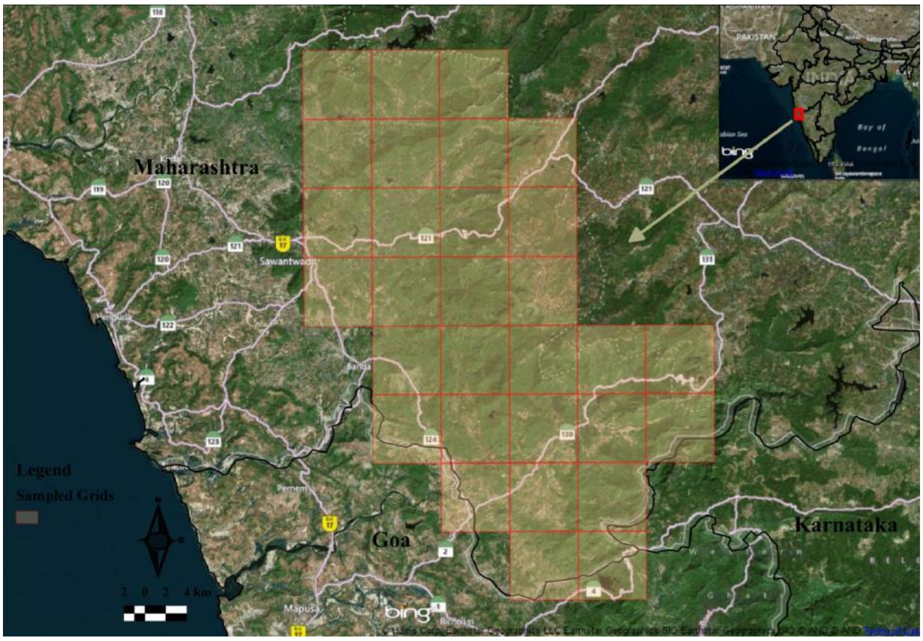


Figure 29: Map of the study area in the Sindhudurg district showing the grids sampled and underlying vegetation as seen in a satellite map of the region

The vegetation type is broadly composed of Tropical evergreen, semi-evergreen and moist deciduous forests (Champion & Seth 1968), interspersed by open forest and scrub areas in the landscape. Characteristic species of semi-evergreen forests include *Olea dioica*, *Mallotus philippensis*, *Macaranga peltata* and *Terminalia paniculata* (Ghate et al. 1998; Pascal 1988). Some characteristic species of stunted evergreen forests are *Actinodaphne angustifolia*, *Memecylon umbellatum* and *Syzygium cumini* while *Terminalia crenulata*, *Lagerstroemia lanceolata*, *Grewia tiliaefolia*, *Dillenia pentagyna*, *Careya arborea* and *Xylia xylocarpa* are typical of moist deciduous forests of the northern Western Ghats (Ghate et al. 1998). The study area witnesses distinct seasonal shifts from the hot season (March to May), to the monsoon season (June to October) and the cold season (November to February). Temperatures vary from about 10 °C in the cold season to about 38 °C in the hot season. Elevation ranges from near sea level to 700 m above sea level. Average rainfall during the monsoon season in the study area is about 3200 mm.

Methodology

We also surveyed grid cells to examine habitat use of tigers and occupancy of leopards in the mixed-use landscape. Each grid measured 47 km^2 in size and a survey effort on trails of 2 to 10 km was invested in each grid, based on the amount of cover available to large carnivores. Potential covariates that could influence occupancy/ use of large felids were also collected. These included noting signs of wild prey species of ungulates, gaur (*Bos frontalis gaurus*), sambar (*Rusa unicolor*), barking deer (*Munticus muntjac*), wild boar (*Sus scrofa*), and four-horned antelope (*Tetracerus quadricornis*) at every 100 meters replicate length. Signs of livestock (cattle, buffalo, and goat) were also noted at every 100 meters replicate length. We also noted signs of anthropogenic activities, such as local biomass extraction, occurrence of fire, clear felling of forest or organized commercial extraction of biomass, mining, and signs of poaching along every 1 km replicate. Such anthropogenic activities may cumulatively have a negative impact on the occurrence of large felids. Percentage forest cover of each grid cell was extracted using Google, Earth imagery of the study-site.

Detection histories were formed by combining detections and non-detections of species for replicates of each cell. Covariates such as percentage forest cover (F.cov), index of human disturbance (disturb.index), index of wild prey availability (prey.index), and index of livestock abundance (lvs.index) and walk effort (walk.effort) were z-transformed and used as site-specific covariates for species occupancy. Signs of ungulates and livestock were summed over ten 100-meter replicates for each 1 km replicate. These were then further added and divided by the walk effort invested in each cell to create an index of prey or livestock abundance. This made it a comparable metric across sampling grids as the number of encounters of ungulates or livestock for every km surveyed. Wild prey for tigers included detections of all wild ungulate species. For leopards, a separate prey index was created, where detections of gaur were removed, but livestock were included since leopards are known to prey on livestock. Similarly, all detections of anthropogenic activities were indexed over every 1 km replicate.

We used the Markovian model, as described in Hines et al. (2010), that enables estimation of five parameters of interest, probability of site-level occupancy (ψ), probability of presence on first replicate ($\theta_{0\pi}$), probability of presence on replicate, given absence on previous replicate (θ_0), probability of presence on replicate, given presence on previous replicate (θ`), and replicate-level detection probability, given presence (p_t). Hines et al. (2010) and Karanth et al. (2009) can be referred to, for more details on model parameters and their estimation.

We first tested for possible biases and lack of precision in estimation of parameters by doing a simulation study in the software GENPRES. We used the "single-season spatial correlation" model type using the p (.) model variant as described in Harihar and Pandav (2012). We fixed the number of sites to 30, and number of surveys to 10 and then ran simulations under different scenarios of occupancy and detection probability set as truth, and noted the predicted values of occupancy and detection probability and standard deviations associated with each case. The results of our simulations and potential implications of our sampling strategy are discussed in the results section. Next for our actual occupancy analysis, similar to Karanth et al. 2009, we first fixed a model structure for detection probability by using the Hines et al. (2010) model. We used a global occupancy model and used alternative structures with walk effort and index of livestock abundance and null (no covariate) for detection probability, to fix the covariate structure for replicate-level detection probability pt for each carnivore species. Based on Akaike‟s information criterion (AIC) model rankings and Akaike weights (*wi*), we first chose the structure of the model for detection probability. We then kept the covariate structure for detection probability unchanged, and tested a set of candidate models to examine factors and test predictions underlying occupancy/ use of the two large carnivores. Since surveys did not start at the boundary of the grid cell, we expected $\theta_{0\pi}$ would not be equal to rest of thetas. $\theta_{0\pi}$ (theta0pi) was fixed to „eq." in the fixed parameters option, which meant that it was computed using values of θ_0 and θ` in the likelihood function. We performed all analyses in Program PRESENCE (version 5.9, Hines 2006) using the custom „w/spatial correlation‟ option and evaluated candidate models using the Akaike‟s information criterion (AIC) and model weights.

Density was estimated using camera trapping and DNA sampling. We initially deployed camera traps (Deercam) on forest-trails in the study area to assess the possibility of density estimation of large felids using camera trapping. Sites were selected based on a survey of trails and wildlife sign encounters in an area. Cameras were placed either singly or in pairs depending on the width of the trail (see figure 29 below). Most cameras were checked daily, but cameras in some remote areas could only be checked once in a week or sometimes even lesser. An effort was made to deploy each camera for a minimum of one-week at a site; however, this was not possible in some cases due to excessive livestock movement, which exhausted camera rolls. Density estimation using camera trapping was not attempted due to large wastage of film and the high possibility of theft in the areas. Since the area was large it was not possible to remove all the cameras and redeploy them every day.

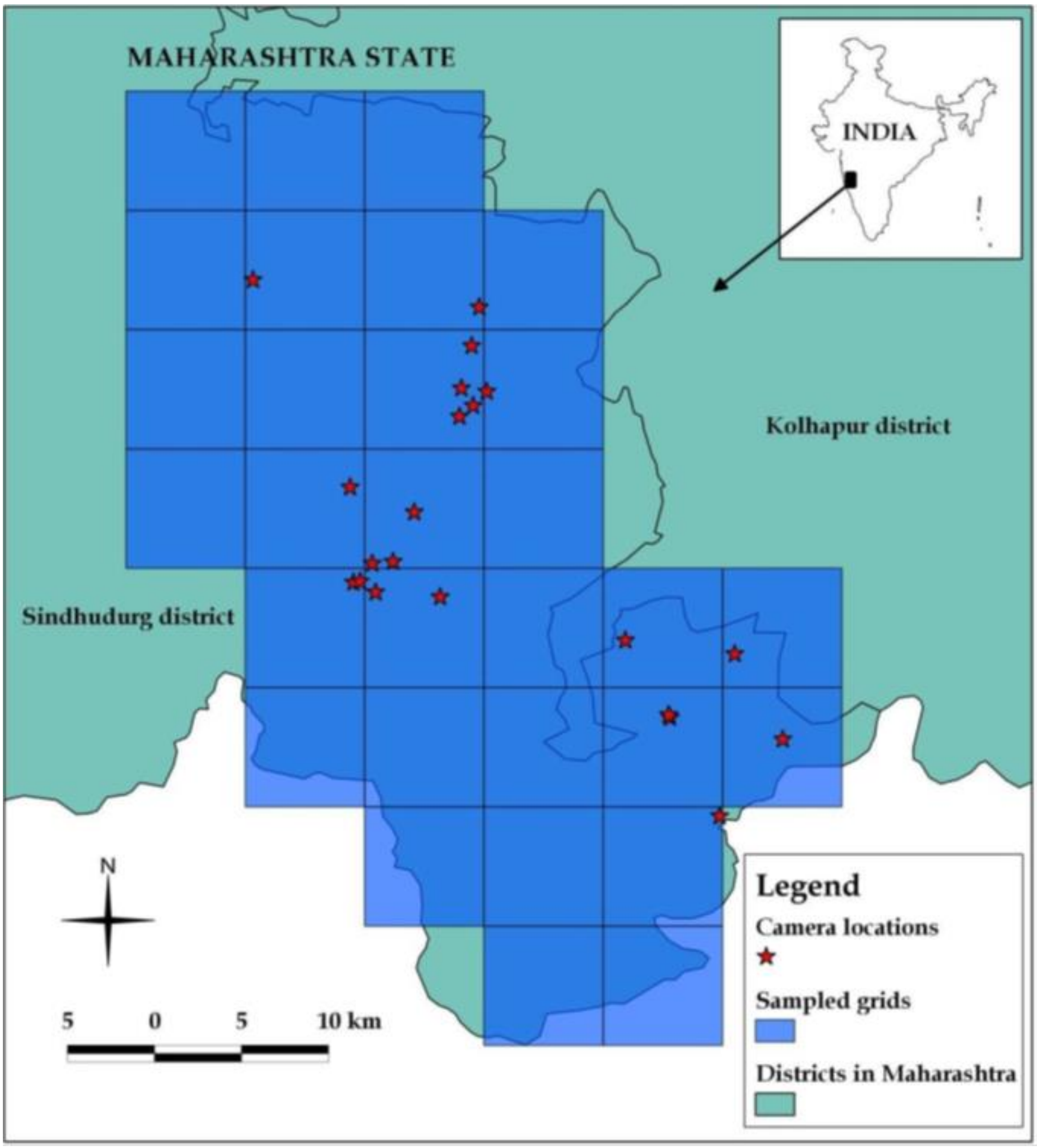


Figure 30: The map depicts the number of grids sampled and the location of the camera points (21 locations) placed in the study area from 20th December 2012 to 20th March 2013.

Lastly, to estimate population sizes using DNA sampling, we collected fresh scat samples of tigers and leopards if we encountered them on survey trails. Since scats were not very common (based on encounter rates during our occupancy surveys) and would not have provided us the sample sizes to allow for good estimation of density of large felids we did not attempt density estimation using DNA sampling either.

Results from the occupancy simulations

We surveyed 30 grids in the study area from 20th December 2012 to 20th March 2013. Since the sample size for our study was small, we initially ran a simulation study to examine its effect on bias and precision, the results of which are summarized in table 9 below.

Case	Psi	p	Predicted Psi	STDEV_Psi	Predicted_p	STDEV_p
1	0.3	0.2	0.55	0.36	0.54	0.38
2	0.3	0.3	0.54	0.33	0.56	0.33
3	0.3	0.5	0.46	0.29	0.64	0.27
4	0.5	0.2	0.64	0.29	0.50	0.36
5	0.5	0.3	0.64	0.25	0.52	0.32
6	0.5	0.5	0.63	0.23	0.60	0.26
7	0.7	0.4	0.79	0.18	0.56	0.28
8	0.7	0.6	0.78	0.15	0.66	0.21
9	0.7	0.75	0.76	0.14	0.77	0.16

Values for θ_0 and θ' were fixed to 0.2 and 0.7 respectively (derived from Karanth et al. 2011), Psi= occupancy, p = detection probability, Predicted Psi = predicted occupancy, STDEV_Psi = predicted standard deviation of occupancy, Predicted_p = predicted detection probability, STDEV_p = predicted standard deviation of detection probability

Table 9: Table indicates the different scenarios (cases) of occupancy and detection probabilities (set as truth) that were simulated with sample size = 30 and surveys = 10 to examine bias and precision in the occupancy analysis.

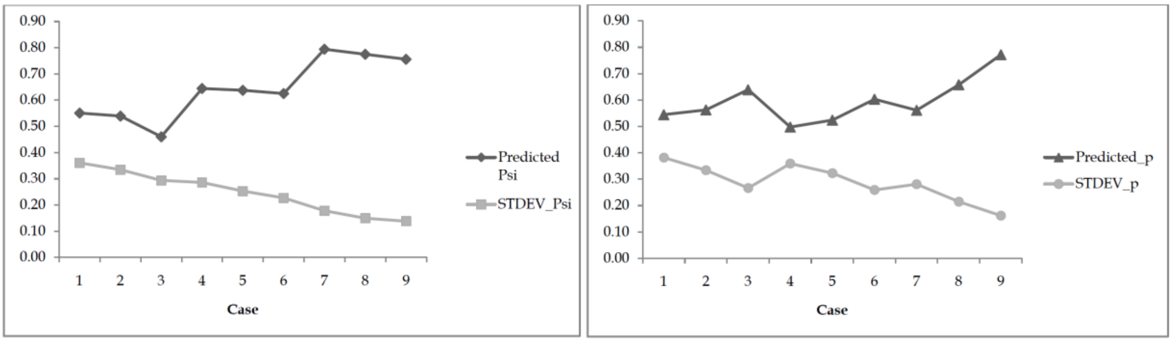


Figure 31: The graphs above indicate the values of predicted occupancy Psi (to the left) and detection probability p (to the right). Their associated standard errors in the different scenarios (cases) are presented in Table 9 above.

The simulations in figure 30 above suggest that with few samples (n = 30), cases with low occupancy and low detection probability will be biased (further away from truth) and less precise (high standard deviation). Since tiger sign encounters were low, we expected results of tiger habitat use to be more biased and less precise, while leopard occupancy to be relatively unbiased and precise.

Results from tiger use and leopard occupancy

For both tigers and leopards, models for detection probability suggested index of livestock abundance (lvs.index) and walk effort (walk.effort) to be important covariates (Table 10 below). For leopards, the model that included both covariates for detection probability stood second, however the difference in AIC scores was less than 2, indicating index of livestock abundance (lvs.index) and walk effort (walk.effort) to be important. We therefore included both covariates for explaining detection probability in further analysis of occupancy models.

Species	Model	AIC	ΔAIC	*wi*	No. Par.
Tiger	ψ (F.cov + disturb.index + prey.index + lvs.index), θ_0 (.), θ' (.), p_t (lvs.index + walk.effort), $\theta_{0\pi}$ (eq.)	79.58	0	0.42	11
	ψ (F.cov + disturb.index + prey.index + lvs.index), θ_0 (.), θ' (.), p_t (lvs.index), $\theta_{0\pi}$ (eq.)	80.19	0.61	0.31	10
	ψ (F.cov + disturb.index + prey.index + lvs.index), θ_0	80.7	1.12	0.24	10

	(.), θ' (.), p_t (walk.effort), $\theta_{0\pi}$ (eq.)				
	ψ (F.cov + disturb.index + prey.index + lvs.index), θ_0 (.), θ' (.), p_t (.), $\theta_{0\pi}$ (eq.)	84.81	5.23	0.03	7
Leopard	ψ (F.cov + disturb.index + prey.index), θ_0 (.), θ' (.), p_t (.), $\theta_{0\pi}$ (eq.)	259.59	0	0.48	8
	ψ (F.cov + disturb.index + prey.index), θ_0 (.), θ' (.), p_t (lvs.index + walk.effort), $\theta_{0\pi}$ (eq.)	261.26	1.67	0.21	10
	ψ (F.cov + disturb.index + prey.index), θ_0 (.), θ' (.), p_t (lvs.index), $\theta_{0\pi}$ (eq.)	261.86	2.27	0.16	9
	ψ (F.cov + disturb.index + prey.index), θ_0 (.), θ' (.), p_t (walk.effort), $\theta_{0\pi}$ (eq.)	261.92	2.33	0.15	9

Statement functions:
ψ = probability of site-level occupancy; $\boldsymbol{\theta_{0\pi}}$ = probability of presence on first replicate; $\boldsymbol{\theta_0}$ = probability of presence on replicate, given absence on previous replicate; **θ'** = probability of presence on replicate, given presence on previous replicate; $\boldsymbol{p_t}$ = replicate-level detection probability, given presence; **F.cov** = percentage forest cover; **prey.index** = index of prey availability (for tigers only wild ungulates, for leopards gaur were removed but livestock added); **lvs.index** = index of livestock abundance; **walk.effort** = effort walked in each grid; **eq.** = $\theta_{0\pi}$ computed using values of θ_0 and θ'

Table 10: Table shows models in explaining detection probability for the tigers and leopards ranked using Akaike"s information criteria (AIC), along with difference in Akaike scores (Δ AIC), Akaike weights (wi) and number of parameters.

In terms of occupancy models, four models received most support (ΔAIC less than 4) in explaining tiger use (table 11), while five models received most support in explaining leopard occupancy. For tigers, percentage forest cover and wild prey index showed a positive effect on tiger use, while anthropogenic disturbance showed a negative effect as expected (table 12). The variation associated with these parameters was high; yet the results suggest the positive effect of increased forest cover and wild prey and the negative effect of anthropogenic disturbances for tiger use. Walk effort and livestock index had a negative effect on tiger detection probability.

For leopard occupancy, anthropogenic disturbance and percentage forest cover had a positive effect on occupancy, while contrary to our expectation prey index (which included signs of sambar, muntjac, wild pigs and the presence of livestock) showed a negative effect. The variation associated with these parameters was high, thus these patterns are only suggestive. Walk effort had a negative effect, while livestock index had a positive effect on detection probability of leopards.

Species	Model	AIC	ΔAIC	*wi*	No. Par
Tiger	ψ (F.cov), θ_0 (.), θ' (.), p_t (walk.effort +lvs.index), $\theta_{0\pi}$ (eq.)	79.05	0	0.27	8
	ψ (F.cov + prey.index), θ_0 (.), θ' (.), p_t (walk.effort +lvs.index), $\theta_{0\pi}$ (eq.)	79.26	0.21	0.24	9
	ψ (disturb.index), θ0 (.), θ' (.), p_t (walk.effort +lvs.index), $\theta_{0\pi}$ (eq.)	79.4	0.35	0.23	8
	ψ (F.cov + disturb.index), θ_0 (.), θ' (.), p_t (walk.effort +lvs.index), $\theta_{0\pi}$ (eq.)	79.62	0.57	0.20	9
Leopard	ψ (disturb.index), θ_0 (.), θ' (.), p_t (walk.effort +lvs.index),$\theta_{0\pi}$ (eq.)	260.47	0	0.28	8
	ψ (disturb.index+ prey.index),θ_0 (.), θ' (.), p_t (walk.effort +lvs.index),$\theta_{0\pi}$ (eq.)	260.55	0.08	0.27	9
	ψ (F.cov + disturb.index+ prey.index),θ_0 (.), θ' (.), p_t (walk.effort +lvs.index),$\theta_{0\pi}$ (eq.)	261.26	0.79	0.19	10
	ψ (.),θ_0 (.), θ' (.), pt (walk.effort +lvs.index),$\theta_{0\pi}$ (eq.)	261.26	0.79	0.19	7
	ψ (F.cov),θ_0 (.), θ' (.), p_t (walk.effort +lvs.index),$\theta_{0\pi}$ (eq.)	263.18	2.71	0.07	8

ψ = probability of site-level occupancy; $\boldsymbol{\theta_{0\pi}}$ = probability of presence on first replicate; $\boldsymbol{\theta_0}$ = probability of presence on replicate, given absence on previous replicate, **θ'** = probability of presence on replicate, given presence on previous replicate; $\boldsymbol{p_t}$ = replicate-level detection probability, given presence; **F.cov** = percentage forest cover; **prey.index** = index of prey availability (for tigers only wild ungulates, for leopards gaur were removed but livestock added); **lvs.index** = index of livestock abundance; **walk.effort** = effort walked in each grid; **eq.** = $\boldsymbol{\theta_{0\pi}}$ computed using values of $\boldsymbol{\theta_0}$ and **θ'**

Table 11: Table shows top models in explaining occupancy and detection probability for tigers and leopards ranked using Akaike"s information criteria (AIC), along with difference in Akaike scores (Δ AIC), Akaike weights (wi) and number of parameters.

	Parameter	β-coefficients (SE)
Tiger ψ	F.cov	2.20 (1.22)
	prey.index	0.34 (0.40)
	disturb.index	-1.75 (3.58)
Tiger p_t	walk.effort	-1.65 (0.87)
	lvs.index	-2.28 (0.74)
Leopard ψ	F.cov	0.56 (0.77)
	prey.index	-1.38 (1.18)
	disturb.index	0.36 (2.22)
Leopard p_t	walk.effort	-2.40 (2.12)
	lvs.index	2.23 (2.68)
ψ = probability of site-level occupancy; **p_t** = replicate-level detection probability, given presence; **F.cov** = percentage forest cover; **prey.index** = index of prey availability (for tigers only wild ungulates, for leopards gaur were removed but livestock added); **lvs.index** = index of livestock abundance; **walk.effort** = effort walked in each grid		

Table 12: Table showing model-averaged β-coefficients with associated standard errors (SE) of covariates explaining tiger use and leopard occupancy in the northern Western Ghats.

The final estimates of use for tiger and occupancy for leopards are summarized in table 13. Tiger use in the region was predicted to be 0.43 (0.16), as opposed to a naïve estimate of 0.23, while leopard occupancy was 0.92 (0.06), while the naïve leopard occupancy estimate was 0.87. Spatial maps of tiger use and leopard occupancy are shown in figure 31 and 32. Detection probability for tigers was very low (0.21 ± 0.09), while for leopards it was high (0.91 ± 0.1).

Species	θ_0 (SE(θ_0))	θ' (SE(θ'))	θ_π (SE(θ_π))	p_t (SE(p_t))	Ψ (SE (Ψ))	näive Ψ
Tiger	0.78 (>10)*	1*	1*	0.21 (0.09)	0.43 (0.16)	0.23
Leopard	0.45 (0.08)	0.56 (0.08)	0.51 (0.07)	0.91 (0.1)	0.92 (0.06)	0.87

*Indicates biased estimates due to non-convergence

θ_0 (SE(θ_0)) = probability of species presence on replicate, given absence on previous replicate.
θ' (SE(θ')) = probability of species presence on a replicate given presence on previous replicate.
θ_π (SE(θ_π)) = probability of species presence on first replicate.
p_t (SE (p_t)) = probability of detecting a species" sign on a replicate, given presence on the replicate.
Ψ (SE (Ψ)) = overall occupancy of a species in the available habitat.
näive Ψ = naive estimate of occupancy of a species in the available habitat.

Table 13: Table showing final parameter estimates for tiger use and leopard occupancy and sign detection probability from model averaging

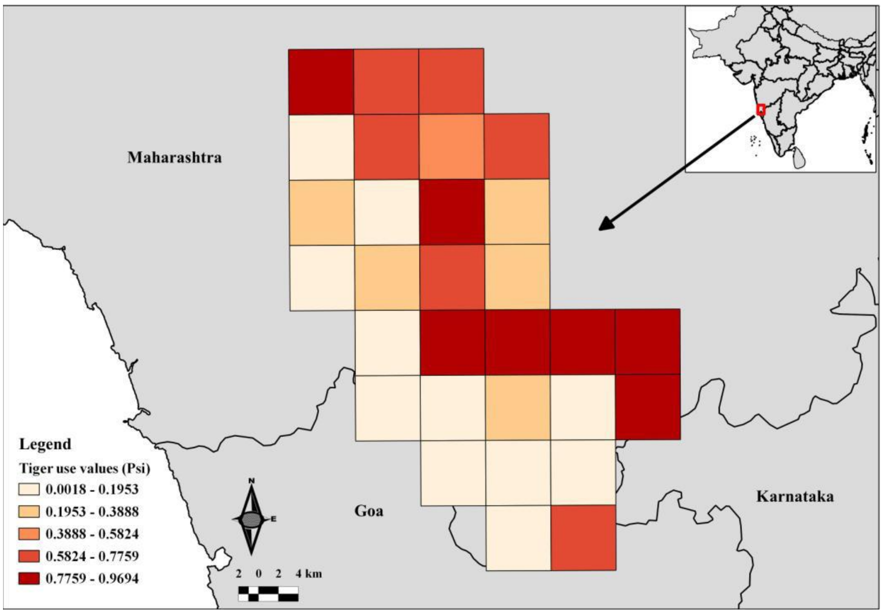


Figure 32: Predicted values of tiger use in the mixed-use landscape in Maharashtra, northern Western Ghats

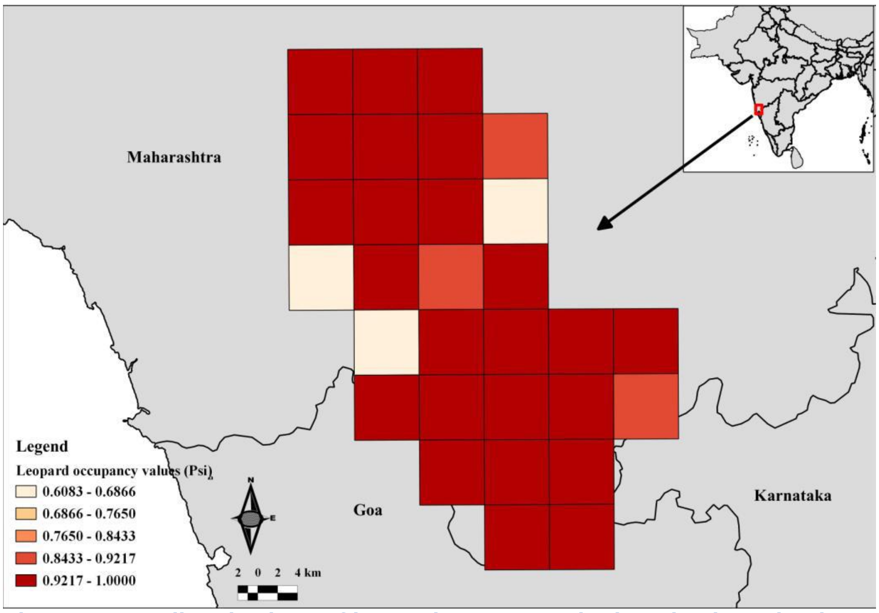


Figure 33: Predicted values of leopard occupancy in the mixed-use landscape in Maharashtra, northern Western Ghats

DNA analysis of scats for population estimation

The encounter rate of scats of the different wild carnivores during the occupancy rate was too low to allow population estimation; therefore, we have not attempted to carry out the DNA analysis work as planned. We hope to use the results of this work to identify potential areas where such work can be done in an intensive manner for a future study. Detections of tigers, leopards, and important prey species are shown in figure 33, 34, 35, 36 and 37 below:

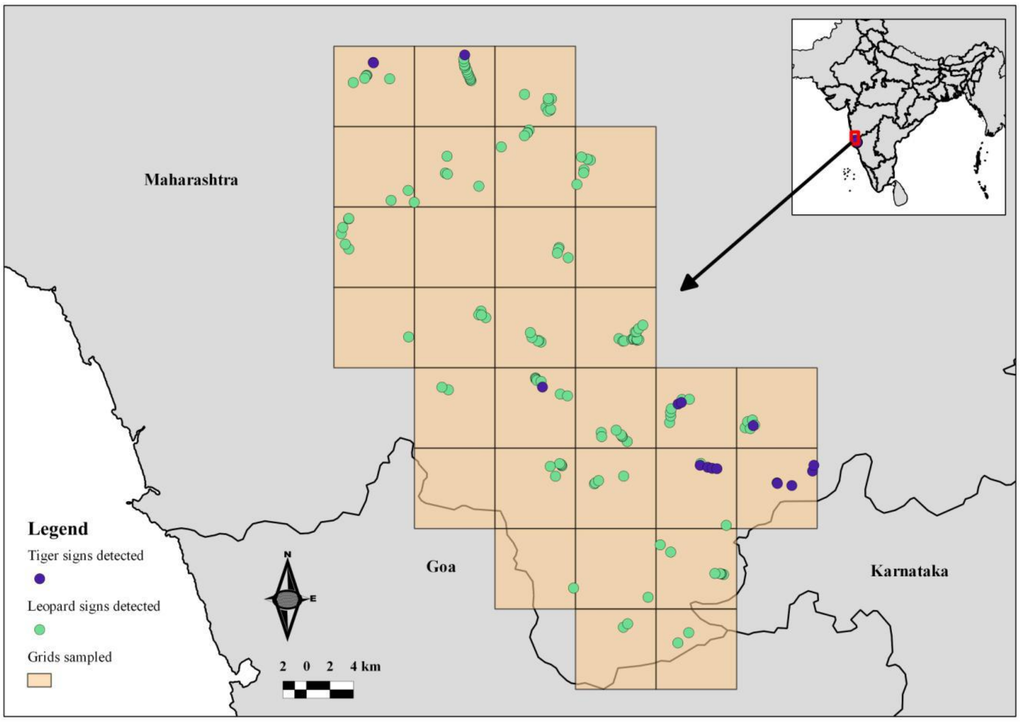


Figure 34: Tiger and leopard signs detected in the study region from December 2012 to March 2013

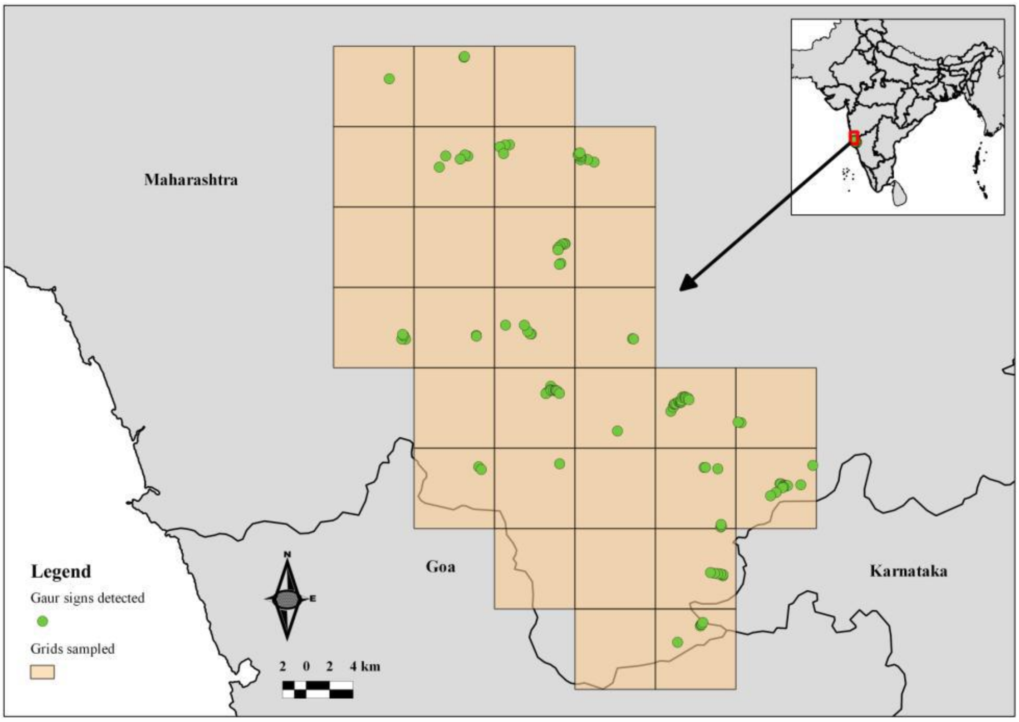


Figure 35: Gaur signs detected in the study region from December 2012 to March 2013

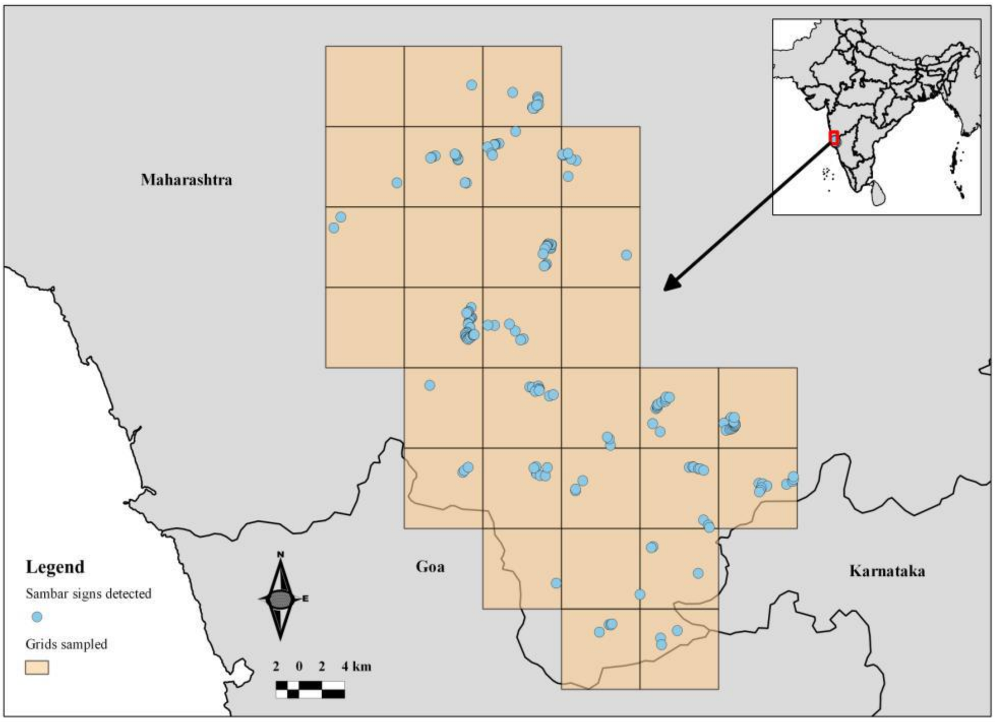


Figure 36: Sambar signs detected in the study region from December 2012 to March 2013

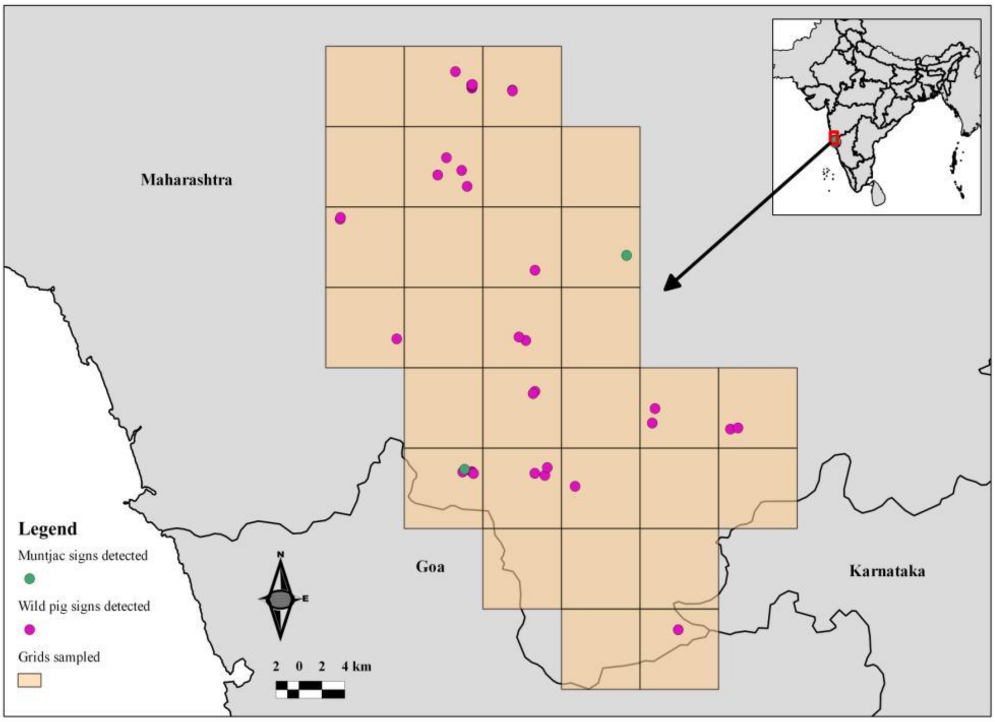


Figure 37: Muntjac and wild boar signs detected in the study region from December 2012 to March 2013

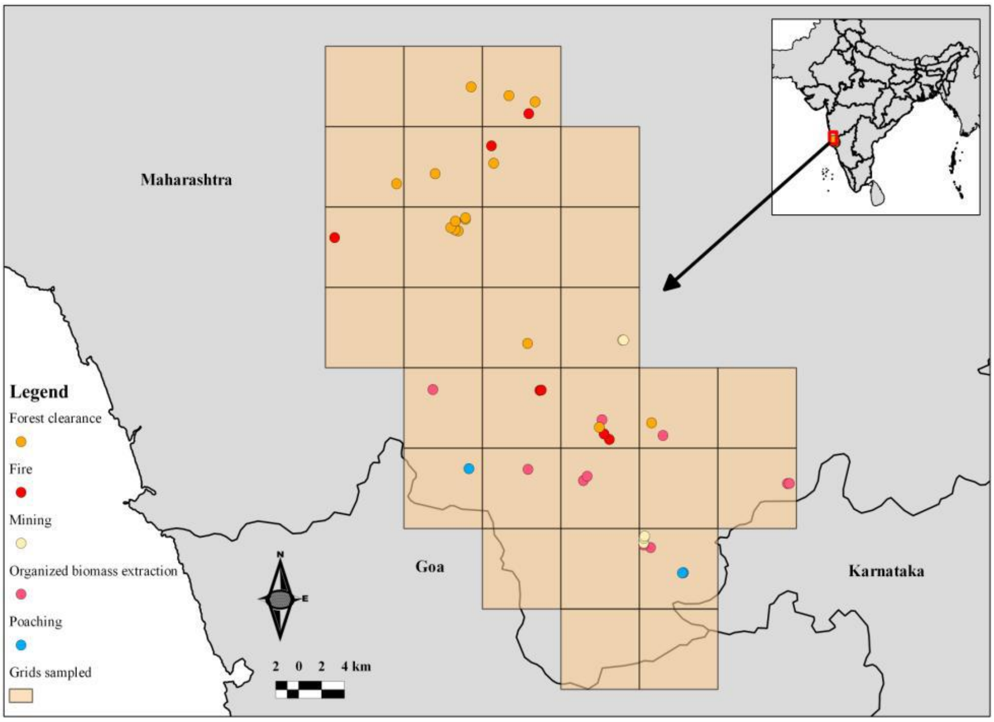


Figure 38: Human disturbance signs detected in the study region from December 2012 to March 2013

Conclusion

The results of our study highlight important areas for tigers and leopards in this region. Tigers seem to occur in low density in the region, evidenced from the overall low estimated use of 0.43 (0.16) and no captures during preliminary camera trapping activities. Leopards, on the other hand, showed a high occupancy of 0.92 (0.06) and were captured on seven camera trap locations out of 21 (30% of camera trap locations). Overall tiger signs were detected in seven out of 30 grid cells sampled, while leopard signs were detected in 26 grid cells.

Key recommendations from our study are as follows:

1. This region is part of a tiger corridor connecting Dandeli- Anshi tiger reserve in Karnataka to Radhanagri wildlife sanctuary in Maharashtra, thus there should be immediate policy decisions to increase the protection level in these areas to ensure tiger persistence in the future.
2. Status of tigers, leopards and other large carnivores and herbivores needs to be monitored on a regular basis and large-scale disturbances due to mining or infrastructural development should be strictly prohibited.
3. Since the region is human-dominated, with a large amount of forest under private ownership, incentive mechanisms that encourage landowners to keep areas under forest cover should be developed. There is a worrying trend of large-scale rubber estates taking over private forest areas in the region. These estates are rubber monocultures that seem to support little biodiversity and are often electric-fenced which creates a barrier to movement of wildlife. Tourism through „eco-lodges" may encourage landowners to retain forests and derive benefits out of it.
4. Wild herbivore densities appeared quite low in the region, possibly because of hunting. Few cases of poaching activities were observed during the study, therefore protection efforts should be enhanced in areas with higher occupancy of tigers. Some areas in Dodamarg tehsil could be potentially declared as a wildlife sanctuary to ensure connectivity for tigers in the long-term.

7.3.5 A survey for wildlife along the Khanduli River

The survey case study has been performed and reported by Girish Punjabi, with support from Dr. Vidya Athreya (Wildlife Conservation Society and India Program & Centre for Wildlife Studies, Bangalore), the Tiger Monitoring Cell (Ranthambore Tiger Reserve, Rajasthan State Forest Department) and Dr. Dharamendra Khandal (Tiger Watch, Sawai Madhopur).

Study area
The river Khanduli emanates from the Mansarovar dam, situated south of Ranthambore National Park and heads along the Eastern boundary of Sawai Mansingh Sanctuary. It gradually drifts southeast and merges with the mighty Chambal, in the National Chambal Sanctuary. The Khanduli flows through a mixed-use landscape comprising of forest, agricultural fields and plantations. However, like the Chambal, the river floods heavily during the monsoon and therefore the most dominant feature along its course is its ravines. These ravines are a myriad network of gullies and channels and form an important refuge for wildlife. In the dry season, segments of riverbed become attractive pastures for hundreds of heads of cattle, while there is also some marginal dependence on the water for agriculture. A portion of these ravines is part of the tiger reserve buffer flanked by agricultural fields on one side and Sawai Mansingh sanctuary on the other. It was this interface along the Khanduli that was surveyed to understand what species occur in such human-dominated environments in the buffer area as well as outside Ranthambore Tiger reserve.

14 camera trap locations (figure 38) covered the entire landscape of about 40 km^2 along the Khanduli and an adjoining rivulet outside Ranthambore Tiger reserve. The survey was conducted in the months of April and May 2012. A total effort of 130 trap nights was invested over the entire survey period.

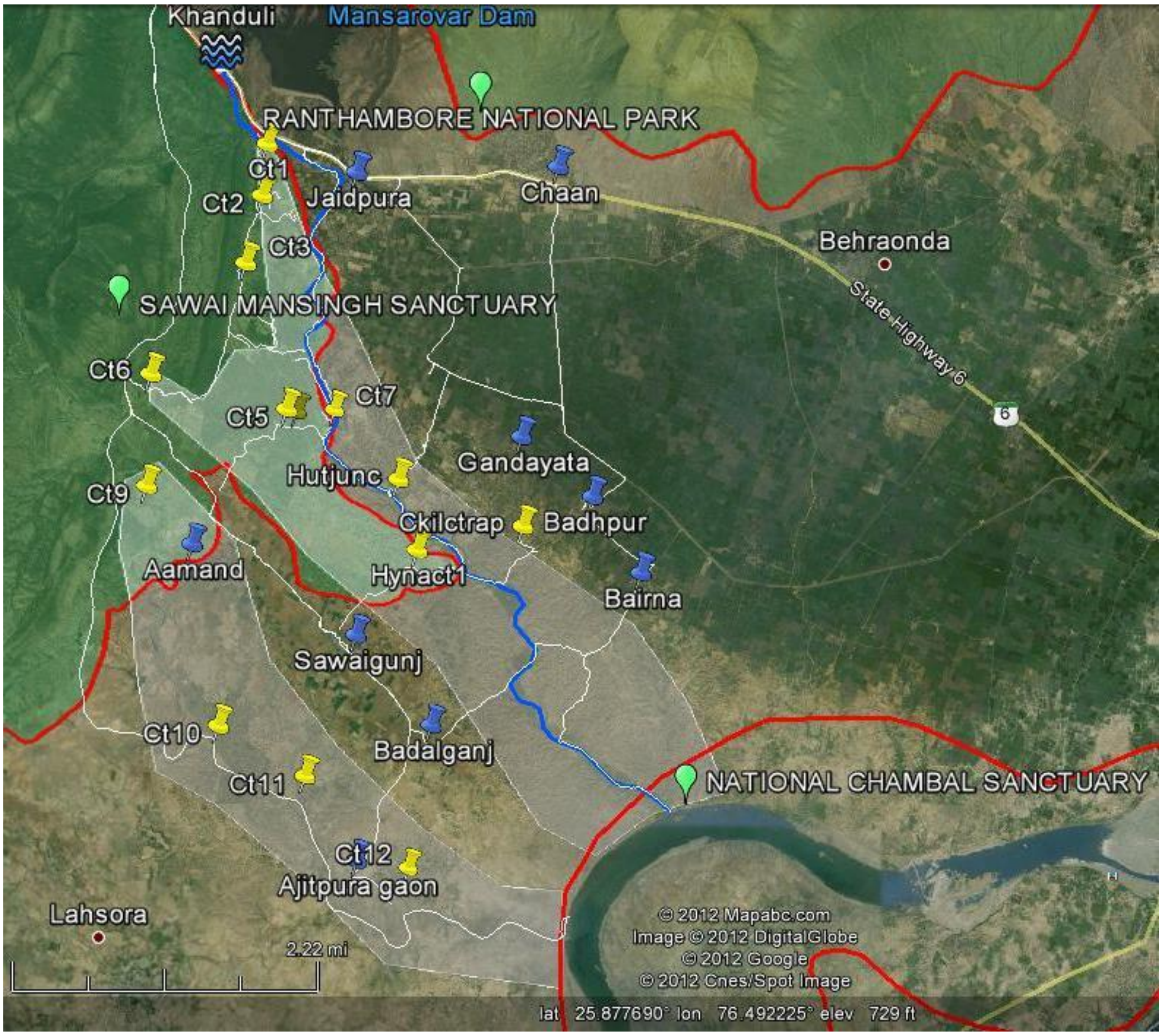


Figure 39: Google Map showing the study area (white polygons) around the Khanduli River (blue line), the location of camera traps (yellow pointers), villages (blue pointers) and roads/paths (white lines)

Results

The survey detected 12 species of mammals, including seven species of carnivores occurring in the area. Carnivores captured on camera included the tiger, leopard, hyena, sloth bear, jackal, jungle cat and the rare caracal. Other species found were sambar, nilgai, wild pig, Indian hare and porcupine.

7.3.6 Carnivores outside protected areas in India

This citizen science project www.carnivore.in has developed a web- application (figure 39 below) for uploading images of wild carnivores (sloth bear, brown bear, black bear, wild dog, foxes, hackals, wolves, jungle cat and other lesser cats, mongoose, civets, tiger, leopard, snow leopard, asiatic lion and hyena) that has been photographed outside (even far away from) any protected area in India. 408 images have so far been uploaded and registered into the portal.

Dr. Vidya Athreya has coordinated this project. The project has been supported by Conservation India, Center for Wildlife studies, Nature Conservation Foundation, Tiger Watch, the Wildlife Institute of India and the Norwegian Institute for Nature Research.

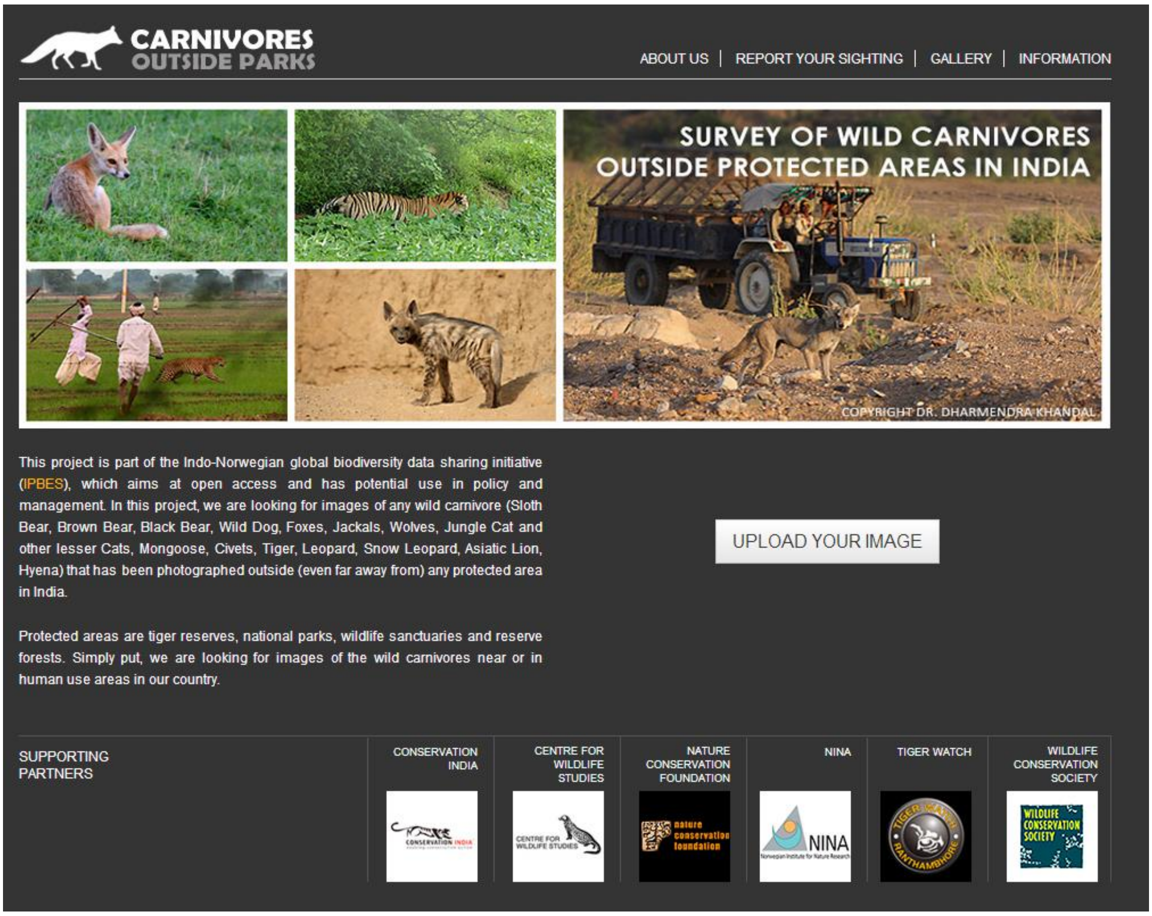


Figure 40: Screenshot of the Web- application interface of Carnivores Outside Parks

7.4 Mobilizing camera trap data (example from the Rajaji NP)

The camera trap data acquired by WII in Rajaji National Park had first to be organized using Geo- Tagging and metadata standards so that it could be mobilized and accessed by individuals, researchers, decision makers and the civil society.

Standardizing camera trap data
All the images from individual camera trap location were downloaded from the SD cards of cameras using a laptop and stored in different folders respectively. Individual tigers were identified based on their stripe pattern on the flanks, limbs and forequarters and given a unique identification number. Within the same folder bearing the name of the camera trap ID/code, two subfolders were created to store images from each of the paired camera traps that enabled easy Geo-tagging.

Geo-tagging images
Geotagging images is the process of embedding geographical information i.e. latitude and longitude coordinates into the Exchangeable Image File Format (EXIF)[74]. The EXIF format stores technical metadata about capture, image characteristics and more of an image. Geotagging can be done with the help of the Geosetter software[75]. This software is a freeware tool for Windows (XP or higher) for showing and changing geodata and metadata (such as EXIF) of digital image files. Once geo- tagged, an image can be visualized in a GIS platform.

[74] http://www.photometadata.org/meta-resources-metadata-types-standards-exif
[75] http://www.geosetter.de/en/

Extracting image metadata
For images captured using digital camera traps, date, time, ISO setting, exposure mode, flash usage, focal length and geographic coordinates (geo-tagged images) extracted using freeware program such as the BR's EXIFextractor[76]. This simple freeware program will extract the EXIF metadata from digital photos of JPEG- format in a folder and saves the data in a CSV-file (Comma Separated Values). Any program that is capable of reading CSV-files, for instance Microsoft Excel, Microsoft Access, PixFiler, and most database platforms can read this format.

Assigning unique Identifiers to images
After the identification of individual tigers, the data is organized in the Modified Audubon core template where a unique identifier number is assigned to the images. A 22-letter alphanumeric string proposed as unique identifiers for camera trap images (as described in section 4.2).

The unique identifier of an image from Rajaji NP was assigned as:
CTP050612012001A00049a
CTP: Camera trap photograph
05: State code for Uttarakhand (Census of India)
061: District code for Pauri (Census of India)
2012: Year in which photograph was captured
001A: Camera trap ID with A/B denoting one of paired camera traps
00049: sequential photo-capture number
a: **a/b/c** distinguishes between multiple objects in the same photograph

Registering metadata using the Audubon Core Template
In order to make large numbers of biodiversity-related multimedia data efficiently available for a research infrastructure, there is a great need for a standardized metadata regime. The GBIF- and TDWG (Taxonomic Databases Working Group) joint task group[77] has developed a multimedia resources metadata schema called the Audubon Core[78].

The Audubon Core is a set of vocabularies designed to represent metadata for biodiversity multimedia resources and collections. These vocabularies aim to represent information that will help to determine whether a particular resource or collection will be fit for some particular biodiversity science application before acquiring the media. Among others, the vocabularies address such concerns as the management of the media and collections, descriptions of their content, their taxonomic, geographic, and temporal coverage, and the appropriate ways to retrieve, attribute and reproduce them. The Audubon Core describes the media resources with consistent metadata. One Audubon Core metadata record is a set of terms and term values describing an underlying multimedia object and its attributes. The Audubon Core schema consists of 80 terms of which six are mandatory (Identifier, Type, Title, Metadata Language, Copyright Owner, and Copyright Statement).

WII have Geo-tagged and completed metadata for the captured tiger images from Rajaji National Park. The modified Audubon template is provided in Annex 1.

7.5 The national camera trap database

The general ambition of this project is that the national WII database will share image data and metadata from all the described case studies: The Rajaji National park, the Sanjay Gandhi National Park, the Pune District in Maharashtra, the Sindhudurg district in Maharashtra, the Khanduli River and the citizen scientist project “Carnivores Outside Parks”.

76 http://www.br-software.com/extracter.html
77 http://www.tdwg.org/activities/img/multimedia/charter/
78 http://www.tdwg.org/homepage-news-item/article/audubon-core-public-review/

7.6 The WII camera trap data Web Portal

The Wildlife Institute of India (WII) has developed a Web Portal application designed for making the standardized camera trap data (images and metadata) accessible to the stakeholders. The technical environment for this customized application is summarized in table 14 below.

Fields	Details
Location	WII
Operating System	MS Windows Server 2012 - 64 bit
Server Specifications	• Processor : One Intel Xeon, E5-2640, 20MB Cache, 8 Core • Chipset : Intel C600 • Memory: 64 GB DDR3 1600 RDIMM Maximum 768 GB • DIMM Slots - Minimum 24 DIMM slots supported by memory protection • Storage: HDD - 3 x 1.2 TB 6G SAS 10K rpm SFF with maximum scalability up to 72 TB with 24 drive bays. Smart Array P420i/1Gb FBWC Controller (RAID 0/1/1+0/5/5+0/6/6+0) • Optical Drive - SATA DVD ROM • NIC : 1Gb Ethernet four RJ45 port Expansion Slots: Nine total expansion slots. Three PCIe 3.0 x16 (x16 speed); One PCIe 3.0 x16 (x8 speed); Four PCIe 3.0 x8 (x4 speed); One PCIe 2.0 x8 (x4 speed). 64 GB RAM, x-64 based processor
Software	ERDAS APOLLO 2014
Database	PostgreSQL 9.2

Table 14: Web portal web application technical environment

Application Access and Environment Details
The application can be accessed from any system that has network access to the system. The user would access the application using a defined URL. The application can be accessed from any of the commonly used modern browsers. The supported browsers are Microsoft ® Internet Explorer 9+, Mozilla Firefox 14+, and Google Chrome 21+. The minimum supported screen resolution is 1024 x 768.

Login Page or Home Page
Login Page is the default start page for all users trying to access the application. An extra link is provided for the guest users. These users do not require any authentication to view this portal. Guest users can click on the link and will be redirected to the portal. The login page contains:

- Username text-box
- Password text-box
- Registration link
- Link to login as guest user
- Forgot password link
- Information on the application (Optional)
- Relevant header and footer information

Login Mechanism
There are primarily three kinds of users: Administrator Users, Registered Users and Non-registered/Guest Users.

Administrator Users
These administrators have access to all features of the customised application. One of their main functionality will be user management. The administrators need to login to access the customised application by providing valid username and password. The customised application have one preconfigured administrative account, which is used to login to the application and create required users. Success: The end-user is able to login to the application. Failure: The end-user stay on the login page with an alert statement mentioning that the user cant login.

Registered Users
The registered users are the users who have active login information, which is either managed by the administrator or approved by administrator. The registered users need to login to access the customised application. Success: The end-user is able to login to the application. Failure: The end-user stay on the login page with an alert statement mentioning that the user could not login.

Non-registered/Guest Users
The non-registered users are the users that can access the application without approved login authentication details. There are only one kind of user managed by the administrator, which are the “Guest User”. The details of the guest user are configurable.

Login Registration
Login should be through email-ID. The login page provides a facility for the new users to be registered. Clicking on the link opens up an interface asking user for the relevant information. Once the user provides the required information, a mail is sent to the administrator. The administrator approves the required users. Once it is approved, a mail is sent to the user on the registered email address. The mail contain the information to access the application. The users can then login to the application with the provided credentials and then change the password.

Forgot Password
The users can retrieve forgotten password by using a link on the login page. Clicking on the link opens up an interface asking the user for relevant information (required to identify the user). Once the user provides the required information, it is validated and a mail is sent to the user with new temporary password. The users can login to the application with the new credentials and then change the password.

Access Rights
The Table 15 is a mapping of what can be seen and accessed by the end-user depending on their credentials and the group that they belong to.

Functionality	Administrator Users	Registered Users	Non-registered Users (Guest Users)
Access the application	Allowed	Allowed	Allowed
View the map details (scale, projection, extents)	Allowed	Allowed	Allowed

Functionality	Administrator Users	Registered Users	Non-registered Users (Guest Users)
Change the map viewer's base projection	Allowed	Allowed	Allowed
View the Google images and ASTER DEM as background	Allowed	Allowed	Allowed till certain specified scale or zoom
View the geo-tagged photos layer with symbols	Allowed	Allowed	Allowed till certain specified scale or zoom
Viewing photographs	Allowed in full resolution	Allowed in full resolution	Only thumbnail is allowed
Uploading photographs	Allowed	Allowed	Allowed
Geo-tagging the photographs	Allowed	Allowed	Allowed
Provide metadata information for photographs during upload	Allowed	Allowed	Allowed
Edit the metadata information of the uploaded photograph	Allowed	Not Allowed	Not Allowed
Editing the geo-tagged layer features and attributes	Allowed	Not Allowed	Not Allowed
Approve, categorise or reject the photographs	Allowed	Not Allowed	Not Allowed
Authenticating Photographs that can be downloaded	Allowed	Not Allowed	Not Allowed
Download of authenticated photographs	Allowed	Allowed	Not Allowed
User Management	Allowed	Not Allowed	Not Allowed
View the attribute information of selected photograph	Allowed	Allowed	Allowed

Table 15: Web portal web application functionality

Data Sources

Vector Data
Vector data used in the customised application is in the format of shape files. The main application do access this data using the OGC web services created by ERDAS APOLLO. All the data is in standard and defined projection system and there are not any data in custom projection. If there is any, then the custom projection parameters are shared by WII. In addition, a new layer stores relevant information for the geo-tagged photographs.

Raster Data
Google Map (with Satellite, Map and Hybrid options) and ASTER DEM is used as background imagery. ASTER DEM is a single mosaicked raster data. All the data is crawled, managed, and configured using *ERDAS APOLLO Data Manager*. The display of data in the map viewer is based on the configurations defined for the layer in the *ERDAS APOLLO Data Manager*.

Performance Improvement
To improve the performance, Intergraph focussed on delivering the data in optimum way. One of the ways was to serve the raster datasets as OGC WMTS (over ECW data). This allowed users to view the datasets without installing any plug-in. To extract the best performance, Intergraph worked with WII to use ECWs or OTDFs as the raster data formats. If creating ECW is not an option, then Intergraph shall use the data in its original format. WII will need to confirm whether creation and using of ECW is an option.

User Management
This allows the administrators to create and approve new users, update users, and delete users. User management includes the following options Add/Approve User, Update User and Delete User. Assumption: All the user related information like username, password, and other user details are stored in the database.

Basic Map Controls and Toolbar Controls
The application contains map control toolbar buttons for different map operations. All users have access to the following tools: Zoom in, Zoom out, Interactive Zoom, Zoom to initial extent and Pan. Some of these tools are available as quick-navigation tools allowing the users to click and perform the operation (like zoom by one level, or pan by one screen, etc.)

Distance and Area measurements
The distance (segment and total) and surface area tools are available to all users.

Layer Manager and Functionalities
All users have access to the layer manager and its functionalities. The users can:

- Style the feature layer
- Reorder the layer
- Set to view the data in specific scale ranges
- Render the data as tiles or as map
- Choose output format (if want to change the default)
- Show or hide datasets by setting the visibility

Overview Window
All users are able to view the overview of the map viewer in a simple and separate small window. The data used in the overview window can be configured.

Uploading the Photographs

The application allows the users to upload static images or photographs. The users are provided with an option to choose the photographs, stored locally, to be uploaded to the server. The uploaded photographs are to be of either JPG or PNG file format. The photographs are copied and stored in a specific directory structure on the server. The path of these photographs are referenced as one of the attributes. The user have an option to geo-tag these photographs. The user are provided with additional option to attach metadata related to these photographs. All photographs, approved by administrator, are shown as a fixed symbology in the map viewer. When the user clicks on the location where the photographs are geo-tagged, the user has an option to view the photograph and its metadata. These are uploaded based on the rights defined by the administrator. Only the photographs that have been approved by the administrator are shown in the portal to the users.

<u>Metadata for the Uploaded Image</u>

The user fills in Metadata for the uploaded image during the upload process. The user have to enter the mandatory fields and additionally optional fields. The default is populated where needed. The administrator is intimated on each upload of photograph via email notification. Once the administrator approves these photographs, all users are able to download these geo-tagged photographs.

<u>Geo-tag the Photographs</u>

The user uploads the static images or photographs. The user can define a location and then upload the photo to that location. Geo-tagging the photographs are mandatory. The photographs and its metadata are not uploaded to the server until the photos have some location defined. Assumption: Geo-tagging of the image is based on user click while uploading of the image. The administrator have the option of editing it and setting it again, if desired.

<u>Symbology of Uploaded Photographs</u>

The portal application shows these uploaded photographs as a separate layer. This layer is a fixed pre-defined theme. The photographs are classified in either “Scientific” or “People’s Initiative” type. The symbology of the photographs is depicted on the map viewer. The depiction is based on either of these two classifications. The user has an option to know the details of each classification with some fixed text defined by the administrator in the form of legends.

<u>Admin Rights for Photographs</u>

This application portal has an option for the administrator to view uploaded images. The administrator has following rights with these photographs:

- Categorize the uploaded image as per classification.
- Edit metadata for the uploaded image.
- Reject the uploaded image.
- Approve the uploaded image before it is shown as a symbol to the general users.
- Assign downloadable rights for this photograph.

<u>Resolution of Uploaded Photographs</u>

The approved photographs are displayed on the map viewer as a thumbnail or in good resolution based on the group to which the user belongs. The registered users and the administrators are able to view the photographs in good resolution. The guest users are able to view the photographs just as a thumbnail. The user needs to click on the symbol to display the photo in an embedded interface or a new window.

Downloadable Rights for the Users

The administrators has an option to assign rights to each photograph. General users do not have any option to download the geo-tagged photograph. Registered users have an option to download a photograph based on user rights. Administrators are able to do update, edit, or delete any photograph.

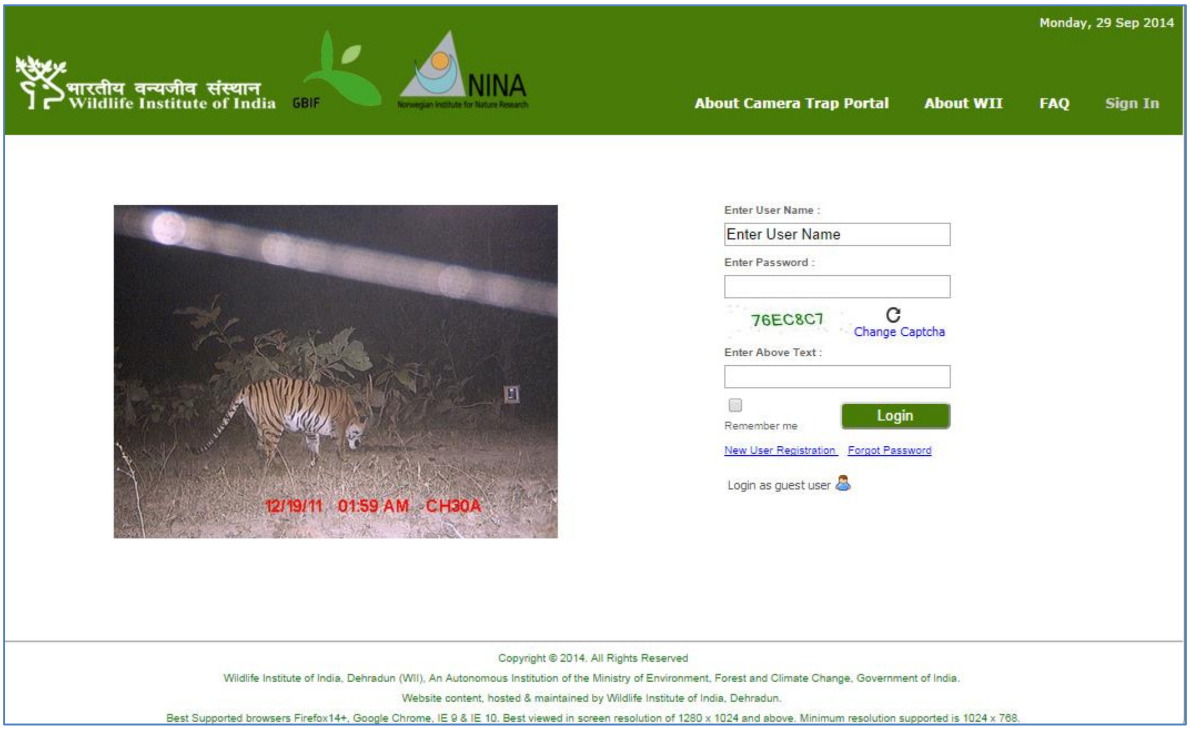


Figure 41: The web portal application login interface

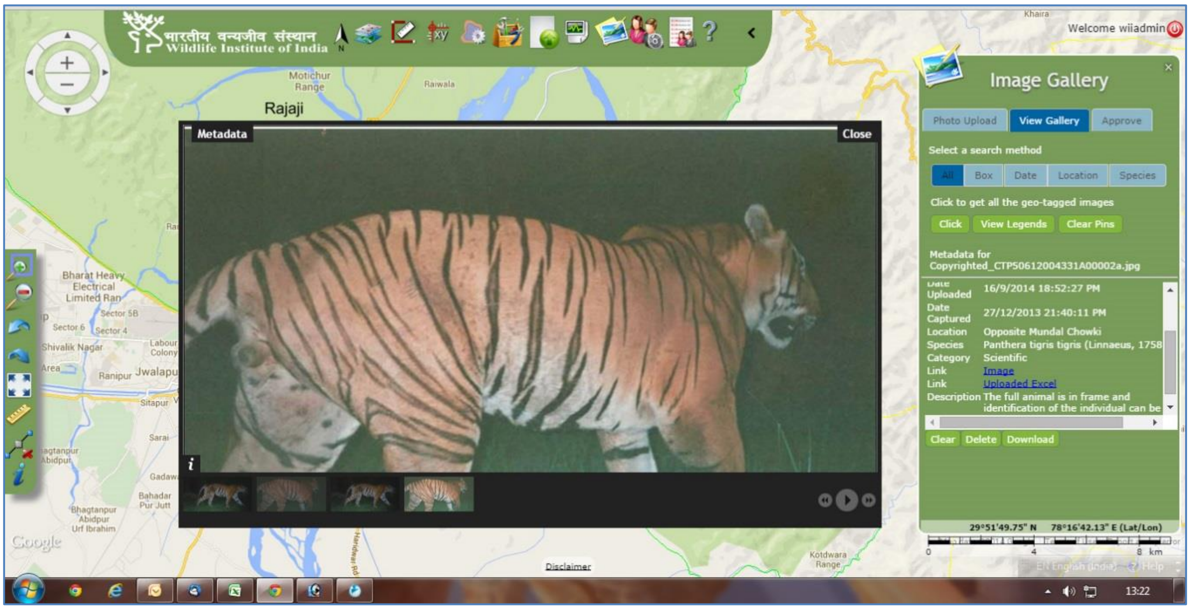


Figure 42: Image metadata interface

7.7 Guidelines for Best Practices

The project has produced a Best Practice Guide (BPG)[79] for publishing of biodiversity data associated with multi-media objects, with a focus on camera traps. The context of this BPG is the recognition of capacity building as an essential component of the Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES).

The guide has implemented the global standards, best practices and technical framework for data publishing developed by GBIF. The current version of the BPG is based on synergies extracted through literature reviews and experiences from several camera trapping projects in India, Norway and South Africa. Based on identified user needs, user experiences, existing standards and technological framework developed by GBIF, the project team hopes that the guide could catalyze the usage of camera trapped biodiversity data in decision making for an environmental friendly future.

Knowledge about the identity, occurrence, abundance and behavior of organisms forms the backbone of our understanding of the biological world, and is essential for monitoring the state of natural ecosystems, for developing sound environmental management policies and making ecologically sustainable development decisions.

Multimedia resources (see figure 42 below) can provide reliable evidence for the occurrence of a species at a particular place and time, and there is growing recognition that a biodiversity-related multimedia object could be used as a primary biodiversity record (as long as the supporting information is reliable and verifiable). Multimedia-related biodiversity data can be used in a wide range of studies that are of relevance to wildlife managers and scientists, and can be used in many biodiversity informatics applications, such as species and specimen descriptions, glossaries and image processing.

'Multimedia Resources'

Morris *et. al.* (2013), define multimedia resources as follows: Multimedia resources can include pictures, artwork, drawings, photographs, sound clips, videos, animations, presentation materials, and interactive online media (e.g., identification tool packages involving text and other media), and the likes. A multimedia collection is an assemblage of such objects, whether curated or not and whether electronically accessible or not. For the purposes of this document, we regard a collection of multimedia resources itself as a 'multimedia resource'. Wherever discussion or specification can apply only to one collection or only to a single media resource, we say so explicitly.

Multimedia resources can include:

Familiar multimedia resources include:

- Still images from cameras, scanners, or medical and industrial imaging devices
- Movies with or without sound
- Audio recordings

Less familiar multimedia resources may include:

- Taxonomic identification keys
- Interactive software applications, either on the web or available for stand-alone use
- Collections of multimedia resources

Biodiversity data that can be generated using multimedia resources include:

- Occurrence data –geospatial data, distribution records of what animals are present
- Taxonomic data– identifying species, preparation of inventories
- Behavioral data–activity patterns, dispersal, spatial requirements (habitat range), animal interactions
- Quantitative data – abundance, population size, density
- Morphological and anatomical data - aspects of appearance and structure

Figure 43: Multimedia resources

79 http://www.gbif.org/orc/?doc_id=6045

Open access to well-managed biodiversity data that is in exchangeable formats is essential to enable effective environmental planning, management and decision-making (Chavan and Ingwersen, 2009). However, open access to data, by itself, does not necessarily make the data useful, nor enhance our knowledge. It is only when data is effectively managed, preserved and shared, that science and society can benefit from access to it.

Over the past decade, GBIF has been striving to make digital biodiversity data freely and openly available via the Internet for scientists, researchers, decision-makers and the public. With the advent of technologies such as digital photography and camera trapping, large volumes of biodiversity, data are being generated through multimedia objects. With the increasing need for a high volume of credible, high-quality data for research, instruction and decision-support, biodiversity information systems and networks must now mobilize primary data associated with both traditional and non-traditional sources, including multimedia resource such as camera trap images.

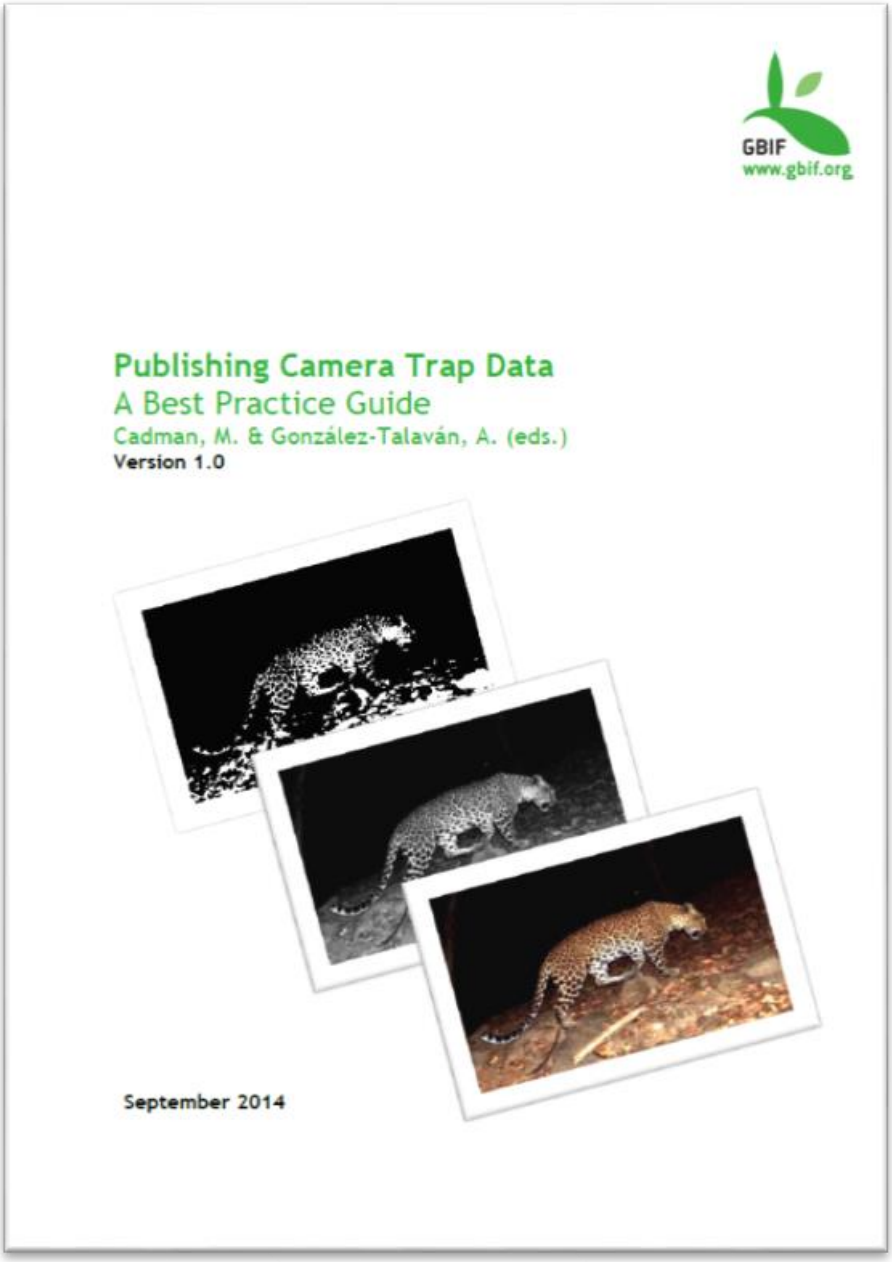


Figure 44: The Best Practice Guide on publishing biodiversity data associated with multi- media objects, with a focus on camera traps

Multimedia objects are created and managed by a wide cross-section of communities and individuals, including research scientists, wildlife managers and interested members of civil society. These multimedia objects are potentially a rich source of biodiversity information, but, currently, much of this is not captured, stored or disseminated in any kind of systematic way, which means that it is not available for assessing the state of biodiversity, or for informing wildlife management policies and actions. One of the reasons for this has been the lack of guidelines that describe the equipment, methods, standards and workflows for capturing and managing the biodiversity data associated with multimedia objects, or for publishing it and making it openly accessible in exchangeable formats. Hence, the need for this best practice guideline (see frontpage in figure 43 abow).

A best practice guide will, according to the prevailing technological and scientific development, always be a working document. To ensure the future relevance of the BPG beyond this project, GBIF will take care of its future updates and maintenance. In addition, GBIF also provide a dedicated community site[80] where people can discuss and contribute to the maintenance of the BPG.

7.8 Planned training workshop at the Wildlife Institute of India

Time	Agenda item	
9:00 - 9:30 AM	Registration	
9:30 - 11:00 AM	Camera trap Data Collection	Welcome address Use of spreadsheets or software to collect, code and record images and metadata
11:00 - 11:15 AM	Tea break	
11:15AM - 1:00 PM	Data Management	Store and manage images and metadata
1:00 PM - 2:30 PM	Lunch break	
2:30 PM – 4:00 PM	Quality Control and Enhancement	Data Cleaning, Backing up etc.
4:00 PM - 6:00 PM	Publish camera Trap Data	Making data publicly accessible through the GBIF network

Table 16: Drafted agenda for a planned training workshop at WII

7.9 Legacy data repatriation

7.9.1 Introduction

This report is a first investigation of the plants, fungi and animal specimens originating from India that are currently housed in the Norwegian natural history museums. GBIF Norway, located at NHM in Oslo, prepared the report.

The present report is based on a survey among the curators of the different natural history collections of the Tromsø University Museum[81], the Museum of Natural History and Archaeology, NTNU in Trondheim[82], University Museum of Bergen[83], and the Natural History Museum of the University of Oslo[84] (hereafter referred to as Tromsø, Trondheim, Bergen and Oslo). A description of relevant material and the state of data management is given below. Currently available metadata on collection specimens are organized in an Excel data sheet and will be available at www.gbif.no by autumn 2014.

80 http://community.gbif.org/pg/groups/17760/
81 http://uit.no/tmu?p_lang=1
82 http://www.ntnu.edu/museum
83 http://www.uib.no/en/universitymuseum
84 http://www.nhm.uio.no/english/

7.9.2 Relevant material from Tromsø

The collection in Tromsø includes very little from India: One bumblebee, 3 springtails, 25 butterflies (all without collection date), 4 crustaceans and 13 mollusks without collection data (pc Arne C. Nilssen, 29-02-2012).

7.9.3 Relevant material from Trondheim

Animals
The zoological collection includes 1 cnidarian, 122 mollusks (mostly marine), 24 birds, 4 mammals and 3 reptiles. These are all old specimens, presumably from the end of the 19th century or the first half of the 20th century, without collection date. In addition, the collection site is poorly documented, often restricted to "India" or "Indian Ocean". There is no easy way to obtain data that are more precise. Data from Indian specimens in Trondheim are not yet available in the GBIF- portal.

Plants
The vascular plant collection has not been digitized, but random sampling suggests it contains virtually no specimens from India (p.c. Torkild Bakken). The most interesting Indian material in Trondheim is found in the bryophyte collection, which houses the legacy of the botanist Ingebrigt Hagen (1852-1917). In the course of 2014 the bryophyte herbarium with its circa 30.000 specimens will be digitized.

In the Trondheim bryophyte collection a total of 252 records of mosses are registered (p.c. Kristian Hassel). These include 38 specimens with type status. Additionally, 28 objects are lacking taxon names. (5 liverworts and 23 bryophytes).These are mostly from the Himalaya, and include relatively many type specimens (not labeled as such) which the Finnish botanist V.F. Brotherus (1849-1929) has worked on. These specimens have relatively complete collecting data. Moreover, the digitization project in Trondheim includes the addition of the currently valid nomenclature (p.c. Tommy Prestø).

7.9.4 Relevant material from Bergen

Animals
The vertebrate collection contains 18 reptile specimens as well as a few bird eggs and fishes from India. There are no bird skins or mammals in this part of the collection (p.c. Ingvar Byrkjedal). However, the osteology collection contains eight craniums and skeletons (Tore Fredriksen). The museum in Bergen contains neither insects nor marine invertebrates from India (p.c. Trond Andersen and Jon Kongsrud). No animal collections from Bergen are currently available from the GBIF portal.

Plants and fungi
The vascular plant collection is likely to hold some specimens from India but these are difficult to find as the material is sorted taxonomically and not yet digitized. While the Fennoscandian herbarium had been digitized, there are yet no plans for the digitization of the general herbarium (p.c. Solfrid Hjemtveit).

Some 30% of the bryophyte herbarium has been digitized, including 41 specimens from India (10 of these are already visible in the GBIF portal). Once the complete bryophyte herbarium is digitized (80 000 specimens) there may be an estimated number of 150 mosses from India. Lichens and fungi have all been digitized and include 39 lichen specimens from India and no fungi (p.c. Astri Botnen). 34 lichen specimens are currently visible in the GBIF portal (p.c. Astri Botnen).

7.9.5 Relevant material from Oslo

Animals

The mammal collection includes 108 specimens (mounted animals, skulls or skins, sometimes from the same individuals) from 'India'. Insofar these are dated at all, they originate from the 19th century. No further collecting information is preserved. These data are already available in the GBIF portal.

Oslo has 1027 bird specimens from India, both skins and mounted and demounted specimens. These are either not dated or originate from the 19th century or the first half of the 20th century. Locality is sometimes recorded at the region or district level, with relatively many specimens from Darjeeling. More detailed collecting data are missing. Englishmen, some of whom have had an important role in Indian ornithology, have collected most of this material. These skins may therefore be of particular historical value. Notable are 295 skins labeled as being collected by 'Blyth'. This name most likely refers to the English zoologist Edward Blyth (1810 –1873), who was one of the founders of zoology in India (cf. Wikipedia lemma Edward Blyth). Another known name is Henry Seebohm (1832-1895), to whom twelve skins are attributed (misspelled in one case as Subohm). The bird data are not yet published in GBIF.

The fish collection database contains 34 specimens (p.c. Ann-Helen Rønning).

Vladimir Gusarov is working on Staphylinidae beetles. He reports 508 specimens from India, which are not yet identified to species level. The Hymenoptera collection includes 130 pinned specimens originating from the collection of Charles Thomas Bingham (1848-1908). These have been collected in Sikkim. In addition, there are seven Hymenoptera and one Orthoptera originating from the Deinboll collection, all labelled Trankebar. Some of these may represent types of taxa described by J.C. Fabricius (1745-1808) (p.c. Lars-Ove Hansen). These collections are not digitized. There are virtually no Lepidoptera or Diptera from India in Oslo (p.c. L. Aarvik and G. Søli). Finally, the museum holds circa 10 crustacean specimens (p.c. Lutz Bachmann) and 3 molluscs (p.c. Ann-Helen Rønning).

Plants

There is a small digitized collection of 89 vascular plants from Himachal Pradesh and Maharashtra provinces. These were deposited by the Indian student B. Natarajan who studied in Oslo in the 1990s.

In addition, the older vascular plant type collection in Oslo has been digitized. This includes 12 older type specimens from India. However, most of this herbarium has not been digitized. It may contain some thousands of specimens from India. These are currently difficult to locate as the herbarium is organized in taxonomic rather than geographic units (p.c. Charlotte Sletten Bjorå). The museum intends to digitize the herbarium at a level that would enable the retrieval of taxa per continent or even per country. This enterprise is however still in the planning phase (p.c. Bjørn Petter Løfall).

Likewise, the bryophyte and algae collections might contain material from India, but this can only be retrieved after digitization. Oslo probably holds no Indian fungi (p.c. Karl-Henrik Karlsson). The digitization of the Oslo lichen herbarium is ongoing (2014). Currently 34 specimens from India are visible in the GBIF portal. This number may increase to circa 100 once the entire lichen herbarium is digitized. Most of these have been collected after 1950 and have rather complete collecting data (p.c. Einar Timdal).

The Botanical garden at the Natural History Museum in Oslo has six living plants originating from India.

As the country of India has banned the export of plant specimens, specimens collected in India prior to the ban are of high value for the research community. Due to ongoing mass digitization of the vascular plant herbarium in Oslo, the angiosperms were only surveyed up to and including the family of Cyperaceae. A total of 687 specimens were identified. The specimens were primarily collected in the mid or late 19th century. Whereas most are personal collections and some are from “flora exsiccata”, which were herbarium sheets sold by sellers that did not necessarily collect the specimens themselves.

One of the earliest collectors, which have donated material to Oslo, was Nathaniel Wallich (1786-1854). Unfortunately, he did not specify where in India or when the collection was made. Nevertheless, it is known that he arrived in India in 1807, and that he retired around 1846. It is also known that he spent most of the time in or around Calcutta, but he also made several expeditions to what is now known as neighboring countries of India. Wallich described many new species on his journey, and some of the specimens might therefor be type specimens.

The most famous and important of the collectors may be Joseph Dalton Hooker (1817-1911), who collected along with Thomas Thomson (1817-1878), mainly in the Khasia area. They also split up and went for individual surveys where J.D. Hooker went to Sikkim, and T. Thomson went to the western Himalaya and Punjab. J.D. Hooker is known to have collected and described many new species from India, which means that there might be some hidden syntypes in the material present at the herbarium in Oslo. The collections are not numbered which might further complicate the decision of the status of the specimens. J.D. Hooker's main affiliation was to the botanical garden in Kew, where more of their material can be found. However, the value of the collections in Oslo is high as it might add to what is found in Kew. Their journeys are well described, so an approximate date to their collections can be found by tracing their journey.

Major/Captain Francis Jenkins (1763-1866) and John William Masters (1792-1873) collected plant specimens in the area of Assam. F. Jenkins is credited for being the one that discovered the tea plant in Assam. J.W. Masters made most of the collections present in Oslo, with little or no additional information other than the label shared with F. Jenkins "Coll. Jenkins Plants of Assam". They apparently did more collecting than describing.

Thomas Anderson (1832-1870) is represented with a few collections in the herbarium. It seems like some former worker in the herbaria of Oslo confused him with the Swedish botanist Nils Johan Andersson (1821-1880), which was on a circumference within approximately the same period. Some of their collections are quite precise and includes the site and even the date of collecting; however, others are of less precision.

John Firminger Duthie (1845-1922), is strongly represented in the collection of material from India. Most of his collections are from the period of 1880-1900. Therefore, the number of new species described by him is lower than the previous collectors for obvious reasons. His collections are very precise and include both area and date of collection.

One of the collectors from the early 1800's was Dr. Bernhard Schmid (1787-1857). Working as a missionary he mainly collected, but Jonathan Carl Zenker has used his material. The material is almost exclusively collected in the Nilagiri area.

More recently, Robert L. Fleming collected many specimens in the Dehradun area about 1950, mainly pteridophytes. Professor Ove Arbo Høeg from the University of Oslo did some collections in 1951-1952. As these collectors are more recent, the labels are more detailed than the predecessors are.

In addition to these collectors that count for most of the material, several others have contributed. These are mainly persons from the University of New Delhi, which mainly collected around New Delhi, even on the University campus.

A special case is that of Rudolph Friedrich Hohenacker (1798-1874). Many collections bear his label, but these are not collected by him personally. R.F Hohenacker sold flora exsiccates, which consist of specimens collected by other persons. The only additional information on these collections is the area they were collected. These collections have to be considered of lower scientific value than others are, unless the original collectors can be traced, and thereby giving a timespan and an actual collector.

Many of the specimens from India in the herbarium of Oslo are from the 1800's and are therefore of a certain value. The possibility that some of them might be syntypes or isotypes adds additional value. Again, for scientific purposes, material from India collected after their export ban is rare outside India. Although it is not very useful for most modern DNA techniques, morphology is still the backbone of modern botany. It is also worth mentioning the "cool" factor of some of these collections. J.D. Hooker was one of Charles Darwin's closest friends, which gives some perspective to what kind of material we are dealing with and help convey this era of botany.

7.9.6 Conclusion and recommendations for repatriation of legacy data

As expected, the zoological and botanical material from India in the Norwegian natural history museums is rather limited and comprises only a few thousands specimens. The museum in Oslo has the largest collection, though Trondheim holds an important bryophyte herbarium.

The zoological objects from India consist mostly of vertebrate skins, skull and skeletons from the 19th and early 20th century. The metadata is digitized but provides little detail. In many cases, the locality is only indicated as "India", so that it is not even certain these objects originate from the territory of the present Republic of India. In the cases where districts or even place names are mentioned, it will require some effort to find the possible coordinate range for the historical geographic designations. This old material may still be valuable for taxonomic or historical research, especially if it includes rare species. It is therefore desirable that the metadata become publicly available, even if the locality data is very imprecise and the nomenclature needs checking.

The herbaria (notably vascular plants and bryophytes in Oslo and Trondheim) are more promising. While these do not include more specimens from India, the older material tends to be more completely documented and labelled. They also include a number of type specimens. At present locating material from India is almost unfeasible as the herbaria are organized taxonomically. However, the museums are planning digitization efforts in the coming years. Digitization of the bryophyte collection in Trondheim will yield high-quality data that will be directly usable. Photo-Digitization of the herbarium in Oslo is ongoing (2014) with a relatively coarse resolution of 300 dpi. However, it will become possible to locate specimens for detailed digitization whenever there is a demand for it.

Much of the Norwegian collection data has not been digitized, and digitization projects tend to prioritize Norwegian or Fennoscandian flora and fauna. In addition, not all data residing in local databases has been shared through GBIF. For these reasons, the cooperation of many curators was needed to produce this report. The Norwegian natural history museums are currently working on a joint database system called MUSIT[85], which is expected to become operational within a few years. Once this is in place it will be much easier to search at least the digitized collection specimens on, for instance, collecting site.

A number of small projects have been identified that can produce useful Indian biodiversity data in the short run if further financial resources become available:

1. Publication of Indian bryophyte material from the herbarium in Trondheim
2. Delivery of data present in local museum databases to GBIF (e.g. the Oslo bird skin collection)

[85] http://www.musit.uio.no/musit/musitweb/html/english.html

3. Digitization and identification of possible type specimens from the Charles Thomas and Deinboll collections in the museum in Oslo.
4. In a few years targeted digitization of Indian herbarium specimens in Bergen and Oslo, once coarse-grained digitization of these herbaria is completed.

7.10 Use and reuse of data

7.10.1 Camera trap image helps identify poached tiger skin

Direct killing of tigers is the most immediate threat to the remaining wild tiger populations. Despite increased efforts in international tiger conservation, including law enforcement and anti-poaching efforts, a substantial market exists for tiger parts and products. Each time a tiger skin is seized, ascertaining the landscape from where the individual may have been poached involves forensic examination using molecular genetic techniques. However, if a substantial photographic database of live tiger pictures obtained from camera trapping studies is available, assigning individual identity to skins of tigers poached from sites is possible.

On February 9th 2012, a seizure of tiger skin and bones was made in the town of Najibabad in Northern India while in transit. The poachers admitted that the individual was killed in a non-protected forest area in close proximity to Rajaji National Park. Due to a long term photographic capture-recapture study on tigers in this region a database of individual tigers was available for comparison. Using standard visual comparison procedures, this individual was identified to be a female, captured once along the southeastern boundary of the park in October 2009 (For more details see Hiby et.al. 2009).

Figure 45: Seized tiger skin from the town of Najibabad (Northern India) and accompanying camera trap images from the southeastern boundary of the Rajaji National park.

7.10.2 The proposal for a tiger reserve in Rajaji National Park

Studies performed by WII on the recovery of habitat, wild prey and tiger following relocation of Human settlements from the Rajaji National Park (described in section 7.3) clearly demonstrates the need for a Rajaji Tiger Reserve. The studies identified a multitude of factors such as availability of inviolate space, a healthy prey biomass and a small breeding population that provide excellent opportunity for tiger conservation in Rajaji. However, (as stated in section 7.3) recovery of tiger population across the park requires active management intervention, focused attention and sustained funding. This can only be achieved by bringing Rajaji under the umbrella of National Tiger Conservation Authority.

7.10.3 Standard operational procedures regarding human wildlife conflicts

The Ministry for Environment, Forestry and Climate Change (MoEFCC) launched in 2011 specific guidelines for Human- Leopard Conflict Management[86] based on the work of among others Wildlife Institute of India and Dr. Vidya Athreya. These guidelines provide a framework not only to address the conflict after its occurrence, but also to minimize such conflicts through adoption of necessary proactive measures.

7.10.4 Discovering primary biodiversity data from social networking sites

A large amount of geo-referenced primary biodiversity media data are captured through different social networking sites (SNS). Mobilization of these data is challenging. GBIF has taken steps to address this challenge through the GBIF Multimedia Resources Task Group. One of the task group recommendations is to mobilize massive geo-referenced acquisition of media (Morris et al. 2008).

The study of Dr. Vijay Barve et.al presents an interesting alternate resource for primary biodiversity occurrence records discovery, and assesses the value of the same (Barve 2014). The study is a part of Dr. Barve`s doctoral dissertation (with partial support from GBIF under the Young Researcher Award). Several Bird and Butterfly experts are involved with Dr. Barve for exploring and verification of the data from the different SNS.

Detailed, authoritative Digital Accessible Knowledge (DAK) about biodiversity is crucial to any biodiversity informatics or conservation project. In most developing nations, significant DAK gaps exist both geographically and taxonomically. Dr. Barve`s work will explore and implement a novel source of photo-vouchered biodiversity occurrence data in the form of records associated with photos on SNSs. Flickr, Facebook, and Picasa Web allow naturalists to share images and associated metadata with other users. These websites are also becoming increasingly geo-aware.

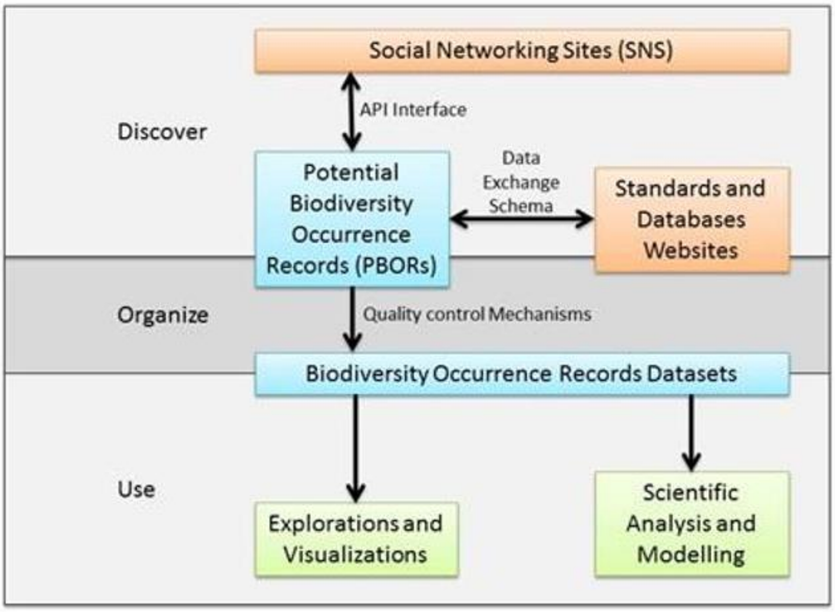


Figure 46: Discovering and developing primary biodiversity data from social networking sites

[86] http://envfor.nic.in/sites/default/files/moef-guidelines-2011-human-leopard-conflict-management.pdf

Dr. Barve propose to discover, organize, assess, and share massive numbers of biodiversity occurrence records now available on SNSs. He will explore this data source with two case studies on birds and butterflies as a proof-of-concept. However, the tools and methods can easily be extended to any region or species group, particularly for developing, mega diverse countries where the need for biodiversity DAK is particularly acute.

Dr. Barve plan to compare data acquired from SNSs with existing GBIF data. This approaches are broadly applicable to animal and plant groups that are photographed and that can be identified from photographs with some degree of confidence, and thus offer a rich new source of biodiversity data for developing nations. This could be especially useful for countries like India that do not have lot of available data in GBIF, but have a growing population of internet savvy naturalists and professionals interested in photography and biodiversity.

7.11 Outreach and promotion

Publications

- Cadman, M., Chavan, V., Ghosh, Athreya, V., Hanssen, F., Lindgaard, A., Mathur, V.B., Mehlum, F., Pandav, B.Talavàn, A.G. & Vang, R. NINA-GBIF-WII Best Practice Guide 2014: Publishing biodiversity data associated with multi-media objects, with a focus on camera traps.
- Harihar, A., Pandav, B. & Goyal S. P. (2011). Responses of leopard Panthera pardus to the recovery of a tiger Panthera tigris population. Journal of Applied Ecology, 48: 806-814.
- Harihar, A., Kurien, A. J., Pandav, B. & Goyal, S. P. (2007). Response of tiger population to habitat, wild ungulate prey and human disturbance in Rajaji National Park, Uttarakhand, India. Final Technical Report, Wildlife Institute of India, Dehradun. Pp iii+165.

Conference participation (presentations and posters)

- GBIF Governing Board meeting, 17-19 September 2012 at Lillehammer- Norway (annex 2).
- The Conference of the Parties (COP), 8-19 October 2012 in Hyderabad- India (annex 3).
- The Seventh Conference on Biodiversity - Ecology and Economy for a Sustainable Society, 27-31 May 2013, in Trondheim, Norway

Coverage in public media

The pilot project has been presented at the web- pages of NINA, NBIC and GBIF several times during the project period.

- Hindustan times paper, 2012. Wildlife exists outside protected areas also.
- Sakal Paper, 2012. Marathi article about wildlife outside protected area.
- Sakal Times Paper, July 11. 2012. Article about the project (see figure 45 below).
- The movie Azoba[87]. The human-leopard conflict in Maharashtra has become a subject of concern following the numerous incidents of the feline being spotted in human settlements. Taking this as the crux of its story, "Ajoba"' takes you on an adventure that starts in the town of Junnar in Maharashtra, across the Malshej Ghat area into Vasai and ends near Nashik. The film is based on wildlife conservationist Vidya Athreya's experiences with the spotted animal and starts with Purva Rao (Urmila Matondkar) getting a call about a leopard that has fallen in a well in a village. Accompanied by Shinde (Shrikant Yadav) she rescues the leopard and inserts an electronic chip in its tail to help them track its whereabouts. In reality, this was the first instance of its kind and helped a lot in further research on the animal. Christened Ajoba, the leopard moves from the place of its release in Malshej Ghat to Vasai and then to

[87] https://www.youtube.com/watch?v=pZNLbBP6Q0M&feature=kp

Sanjay Gandhi National Park in Mumbai over a journey of 29 days. Read more about the movie review at the web- pages of The Times Of India[88]

CITY ECOLOGIST PART OF INTERNATIONAL TEAM STUDYING WILDLIFE IN RURAL PUNE

Sakal Times

SHRIRAM SHINDE
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Pune: There is a strong Pune connect in an international project to study the impact of wildlife on human habitat in rural India. City-based ecologist with the Centre for Wildlife Studies **Vidya Athreya** is part of the international team carrying out the survey in the villages of Takli Haji near Shirur on the Pune-Ahmednagar highway.

The survey is being conducted by the Norwegian Institute for Nature Research (NINR) in collaboration with the Ministry of Environment and Forests (MOEF) with an aim to support capacity building in biodiversity informatics under the UN programme, "Intergovernmental platform for biodiversity and ecosystem services (IPBES)."

Athreya said on Tuesday, the project would enhance decision making and improve nature management in India. According to Vidya, the surveyors have spotted bigs cats like leopards, hyenas and jackals along with small ones like palm civets in the villages in Shirur and Ambegaon tehsils.

Vidya said India had been identified as a national partner in the project both because of its rich natural biodiversity and the recent development of the Indian Biodiversity Information Facility (INBIF). INBIF is led by the Wildlife Institute of India (WII) which has the national mandate from the MOEF to build capacity for effective biodiversity and information management.

According to Vidya, the key objective of the pilot project is to enhance the capacity of India to take policy decisions about its own biodiversity management and conservation issues based on updated information.

Findings of the survey will be used for a case study focusing on the use of biodiversity data for decision-making.

ON THE JOB: (Above) Curious villagers are gathered around surveyors as they installed night vision cameras around Takli Haji in Shirur for a survey – a part of an international project. (Left) Special night-vision cameras being installed outside Takli Haji for a survey of wild animals.

Figure 47: Article about the project in the Sakal Times Paper, July 11. 2012.

[88] http://timesofindia.indiatimes.com/entertainment/marathi/movie-reviews/Ajoba-Urmila-Matondkar-Sujay-Dahake-Om-Bhutkar-Hrishikesh-Joshi/movie-review/34784429.cms

8 Project capacity building towards IPBES

In the initial project phase this capacity building pilot- project was targeted on a reviewed list of capacity building needs and recommended approaches and actions identified in the pre- IPBES scoping paper[89] launched by the UNEP World Conservation Monitoring Centre[90] (UNEP World Conservation Monitoring Centre, 2011) at the request of the Norwegian Government.

The later approved Work programme for IPBES 2014- 2018[91] (IPBES 2014) features a sequenced and prioritized set of objectives, deliverables, actions and milestones for advancing the four functions of the IPBES (assessment, knowledge generation, policy support and capacity building).

This final report highly address the actions and recommendations in the IPBES working program. Our project results have great potential synergies with other countries. IPBES has organized a Task force on Capacity building, and we are very comfortable having Dr. Vinod B. Mathur (Director of WII) as a member of this Task force. This will ensure that our project results are well communicated within the IPBES Task force. In addition, Dr. Mathur has valuable insights in national/international capacity building needs, biodiversity management and conservation issues that is highly relevant for the IPBES Task force. As Director of WII, Dr. Mathur will also represent an important link between the IPBES and the ongoing research activities in India and the neighboring countries in the region.

One of the IPBES Technical Support Unit`s (TSU) with focus on capacity building is located in Trondheim (Norway). This unit is currently under development (medio September 2014). Both the Indian and the Norwegian project partners will actively support the TSU and share our competencies and experiences whenever requested.

During the project period (2011- 2014), we have had a very good dialog with the IPBES responsible officers at the Norwegian Environmental Agency and in the Indian Ministry of Environment, Forestry and Climate Change (MOEFCC). The mandatory support of these two contact points have been very important for calibrating the project developments with the developments of IPBES.

8.1 Collaboration with GBIF

From the beginning of the project, we established a close collaboration with GBIF who offer capacity building, international common standards and an operational open data infrastructure. By encouraging and helping institutions to publish data according to common standards, GBIF enables research not possible before, and informs better decisions to conserve and sustainably use the biological resources of the planet. GBIF operates through a network of national nodes, coordinating the biodiversity information facilities of participant countries and organizations, collaborating with each other and the Secretariat in Copenhagen to share skills, experiences and technical capacity. The capacity-building component of this project has been prominent, thanks to GBIF, and we would highly recommend similar future capacity building initiatives to collaborate with GBIF.

8.2 International networking across disciplines

This capacity building pilot-project has brought together Indian and Norwegian experts in ecology, biodiversity informatics, IT and GIS. These experts have shared their knowledge, and they are currently networking internationally to establish new partnerships and future collaboration.

[89] http://dnweb14.dirnat.no/multimedia/48586/IPBES-Capacity-Building-Scoping-Paper.pdf
[90] http://www.unep-wcmc.org/about-us
[91] http://www.ipbes.net/images/decisions/Decision%20IPBES_2_5.pdf

8.3 The Best Practice Guide

The Best Practice Guide (BPG)[92] for publishing of biodiversity data associated with multimedia objects, provides great capacity building towards the international context in terms of implementing global standards, best practices and technical framework for data publishing developed by GBIF. The guide is based on synergies extracted through international literature reviews and experiences from camera trapping projects in India, South Africa and Norway. The project team hopes that the guide could catalyze the usage and mobilization of camera trapped biodiversity data in research and decision-making. Of course, a guide like this has to be continuously updated to keep its relevance. As a response to this, GBIF will host and maintain the BPG for the future.

8.4 Technological development supporting data mobilization

One of the core components of this project has been capacity building in data mobilization and data sharing through online WEB portals, and use of international standards. NINA has shared experiences with the Indian partners about how data, images and video from the national camera trapping monitoring program of the Norwegian lynx population has been organized and disseminated through http://viltkamera.nina.no/. GBIF Norway has shared information about their developments of the Norwegian GBIF- portal[93]. Furthermore, NBIC has shared the Norwegian experiences on data mobilization and coordination of (legal and financial) means related to data mobilization, citizen science and the implementation of the national biodiversity infrastructure[94]. These experiences have been useful for the Indian project partners in their developments of the WII Database and WEB application, as well as the citizen science project portal Carnivore outside parks[95].

8.5 Validating the Audubon Core metadata standard

There is a great need for a metadata standard for biodiversity related multimedia. The GBIF- and TDWG (Taxonomic Databases Working Group) joint task group[96] has developed a multimedia resources metadata schema called the Audubon Core[97]. Through their work on standardization of camera trap data from Rajaji National Park, WII have gained valuable experience with the standard and its metadata template. This template was validated with practical needs, and modified. The modified Audubon template is provided in Annex 1.

8.6 The case studies

The Indian project partners have performed six case studies in India in order to demonstrate how biodiversity informatics, camera trapping, data mobilization and access policies can contribute to improved decision making. The outcomes of these case studies have led to a better understanding of methodologies (camera trapping techniques, occupancy modelling and DNA- analysis), species distribution, human- wildlife conflicts, human disturbance effects on wild mammals, habitat recovery, tiger population management needs and investigation of poaching based on forensics, camera trapping and digital image analysis. In the case of India, a national database of tiger photo-captures could greatly complement law enforcement agencies in identifying the sites most vulnerable to poaching. All these case studies have involved networks of research scientists and citizen scientists. The lessons learnt from these case studies are relevant for international capacity building in Biodiversity informatics.

92 http://community.gbif.org/pg/groups/17760/
93 http://gbif.no/
94 http://www.biodiversity.no/frontpage.aspx?m=23
95 www.carnivore.in
96 http://www.tdwg.org/activities/img/multimedia/charter/
97 http://www.tdwg.org/homepage-news-item/article/audubon-core-public-review/

8.7 Training, workshops and involvement of citizen scientists

A workshop in compiling Data Papers was organized in Pune (India) by GBIF in June 2013 and an internal training workshop on mobilization and application of camera-trapped biodiversity data is planned to be organized at the Wildlife Institute of India (WII) during 2014/2015. The workshop agenda could easily be adapted to the needs of users in other organizations and countries. Finally, training and involvement of citizen scientists has been very successful as experienced in the case studies outside protected nature areas.

8.8 Repatriation of legacy collection data

Making standardized legacy collection data accessible through GBIF addresses crucial information needs of biodiversity scientists, environmental managers and decision makers both in India and internationally. The minor data repatriation exercise at the Norwegian Natural History Museums does not result in large amounts of data, but more important, it provides capacity building to international legacy collections on how to mobilize collection samples through the GBIF data portal. In an international context, the added value of this exercise therefore lies more in its synergetic effect. Repatriation of data from large-scale legacy collections in other countries could take advantage of the Norwegian experiences.

Globally, the biological legacy collections contain an estimated amount of 1.2 to 3 billion specimens (Duckworth et al. 1993, Ariño 2010). Only about 10 percent of these specimens have been captured in databases, and much less is captured as digital images. This means that 90 percent of the legacy collections are currently unavailable for use through the Internet. Making this available manually will be very labour intensive. Using mass- digitizing techniques and partly automated workflows through imaging techniques should however make the task feasible. Once digitized, the images have to be georeferenced. This can be done by computer-assisted techniques or with the help of gazetteer services (Hardisty et.al. 2013).

Mobilizing legacy data can also be crowd-sourced by using volunteers, or outsourced to private companies. Distributed digitization infrastructures may become essential parts of most natural history collections. A major challenge, is that collections grow much faster than they are digitized. As private collections also must be digitized by their owners, this requires easy to use and inexpensive tools that can be deployed at large scale. To effectively deliver this infrastructure service, digitization requires prioritization and its own funding channels (Hardisty et.al. 2013).

It is estimated that around 6500 museums throughout the world house around 3 billion specimens (large and small holdings) most of which belong to developing nations such as India. Access to these specimens by Indian researchers, when needed most, is time consuming and expensive due to the geographic distances, lack of communication infrastructure and financial support. However, with the advent of information and communication technology, it is now feasible to access data on these specimens, if not the specimens themselves. In the last two decades, many museums in developed nations have digitized specimen collections that they are holding. With several ongoing global and regional biodiversity informatics initiatives, sharing data about these specimens with the countries of origin is gaining momentum.

However, it is equally important that countries of origin too initiate appropriate steps, and share responsibility that would be complementary to these initiatives. A step in this direction would be to support repatriation of data of Indian origin from the Museums in different parts of the world. This will be achieved through competitive grants that will be applicable for Large Museum Collections and Small Museum Collections. This grant will facilitate an Indian researcher to visit the collection and take the help of the Museum to digitize and repatriate the collection data for specimens of Indian origin. The grant will partially cover cost of digitization in the Museum. Criteria for the selection of taxonomic groups and collections, priorities and user groups: Herbaria and natural history museums that set as their priority for digitizing data and making it available, recent taxonomic revisions, taxonomic groups that have been recently curated and the presence of research groups to work with the material. Institutions involved in developing information systems that provide their willingness to share data and information. A collection could be selected based on the taxonomic and regional scope of a collection. As for priority areas for repatriation of biodiversity data, taxonomic data and conservation related data would be of great importance.

8.9 Added values towards the scientists and decision makers

Open biodiversity data can be used to address a wide range of key scientific questions. Possible benefitting research fields, among many others, could be invasive alien species, ecosystem services, climate change, nature conservation and species distributions.

Open data sharing may also support unforeseen spin- off effects for the public community in terms of Research- based policy development, Public awareness (citizen science), Educational values, Efficiency improvements in public management and Commercial interest and opportunities.

An open data policy improves access to public processes and thereby helps citizens gain better insight into the basis for decisions and prioritization, They will also get improved knowledge about how to assess political administrators, political processes and decisions. This may strengthen the public confidence in the public administration and government.

9 Future collaboration and funding possibilities

The results and achievements from this capacity-building project is definitely a good platform for further collaboration under the IPBES. This was discussed at a meeting in Trondheim in June 2014 with representatives from the Wildlife Institute of India (WII), the Norwegian Institute for Nature Research (NINA), The Norwegian Biodiversity Information Center (NBIC), the Nature History Museum at the University of Oslo (NMH), the Norwegian University of Science and Technology (NTNU) and the Norwegian Environment Agency.

The networking component of this meeting was successful and potential areas of collaboration were identified within the fields of Climate Change, Ecosystem Services, Marine Ecology, Behavior studies of fish, Biodiversity informatics, Satellite telemetry, GIS, Remote sensing and development of impact assessment and planning tools for spatial decision support.

The discussions held a specific focus on the general need for training in camera trapping, wildlife management and evaluation of management effectiveness of protected areas. NINA runs a project including these topics in Myanmar on behalf of the Norwegian Environment Agency. Such training activities may represent a potential collaboration platform and should be directly linked to the capacity building and training programs for students and researchers hosted by WII and NTNU.

Possibilities for project collaboration within the IPBES- umbrella should be further investigated. There are four IPBES Task Forces on “Capacity Building”, “Knowledge foundation”, “Regional/Sub regional assessments”, and “Fast track thematic and Methodological assessments”. As a response to this, the project partners and the Norwegian University of Science and Technology (NTNU) aim to establish a MoU under IPBES.

Norway gives research cooperation high priority and India is a main cooperation country. The Norwegian Research Council (NRC) and the Indian Department of Science and Technology (DST) execute the Research and Technology Development (RTD) cooperation agreement between India and Norway (2012-2015).

Funding are currently available from the INDNOR Research programme[98]. INDNOR Calls in 2014 focus on clean energy, antibiotic resistance, polar research and geohazards. The Norwegian Embassy in India have some funds available for scientific cooperation, however, most of this funding is already tied to ongoing projects. NRC manages parts of these funds. Indian participation are eligible in projects funded by other Norwegian RTD programmes. In addition, cooperation with India is also possible in projects funded by the European Union Framework Programme for Research and Innovation (Horizon 2020)[99], The European-Indian RDT collaboration (ERA-net)[100], the New INDIGO[101] and the following INNO INDIGO and INDIGO POLICY. Another programme, The Norwegian Programme for Capacity Development in Higher Education and Research for Development (NORHED)[102] aims at strengthening the capacity of higher education institutions in low and middle income countries within Education and training; Health; Natural resource management; Climate change and environment; Democratic and economic governance; Humanities, culture, media and communication; and Capacity development in South Sudan. NRC are currently developing MoU`s with several Indian RTD funders such as the Ministry of Earth Sciences, the Indian Council of Medical Research and the Indian Council of Social Science Research.

[98] http://www.forskningsradet.no/prognett-indnor/Home_page/1253954776512
[99] http://ec.europa.eu/programmes/horizon2020/
[100] https://www.m-era.net/joint-call-2014
[101] www.newindigo.eu
[102] http://www.norad.no/en/support/norhed

10 Conclusion and recommendations

This capacity-building pilot project has clearly proved relevance in addressing the capacity building needs identified by IPBES. As the project results show, there are great international synergies in capacity building of biodiversity informatics, camera trapping, data mobilization, data repatriation, data management and data sharing policy improvement.

In addition, the case studies have demonstrated how biodiversity informatics, camera trapping, data mobilization and access policies can contribute to improved decision making. This have led to a better understanding of camera trapping techniques, occupancy modelling, DNA- analysis, species distribution, human- wildlife conflicts, human disturbance effects on wild mammals, habitat recovery, tiger population management needs and investigation of poaching.

Involvement of citizen scientists in the project "Carnivore outside parks" has demonstrated the importance of public awareness and the value of local engagement in surveying wild carnivores outside national parks.

The mapping of national needs in India performed by WII, has identified that there are many challenges and constraints due to data management and logistics that has to be solved in order to motivate the data stakeholders to share their data in a national data management system.

In addition, the survey of national needs also identified a great demand for a national Infrastructure for systematic storage and easy retrieval of camera trap images and data in India. Such an Infrastructure has to be coordinated with the developments of the InBIF and aligned with the National Biodiversity Information Outlook (NBIO). The development of the camera trap image database and the web- portal for mobilizing camera trap data (both hosted by WII), is one important step towards open biodiversity data sharing in a national data management system.

We would like to recommend the strategies outlined in the Indian National Biodiversity Information Outlook (NBIO). NBIO is expected to influence free and open access to biodiversity data through the institutionalization of the National Biodiversity GRID (NBG) and InBIF, which will enrich the National Biodiversity Strategy and Action plan. The realization of NBG and InBIF will represent a major step in capacity building of Indian biodiversity informatics.

The collaboration with GBIF has been of great importance for the project. Implementing their international standards, tools and services, ensures the project synergies of this capacity-building project towards other context`s.

Internationally there are large quantities of Indian specimens kept in foreign legacy collections. The project has performed a minor data repatriation exercise at Norwegian nature history museums. This minor exercise did not result in large amounts of data, but more important, it provides capacity building to international legacy collections on how to mobilize collection samples through the GBIF data portal. In an international context, the added value of this exercise therefore lies in its synergetic effect. Repatriation of data from large-scale legacy collections in other countries could take advantage of the Norwegian experiences.

Open data sharing is very important. Academic accreditation of shared data is important for the researcher's scientific career development. To ensure this, we recommend future projects to implement international data citation standards and best practices. Standards for Persistent Identifiers (PID)[103] have reached a mature level of development, and the project recommends implementing the Digital Object Identifier (DOI)[104], which became an ISO-standard (26324)[105] in May 2012.

103 https://openwiki.uninett.no/norstore:roadmap:pid
104 http://www.iso.org/iso/catalogue_detail?csnumber=43506
105 http://www.iso.org/iso/home/news_index/news_archive/news.htm?refid=Ref1561

In 2012, GBIF and PenSoft Publishers[106] designed a workflow between the GBIF Integrated Publishing Toolkit (IPT)[107] and several Pensoft journals to automatically export metadata into the form of a data paper manuscript, based on the Ecological Metadata Language (EML)[108]. The primary purpose of a Data Paper is to describe the dataset(s). A new journal called Biodiversity Data Journal[109], dedicated to publishing data papers (Smith et al., 2013) is now online. We recommend data publishing based on the Ecological Metadata Language (EML) protocol[110]

This project has focused on the identified priorities made by IPBES in their working plan for 2014-2018. Our Best Practice Guide (BPG), for publishing of biodiversity data associated with multimedia objects, provides great capacity building towards the IPBES context, in terms of implementing global standards, best practices and technical framework for data publishing. The guide will be further updated by GBIF in the future.

106 http://www.pensoft.net/
107 http://www.gbif.org/communications/news-and-events/showsingle/article/new-incentive-for-biodiversity-data-publishing
108 http://knb.ecoinformatics.org/software/eml/
109 http://biodiversitydatajournal.com/
110 https://nis.lternet.edu/nis/schemas/eml/eml-2.1.0/docs/eml-2.1.0/index.html

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12 Annexes

12.1 The Audubon Core Template

Modified Audubon Core Template: Audubon Core is the extension of Darwin's core. We have combined few fields of Darwin's core field.

The fields adapted from Darwin's core are:
Decimal Latitude
Decimal Longitude
Flank
Individual ID
Individual Identified By
Pattern Identification Method
Identification Rating

Following are the few fields we have added for our convenience:
CTP
State/district
CamID
Capture number
a/b

Rest of the fields are from Audubon Core Template:

Modified Audubon Core Template

Serial number	Field name	Description	Source	Value
1	CTP	Camera trap photograph	Created at WII	Optional and Filled
2	State/district	State and district code as per Census of India.	Created at WII	Optional and Filled
3	Year	Year in which photograph was captured	Created at WII	Optional and Filled
4	CamID	Camera trap ID with A/B denoting one of paired camera traps	Created at WII	Optional and Filled
5	Capture number	sequential photo-capture number	Created at WII	Optional and Filled
6	a/b	a/b/c distinguishes between multiple objects in the same photograph	Created at WII	Optional and Filled
7	**identifier**	An arbitrary code that is unique for the resource, with the resource being either a provider, collection, or media item.	Audubon Core	Mandatory

8	**type**	http://dublincore.org/documents/dcmi-type-vocabulary/ may be used. Recommended terms are Collection, StillImage, Sound, MovingImage, InteractiveResource, Text. Also recommended are PanAndZoomImage , 3DStillImage, and 3DMovingImage.	Audubon Core	Mandatory
9	**subtype**	Any of Drawing, Painting, Logo, Icon, Illustration, Graphic, Photograph, Animation, Film, SlideShow, DesignPlan, Diagram, Map, MusicalNotation, IdentificationKey, ScannedText, RecordedText, RecordedOrganism, TaxonPage, MultimediaLearningObject, VirtualRealityEnvironment, GlossaryPage. These values may either be used in their literal form, or with their full namespace, e. g. http://rs.tdwg.org/ac/terms/identificationKey	Audubon Core	Optional and Filled
10	**title**	Concise title, name, or brief descriptive label of institution, resource collection, or individual resource. This field should include the complete title with all the subtitles, if any.	Audubon Core	Mandatory
11	**modified**	Date that the media resource was altered. The date and time must comply with the World Wide Web Consortium (W3C) datetime practice, which requires that date and time representation correspond to ISO 8601:1998, but with year fields always comprising 4 digits. This makes datetime records compliant with 8601:2004. AC datetime values may also follow 8601:2004 for ranges by separating two IS0 8601 datetime fields by a solidus ("forward slash", '/'). See also the wikipedia IS0 8601 entry for further explanation and examples.	Audubon Core	Optional and Filled
12	**MetadataDate**	Point in time recording when the last modification to metadata (not necessarily the	Audubon Core	Optional and Filled

		media object itself) occurred. The date and time must comply with the World Wide Web Consortium (W3C) datetime practice, which requires that date and time representation correspond to ISO 8601:1998, but with year fields always comprising 4 digits. This makes datetime records compliant with 8601:2004. AC datetime values may also follow 8601:2004 for ranges by separating two IS0 8601 datetime fields by a solidus ("forward slash", '/'). See also the wikipedia IS0 8601 entry for further explanation and examples.		
13	**metadataLanguage**	Language of description and other metadata (but not necessarily of the image itself) represented in ISO639-1 or -3.	Audubon Core	Mandatory
14	**providerManagedID**	A free-form identifier (a simple number, an alphanumeric code, a URL, etc.) that is unique and meaningful primarily for the data provider.	Audubon Core	Optional and Filled
15	**Rating**	A rating of the media resources, provided by users or editors, with -1 defining “rejected”, “0” defining “unrated”, and “1” (worst) to “5” (best).	Audubon Core	Optional and Filled
16	**comments**	Any comment provided on the media resource, as free-form text. Best practice would also identify the commenter.	Audubon Core	Optional and Filled
17	**reviewer**	If present, then resource is peer-reviewed, even if Reviewers Comments are lacking. The notation of whether an expert in the subject featured in the media has reviewed the media item or collection and approved its metadata description. Must display a name or the literal "anonymous" (= anonymously reviewed).	Audubon Core	Optional and Filled
18	**reviewerComments**	Any comment provided by a reviewer with expertise in the subject, as free-form text.	Audubon Core	Optional and Filled

19	**available**	The date (often a range) that the resource became or will become available. The date and time must comply with the World Wide Web Consortium (W3C) datetime practice, which requires that date and time representation correspond to ISO 8601:1998, but with year fields always comprising 4 digits. This makes datetime records compliant with 8601:2004. AC datetime values may also follow 8601:2004 for ranges by separating two IS0 8601 datetime fields by a solidus ("forward slash", '/'). See also the wikipedia IS0 8601 entry for	Audubon Core	Optional and Filled
20	**rights**	Information about rights held in and over the resource. A full-text, readable copyright statement, as required by the national legislation of the copyright holder. On collections, this applies to all contained objects, unless the object itself has a different statement. Examples: “Copyright XY 2008, all rights reserved”, “© 2008 XY Museum” , "Public Domain.", "Copyright unknown" Do not place just the name of the copyright holder(s) here! That belongs in a list in the xmpRights: Owner field, which should be supplied if dcterms:rights is not 'Public Domain', appropriate only if the resource is known to be not under copyright.	Audubon Core	Mandatory
21	**Owner**	A list of the names of the owners of the copyright. 'Unknown' is an acceptable value, but 'Public Domain' is not. See the Comments below for this term.	Audubon Core	Mandatory
22	**UsageTerms**	The license statement defining how resources may be used. Information on a collection applies to all contained objects unless the object has a different statement.	Audubon Core	Optional and Filled

23	**WebStatement**	A URL defining or further elaborating on the license statement (e. g., a web page explaining the precise terms of use).	Audubon Core	Optional
24	**licenseLogoURL**	A URL providing access to a logo that symbolizes the License.	Audubon Core	Optional
25	**CreditLine**	Free text for "please cite this as…"	Audubon Core	Optional
26	**attributionLogoURL**	The URL of icon or logo image to appear in source attribution.	Audubon Core	Optional
27	**attributionLinkURL**	The URL where information about ownership, attribution, etc. of the resource may be found.	Audubon Core	Optional
28	**source**	An identifiable source from which the described resources was derived.	Audubon Core	Optional and Filled
29	**creator**	The person or organization responsible for creating the media resource.	Audubon Core	Optional and Filled
30	**provider**	Person or organization responsible for presenting the media resource. If no separate Metadata Provider is attributed, this attributes also the metadata.	Audubon Core	Optional and Filled
31	**metadataProvider**	Person or organization originally responsible for providing the resource metadata record.	Audubon Core	Optional and Filled
32	**metadataCreator**	Person or organization originally creating the resource metadata record.	Audubon Core	Optional and Filled
33	**description**	Description of collection or individual resource, containing the Who, What, When, Where and Why as free-form text. This normative document is silent on the nature of formatting in the text. It is the role of implementers of an AC concrete representation (e.g. an XML Schema, an RDF representation, etc.) to decide and document how formatting advice will be represented in Descriptions serialized according to such representations.	Audubon Core	Optional and Filled
34	**caption**	As alternative or in addition to description, a caption is free-	Audubon Core	Optional and Filled

		form text to be displayed together with (rather than instead of) a resource that is suitable for captions (especially images).		
35	**language**	Language(s) of resource itself represented in ISO639-1 or -3	Audubon Core	Optional and Filled
36	**LocationShown**	The location that is shown or the place of the media content, irrespective of the location from which the resource has been created.	Audubon Core	Optional and Filled
37	**WorldRegion**	Name of a world region in some high level classification, such as names for continents, waterbodies, or island groups, whichever is most appropriate. The terms preferably are derived from a controlled vocabulary (to be defined).	Audubon Core	Optional and Filled
38	**CountryCode**	The geographic location of the specific entity(ies) documented by the media item, expressed through a constrained vocabulary of countries using 2-letter ISO country code (e. g. "it, si").	Audubon Core	Optional and Filled
39	**CountryName**	This field can be free text, but where possible, the use of http://iptc.org/std/Iptc4xmpExt/1.0/xmlns/CountryCode is preferred.	Audubon Core	Optional and Filled
40	**ProvinceState**	Optionally, the geographic unit immediately below the country level (individual states in federal countries, provinces, or other administrative units) in which the subject of the media resource (e. g., species, habitats, or events) were located (if such information is available in separate fields).	Audubon Core	Optional and Filled
41	**City**	Optionally, the name of a city or place commonly found in gazetteers (such as a mountain or national park) in which the subjects (e. g., species, habitats, or events) were located.	Audubon Core	Optional and Filled
42	**Sublocation**	Free-form text location details of the location of the subjects, down to the village, forest, or geographic feature etc., below the city or other place	Audubon Core	Optional and Filled

		name, especially information that could not be found in a gazetteer.		
43	**decimalLatitude**	Latitude of the location of the camera trap image in degree decimal	Darwin Core	Optional and Filled
44	**decimalLongitude**	Longitude of the location of the camera trap image in de-gree decimal	Darwin Core	Optional and Filled
45	**temporal**	The coverage (extent or scope) of the content of the resource. Temporal coverage will typically include temporal period (a period label, date, or date range) to which the sub-jects of the media or media collection relate. If dates are mentioned, they should follow ISO 8601. When the resource is a Collection, this refers to the temporal coverage of the collection.	Audubon Core	Optional and Filled
46	**CreateDate**	The date of the creation for the original resource from which the digital media was derived or created. The date and time must comply with the World Wide Web Consortium (W3C) datetime practice, which requires that date and time representation corre-spond to ISO 8601:1998, but with year fields always com-prising 4 digits. This makes datetime records compliant with 8601:2004. AC datetime values may also follow 8601:2004 for ranges by sep-arating two IS0 8601 datetime fields by a solidus ("forward slash", '/'). See also the wik-ipedia IS0 8601 entry for fur-ther explanation and exam-ples.	Audubon Core	Optional and Filled
47	**timeOfDay**	Free text information beyond exact clock times.	Audubon Core	Optional and Filled
48	**physicalSetting**	The Setting of the content represented in a medium like images, sounds, movies. Constrained vocabulary of: "Natural" = Unmodified object in a natural setting of unmodi-fied object (e. g. living organ-isms in their natural environ-	Audubon Core	Optional and Filled

		ment); "Artificial" = Unmodified object in artificial setting of (e. g. living organisms in artificial environment: Zoo, Garden, Greenhouse, Laboratory; photographic background or background sound suppression). "Irrelevant" (e. g. background of Museum shots).		
49	**CVterm**	Controlled vocabulary of subjects to support broad classification of media items. Terms from various controlled vocabularies may be used. AC-recommended vocabularies are preferred and may be unqualified literals (without a URI). For terms from other vocabularies either a precise URI should be used, or, when providing unqualified terms, to provide the source vocabulary in Subject Category Vocabulary.	Audubon Core	Optional and Filled
50	**subjectCategoryVocabulary**	Any vocabulary or formal classification from which terms in Subject Category have been drawn	Audubon Core	Optional and Filled
51	**tag**	General keywords or tags.	Audubon Core	Optional and Filled
52	**taxonCoverage**	A higher taxon (e. g., a genus, family, or order) at the level of the genus or higher, that covers all taxa that are the primary subject of the resource (which may be a media item or a collection).	Audubon Core	Optional and Filled
53	**scientificName**	Taxon names of organisms represented in the media resource (with date and authorship information if available) of the lowest level taxonomic rank that can be applied.	Audubon Core	Optional and Filled
54	**identificationQualifier**	A brief phrase or a standard abbreviation ("cf. genus", "cf. species", "cf. var.", "aff.species", etc.) to express the determiner's doubts with respect to a specified taxonomic rank about the identification given in Scientific Name.	Audubon Core	Optional and Filled
55	**vernacularName**	Common (= vernacular) names of the subject in one or several languages. The ISO	Audubon Core	Optional and Filled

		language name should be given in parentheses after the name if not all names are in Metadata Language.		
56	**nameAccordingTo**	The taxonomic authority used to apply the name to the taxon, e. g., a book or web service from which the name comes from.	Audubon Core	Optional and Filled
57	**taxonID**	Equivalent to Scientific Name, but using GUIDs such as http URIs or LSIDs to refer to the taxon names or concepts.	Audubon Core	Optional and Filled
58	**scientificNameSynonym**	One or several scientific names that are synonyms to the Scientific Name may be provided here.	Audubon Core	Optional and Filled
59	**identifiedBy**	The name(s) of the person(s) who applied the Scientific Name to the sample.	Audubon Core	Optional and Filled
60	**dateIdentified**	The date on which the person(s) given under Identfied By applied a Scientific Name to the resource.	Audubon Core	Optional and Filled
61	**taxonCount**	An exact or estimated number of taxa at the lowest applicable taxon rank (usually species or infraspecific) represented by the media resource (item or collection).	Audubon Core	Optional and Filled
62	**subjectPart**	The portion of the organism, environment, etc. shown or particularly well illustrated.	Audubon Core	Optional and Filled
63	**Flank**	Specific flank (right/left/front/back) of the subject represented in the media resource with respect to the acquisition device.	Darwin Core	Optional and Filled
64	**sex**	A description of the sex of any organisms featured within the media, when relevant to the subject of the media, e. g., male, female, hermaphrodite, dioecious.	Audubon Core	Optional and Filled
65	**lifeStage**	A description of the life-cycle stage of any organisms featured within the media, when relevant to the subject of the media, e. g., larvae, juvenile, adult.	Audubon Core	Optional and Filled
66	**subjectOrientation**	Specific orientiation (= direction, view angle) of the subject represented in the media resource with respect to the acquisition device.	Audubon Core	Optional and Filled

67	**individualID**	A specific ID given to a particular individual subject on the basis of identification.	Darwin Core	Optional and Filled
68	**individualIdentifiedBy**	A list (concatenated and separated) of names of people, groups, or organizations who assigned the Taxon to the subject	Darwin Core	Optional and Filled
69	**patternIdentificationMethod**	The method of identifying the subject e.g. visual or by machine etc.	Darwin Core	Optional and Filled
70	**identificationRating**	A value (rating) is given on the basis of the percentage of identification of the subject. May be a or specific to the data set.	Darwin Core	Optional and Filled
71	**LocationCreated**	The location at which the media recording instrument was placed when the media was created.	Audubon Core	Optional and Filled
72	**digitizationDate**	Date of the first digital version was created, where different Date and Time Original (e. g. where photographic prints have been scanned). The date and time must comply with the World Wide Web Consortium (W3C) datetime practice, which requires that date and time representation correspond to ISO 8601:1998, but with year fields always comprising 4 digits. This makes datetime records compliant with 8601:2004. AC datetime values may also follow 8601:2004 for ranges by separating two IS0 8601 datetime fields by a solidus ("forward slash", '/'). See also the wikipedia IS0 8601 entry for further explanation and examples.	Audubon Core	Optional and Filled
73	**captureDevice**	Free form text describing the device or devices used to create the resource.	Audubon Core	Optional and Filled
74	**resourceCreationTechnique**	Information about technical aspects of the creation and digitization process of the resource. This includes modifi-	Audubon Core	Optional

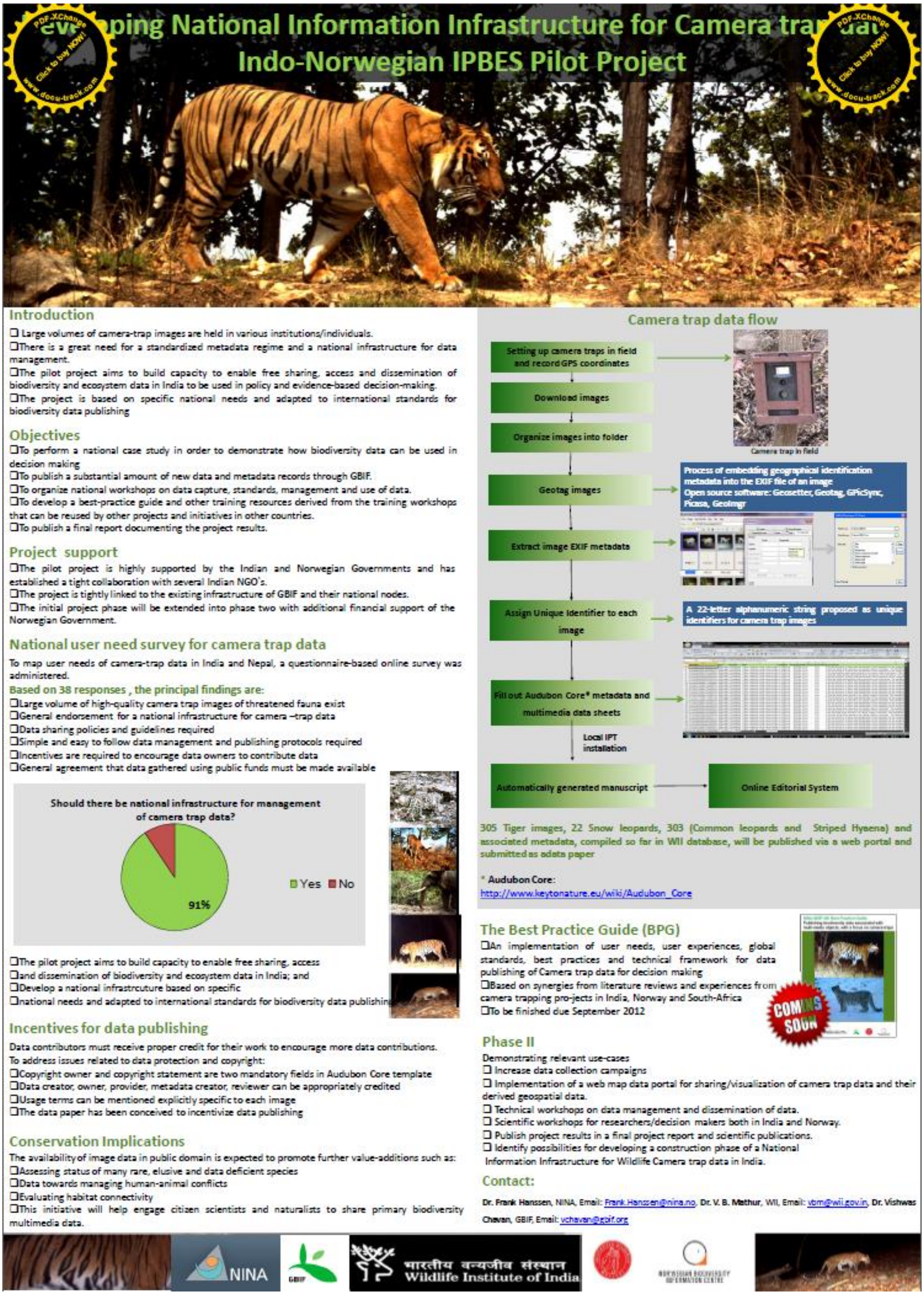
		cation steps ("retouching") after the initial resource capture.		
75	**thumbnailAccessURI**	URI of the resource itself. If this resource can be acquired by an http request, its http URL should be given. If not, but it has some URI in another URI scheme, that may be given here.	Audubon Core	Optional
76	**thumbnailFormat**	The technical format of the resource (file format or physical medium).	Audubon Core	Optional
77	**thumbnailQualityVariant**	What this ServiceAccessPoint provides. Suggested values are "Thumbnail", "Trailer", "Lower Quality", "Medium Quality", "Good Quality", "Best Quality", "Offline"	Audubon Core	Optional
78	**thumbnailExtent**	The size, dimensions, or duration of the variant of the media resource.	Audubon Core	Optional
79	**thumbnailFurtherInformationURL**	The URL of a Web site that provides additional information about (this version of) the media resource.	Audubon Core	Optional
80	**lowerQualityAccessURI**	URI of the resource itself. If this resource can be acquired by an http request, its http URL should be given. If not, but it has some URI in another URI scheme, that may be given here.	Audubon Core	Optional
81	**lowerQualityFormat**	The technical format of the resource (file format or physical medium).	Audubon Core	Optional
82	**lowerQualityVariant**	What this ServiceAccessPoint provides. Suggested values are "Thumbnail", "Trailer", "Lower Quality", "Medium Quality", "Good Quality", "Best Quality", "Offline"	Audubon Core	Optional
83	**lowerQualityExtent**	The size, dimensions, or duration of the variant of the media resource.	Audubon Core	Optional
84	**lowerQualityFurtherInformationURL**	The URL of a Web site that provides additional information about (this version of) the media resource.	Audubon Core	Optional
85	**mediumQualityAccessURI**	URI of the resource itself. If this resource can be acquired by an http request, its http URL should be given. If not, but it has some URI in another	Audubon Core	Optional

		URI scheme, that may be given here.		
86	**mediumQualityFormat**	The technical format of the resource (file format or physical medium).	Audubon Core	Optional
87	**mediumQualityVariant**	What this ServiceAccessPoint provides. Suggested values are "Thumbnail", "Trailer", "Lower Quality", "Medium Quality", "Good Quality", "Best Quality", "Offline"	Audubon Core	Optional
88	**mediumQualityExtent**	The size, dimensions, or duration of the variant of the media resource.	Audubon Core	Optional
89	**mediumQualityFurtherInformationURL**	The URL of a Web site that provides additional information about (this version of) the media resource.	Audubon Core	Optional
90	**goodQualityAccessURI**	URI of the resource itself. If this resource can be acquired by an http request, its http URL should be given. If not, but it has some URI in another URI scheme, that may be given here.	Audubon Core	Optional
91	**goodQualityFormat**	The technical format of the resource (file format or physical medium).	Audubon Core	Optional
92	**goodQualityVariant**	What this ServiceAccessPoint provides. Suggested values are "Thumbnail", "Trailer", "Lower Quality", "Medium Quality", "Good Quality", "Best Quality", "Offline"	Audubon Core	Optional
93	**goodQualityExtent**	The size, dimensions, or duration of the variant of the media resource.	Audubon Core	Optional
94	**goodQualityFurtherInformationURL**	The URL of a Web site that provides additional information about (this version of) the media resource.	Audubon Core	Optional
95	**bestQualityAccessURI**	URI of the resource itself. If this resource can be acquired by an http request, its http URL should be given. If not, but it has some URI in another URI scheme, that may be given here.	Audubon Core	Optional
96	**bestQualityFormat**	The technical format of the resource (file format or physical medium).	Audubon Core	Optional
97	**bestQualityVariant**	What this ServiceAccessPoint provides. Suggested values are "Thumbnail", "Trailer", "Lower Quality", "Medium	Audubon Core	Optional

		Quality", "Good Quality", "Best Quality", "Offline"		
98	**bestQualityExtent**	The size, dimensions, or duration of the variant of the media resource.	Audubon Core	Optional
99	**bestQualityFurtherInformationURL**	The URL of a Web site that provides additional information about (this version of) the media resource.	Audubon Core	Optional
100	**licensingException**	The licensing statement for this variant of the media resource if different from that given in the “License Statement” property of the resource.	Audubon Core	Optional
101	**serviceExpectation**	A term that describes what service expectations users may have of the accessURL. Recommended terms include online (denotes that the URL is expected to deliver the resource), authenticate (denotes that the URL delivers a login or other authentication interface requiring completion before delivery of the resource) published(non digital) (denotes that the URL is the identifier of a non-digital published work, for example a doi.) Communities should develop their own controlled vocabularies for Service Expectations.	Audubon Core	Optional
102	**variantDescription**	Text that describes this Service Access Point variant.	Audubon Core	Optional
103	**IDofContainingCollection**	If the resource is contained in a Collection, this field identifies that Collection uniquely. Its form is not specified by this normative document, but is left to implementers of specific implementations.	Audubon Core	Optional
104	**relatedResourceID**	Resource related in ways not specified through a collection. 12.1.1 Before-after images Time-lapse series Different orientations/angles of view	Audubon Core	Optional
105	**providerID**	A globally unique ID of the provider of the current AC metadata record.	Audubon Core	Optional

106	**derivedFrom**	A reference to an original resource from which the current one is derived.	Audubon Core	Optional
107	**associatedSpecimenReference**	A reference to a specimen associated with this resource.	Audubon Core	Optional
108	**associatedObservationReference**	A reference to an observation associated with this resource.	Audubon Core	Optional

12.2 Poster at the GBIF Governing Board meeting, Sept. 17-19 2012 (Norway)



12.3 Poster at the Conference of the Parties (COP), Oct. 8-19 2012 (India)

SIDE EVENT, CBD COP 11, HYDERABAD, 8 OCTOBER 2012

From the sidelines to the mainstream: engaging new communities in biodiversity data publishing

Free and open access to the world's biodiversity data is critical to monitoring progress towards and ultimately achievement of the Aichi Biodiversity Targets.

Recently, the Global Biodiversity Information Facility (GBIF) has been working with partners to engage newer data communities such as impact assessment practitioners, wildlife managers, local governments and citizen-driven observation networks.

The event will showcase a number of innovative approaches to capturing data from these additional sources, thus increasing the availability of science-grade biodiversity data.

Presentations:

Engaging fence-sitters into biodiversity data publishing
Donald Hobern, Vishwas Chavan, GBIF Secretariat

Enhancing capacity for data and decisions: Indo-Norwegian Capacity Building Pilot Project for IPBES
Vinod B. Mathur, Mousumi Ghosh, Wildlife Institute of India

Engaging local governments in biodiversity data publishing
Russell Galt, ICLEI Local Governments for Sustainability

Access to biodiversity data from environmental impact assessment
Asha Rajvanshi, Wildlife Institute of India

A new best-practice guide for mobilizing data from camera traps, produced by GBIF, NINA and WII, will be launched at the event.

Where: G.02, Hyderabad International Convention Centre
When: Monday, 8 October 2012, 13.15 - 14.45
Contacts: Vishwas Chavan vchavan@gbif.org, Tim Hirsch thirsch@gbif.org

Lunch provided

GLOBAL BIODIVERSITY INFORMATION FACILITY
ICLEI Local Governments for Sustainability
Convention on Biological Diversity
IAIA
NORWEGIAN BIODIVERSITY INFORMATION CENTRE
SANBI Biodiversity for Life
भारतीय वन्यजीव संस्थान Wildlife Institute of India
जहाँ है हरियाली। वहाँ है खुशहाली।।
NINA Norwegian Institute for Nature Research

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NINA Report

The Norwegian Institute for Nature Research (NINA) is Norway's leading institution for applied ecological research.

NINA is responsible for long-term strategic research and commissioned applied research to facilitate the implementation of international conventions, decision-support systems and management tools, as well as to enhance public awareness and promote conflict resolution.

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Cooperation and expertise for a sustainable future