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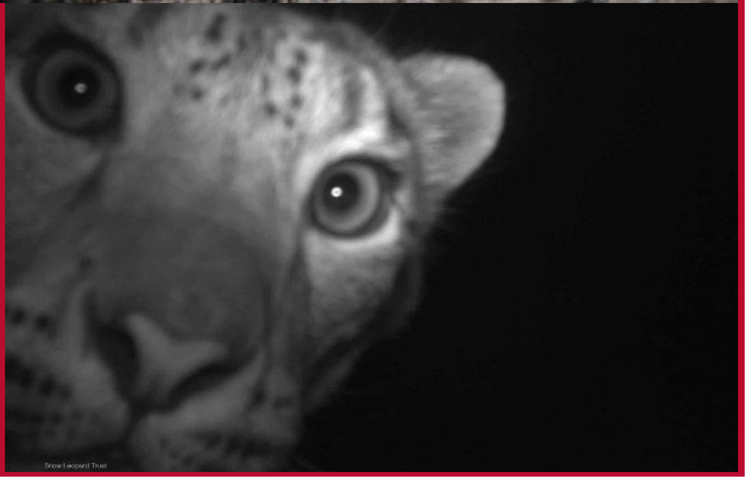
BUILDING A FOUNDATION FOR LINEAR INFRASTRUCTURE SAFEGUARDS IN ASIA

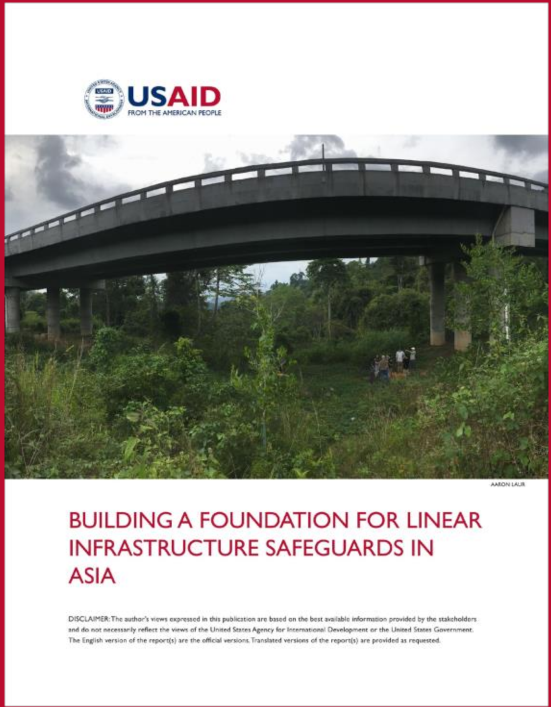
"THE LISA PROJECT"

MODULE 5: WILDLIFE CROSSING STRUCTURES – PLANNING, DESIGN, AND EVALUATION

Prime Contractor: Perez, APC
ESS Work Assignment #13



RESULTS OF THE LISA PROJECT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AARON LAUR

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THE FINAL REPORT

https://largelandscapes.org/lisa-reports

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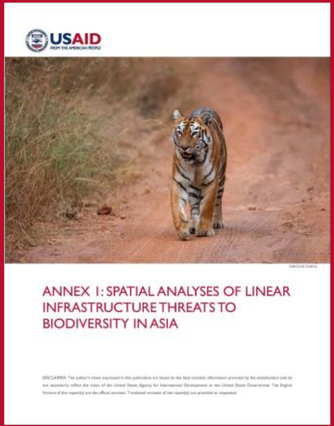
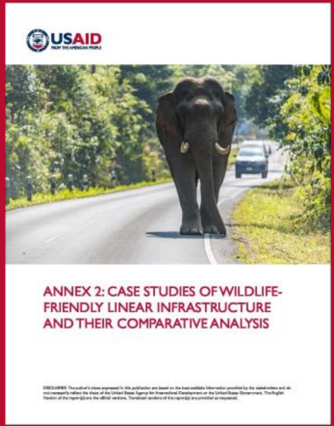
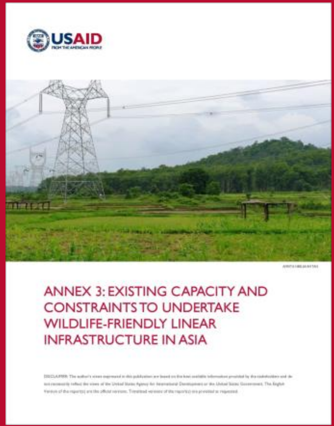
RESULTS OF THE LISA PROJECT

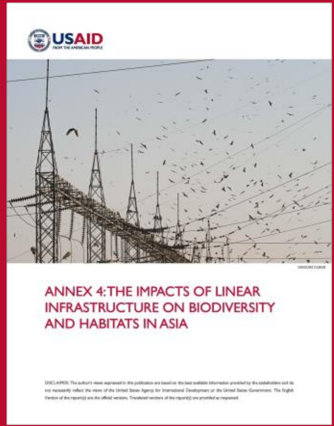
THE FINAL REPORT'S FOUR ANNEXES

Annex 1: Spatial Analyses
Annex 2: Case Studies
Annex 3: Capacity Assessment
Annex 4: Literature Review









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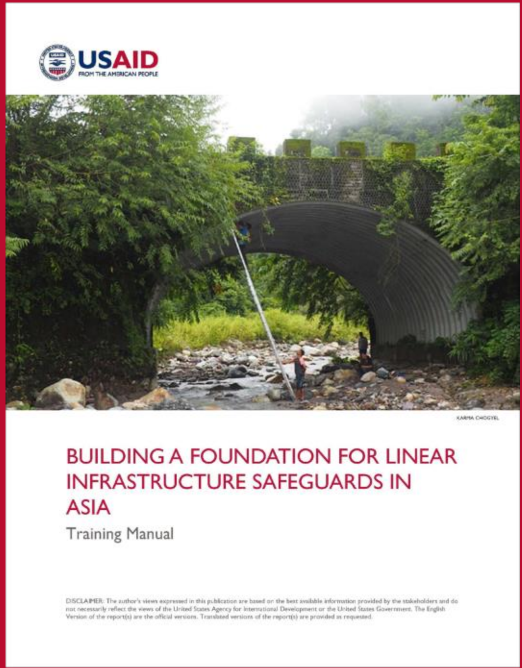
RESULTS OF THE LISA PROJECT

TRAINING MATERIALS AND MANUAL



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MODULE 5 PRESENTERS:

Anthony P. Clevenger, PhD,
Research Wildlife Scientist,
Western Transportation Institute,
Montana State University USA

Benjamin (Ben) Dorsey, MSc,
Ecosystem GIS Specialist
Consultant

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AGENDA – PART 1

- Impacts of roads on wildlife populations and their conservation
- Wildlife crossings: planning and data needs
- Design of wildlife crossings
- Monitoring – methods
- How evaluate performance

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1. IMPACTS OF ROADS ON WILDLIFE POPULATIONS AND THEIR CONSERVATION

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BIODIVERSITY IS DECLINING ACROSS THE GLOBE…

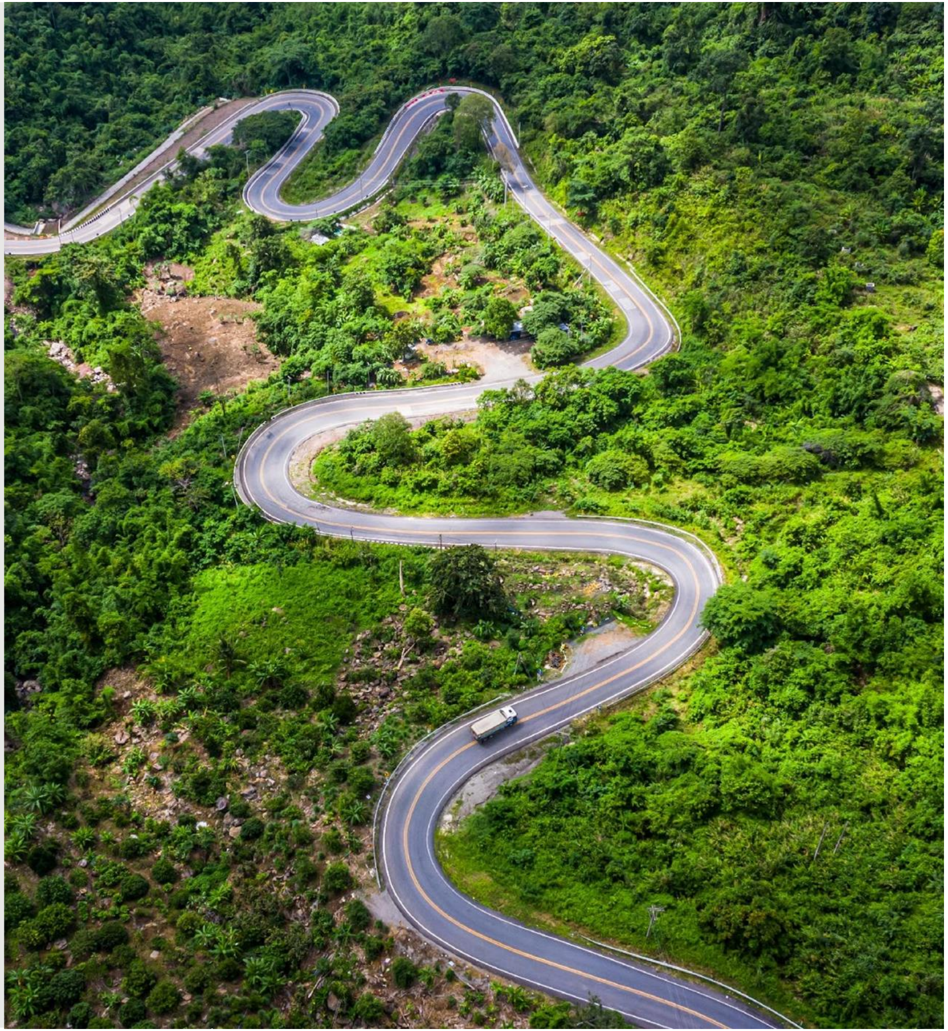
at an unprecedented rate

Approximately 50 to 70% of the Earth's land surface currently modified for human activities

HABITAT LOSS AND FRAGMENTATION

- NATURAL CAUSES
  - Fires
  - Insect Outbreaks
  - Drought

- HUMAN-CAUSED
  - Linear infrastructure
    - Roads
    - Railways
    - Power Lines
    - Canals



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A WORLD OF ROADS… AND MORE COMING

25 million new paved-lane roads by 2050

Urban areas: increase by 1.2 million km2 globally**

Tiger Conservation & Roads***
43% breeding areas; 57% conservation areas
20% reductions in tigers and prey abundance

*Dulac. 2013. Global transport infrastructure requirements, Estimating road and railway infrastructure capacity and costs to 2050. IEA, Paris, France.

**Seto et al. 2012. Proceedings of the National Academy of Sciences Oct 2012, 109 (40) 16083-16088;

*** Carter et al. 2020. Science Advances 6:eaaz9619.

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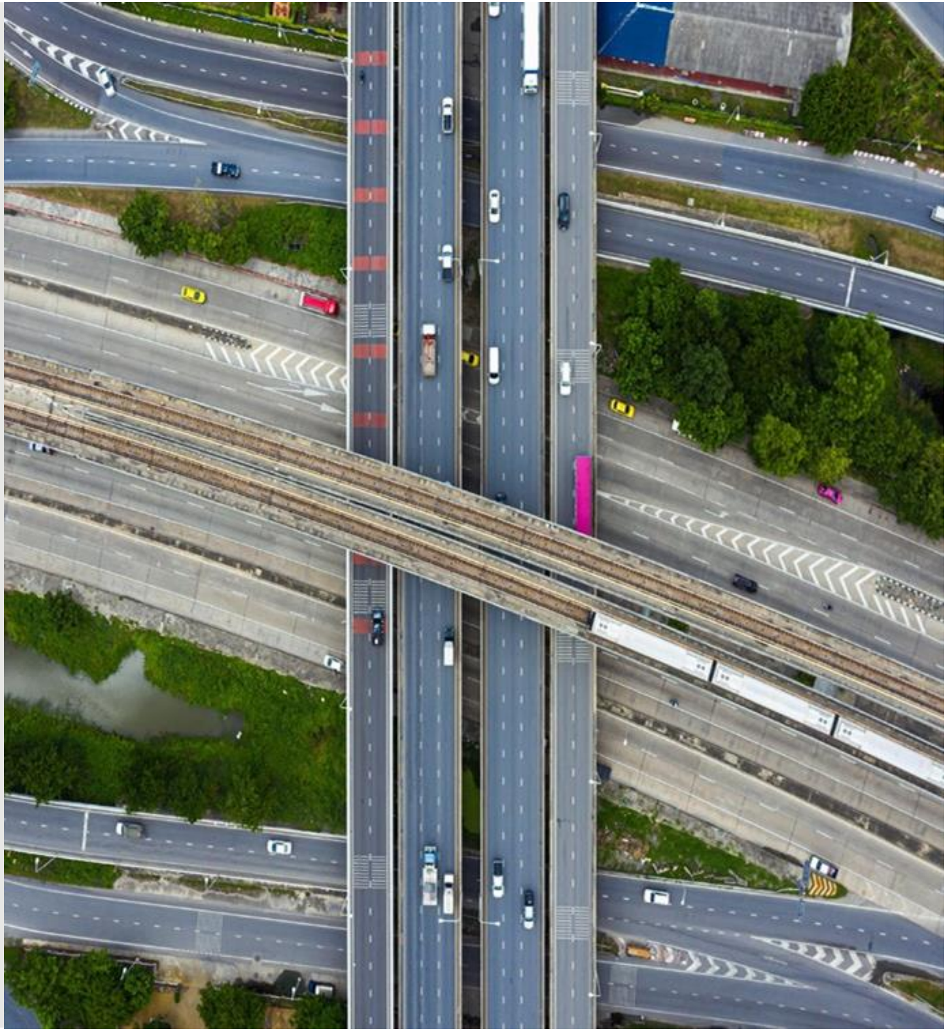

CONSERVATION BIOLOGY, LANDSCAPE ECOLOGY…

WHAT IS ROAD ECOLOGY?

Road ecology is the study of the often complex interaction between roads and the environment over the scales of space and time.

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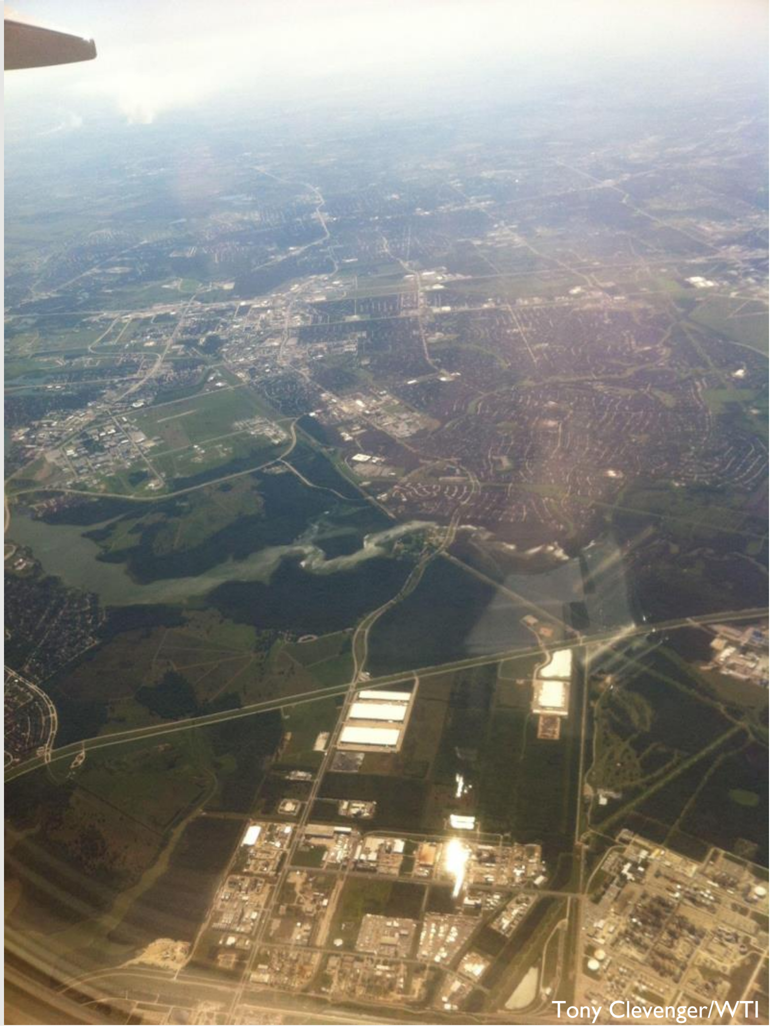
ROAD ECOLOGY TODAY

ROAD SYSTEM NETWORK
- The huge “net”
- Easy access and travel
- Fragments natural areas

ROADS AND THEIR IMPACTS
- “The Sleeping Giant”
- Road-related mortality – largest source of mortality in the world
- 15-20% area impacted by roads

OUR JOB
- Reconnect nature
- Restore connections


Tony Clevenger/WTI

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EFFECT OF ROADS ON THE ENVIRONMENT

- Habitat Loss
- Habitat Disturbance
- Disproportional landscape fragmentation
- Barriers to movement – reduced genetic interchange
- Mortality of animals
- Population sinks
- Biodiversity loss
- Non-native plant spread
- Road impact zone
- Chemicals and Air Pollution effects…stormwater runoff
- Changes in microclimate, hydrology, and many more

ECOLOGICAL IMPACT OF ROADS ON WILDLIFE

- **Mortality (road-kill)**
- Habitat loss
- **Disruption of natural movement**
  - Habitat fragmentation
    - Isolation
    - Local extinction
- Other impacts
  - Human access from new roads
  - Noise, lighting, and pollution (distance effects)
  - Edge effect, microclimate changes, etc.

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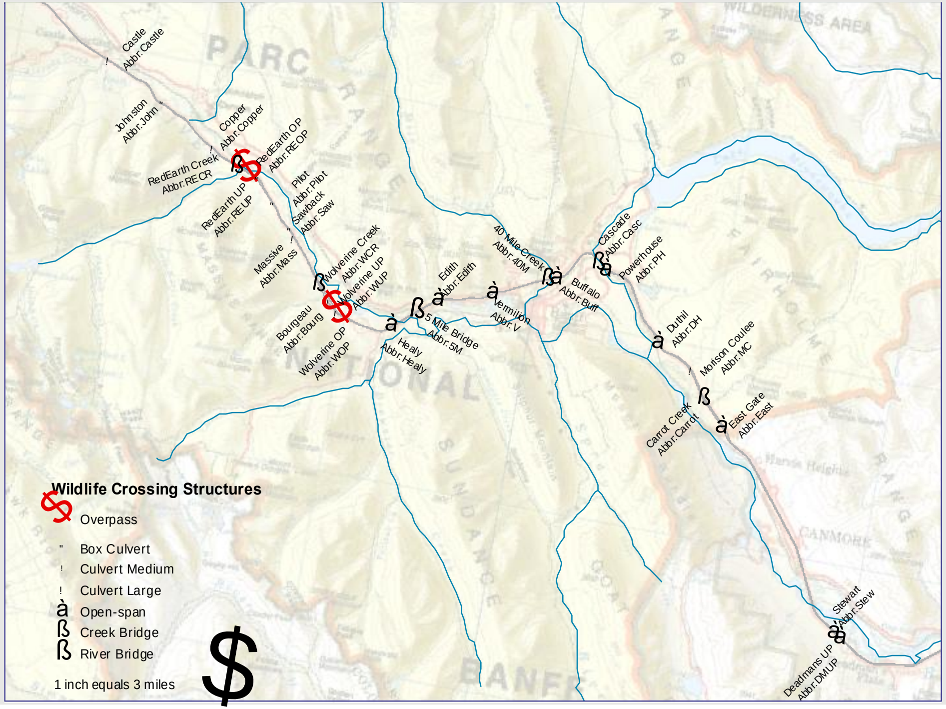
KEEPING CONNECTIONS INTACT

- **Landscape corridors and wildlife crossings are key to maintaining landscape connectivity**

- **Large scale**: land securement and management
  - Corridors and protected area networks
- **Local scale**: site-specific measures



2. WILDLIFE CROSSINGS: PLANNING

WHERE TO PLACE CROSSING STRUCTURES

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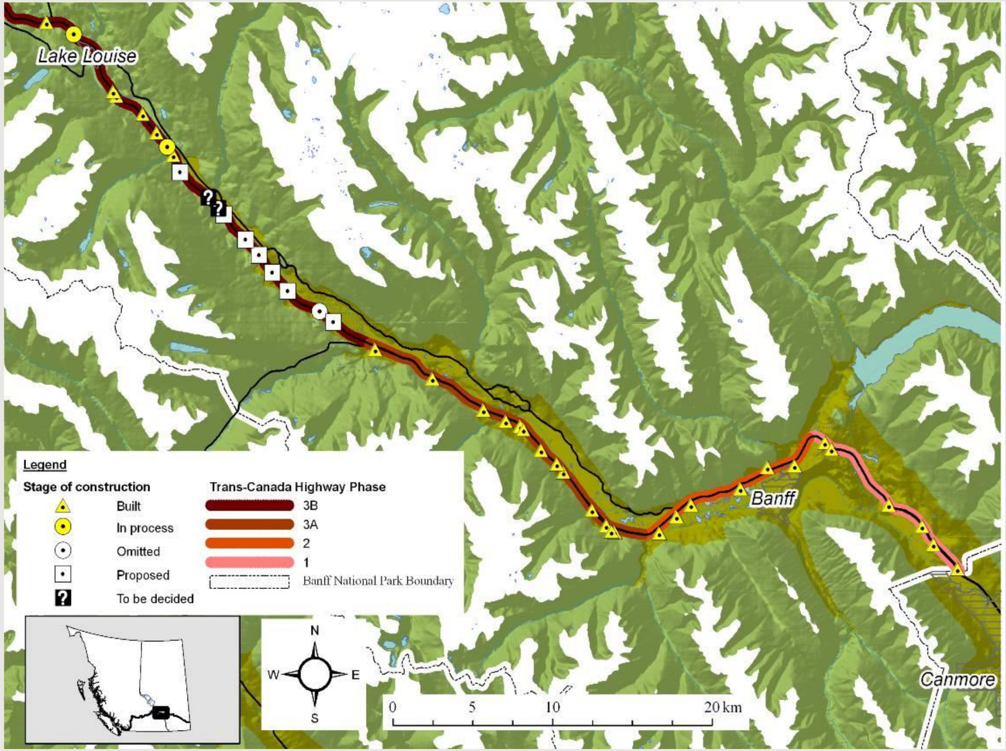
PLANNING SCALES

1. LANDSCAPE OR SYSTEM SCALE

- Intersection of broad transportation & ecological corridors
- Based on ecological integrity

2. PROJECT OR LOCAL SCALE

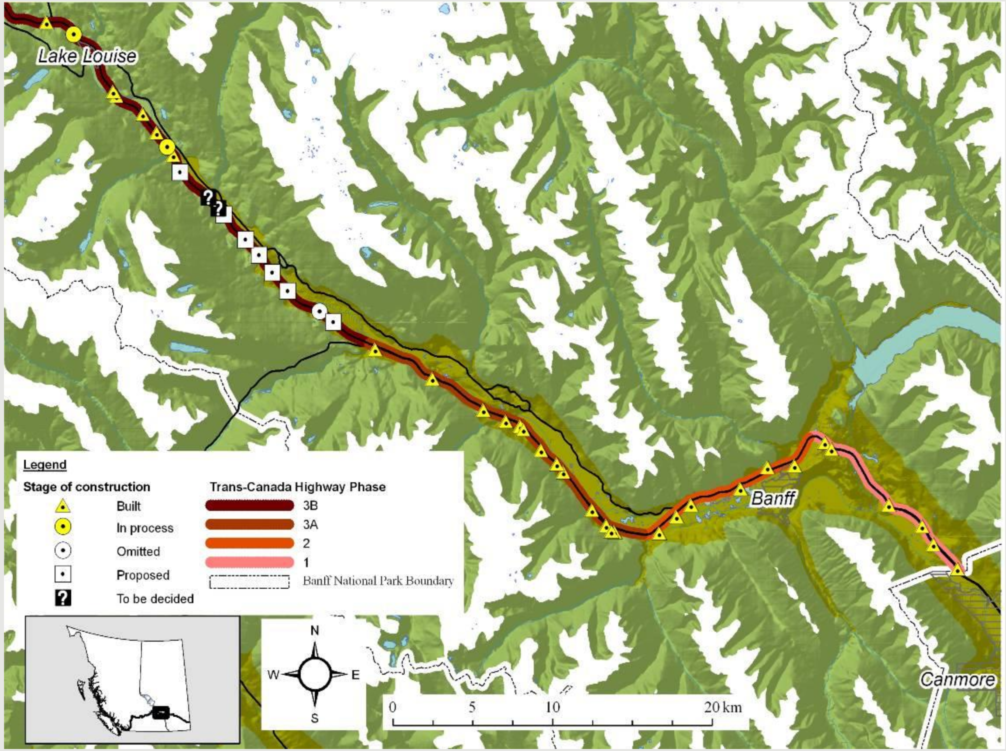
- Site level without ecosystem planning
- Based on species protection



PLANNING DATA AND RESOURCES

DATA REQUIRED

- Road/Rail network data
- **Road- Rail-kill data**
- Aerial photos
- Land cover/vegetation maps
- Topographic maps
- Land ownership maps
- Wildlife habitat maps
- **Empirical field data**
- **Wildlife movement model data**



Wildlife crossing structures, Trans-Canada Hwy, Banff NP, Canada

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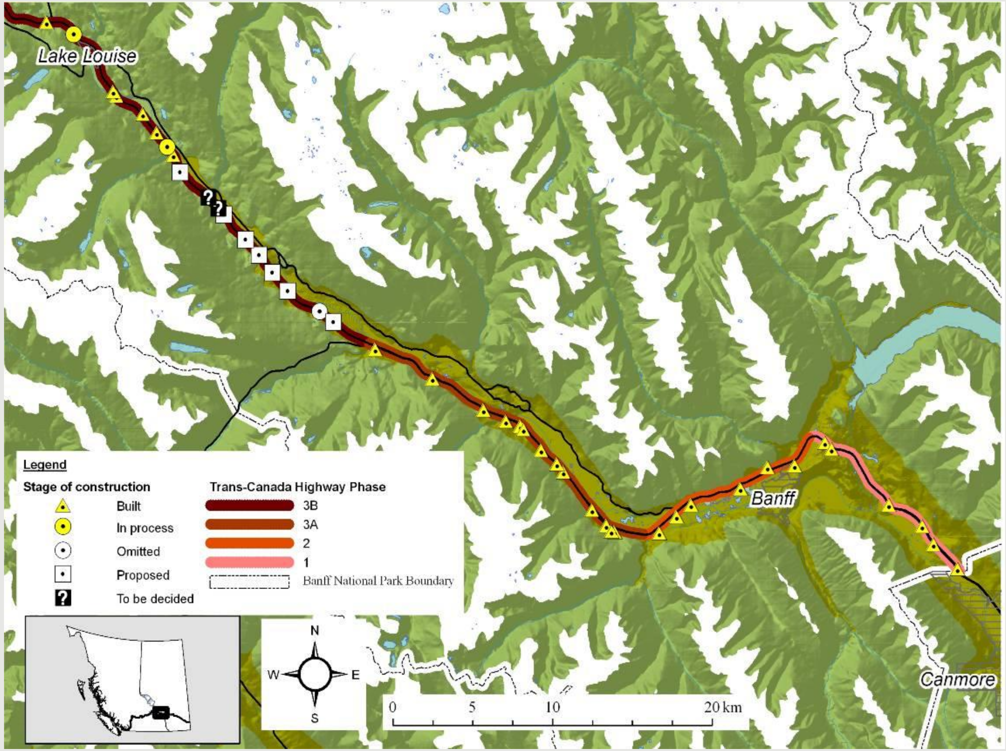
METHODS OF PLACEMENT

GIS/SPATIAL DATA

- Digital elevation models
- Water/hydrology
- Vegetation or landcover system
- Wildlife habitat suitability
- Built areas
- Road/Rail network



PLANNING WILDLIFE CROSSING MITIGATION

FIELD DATA

- Road- Rail-kill hotspots (dead - unsuccessful) & Live crossings
- Species occurrence data: Camera/sign surveys
- Radio-tracking/telemetry (can be high resolution)
- Winter road surveys (seasonally limited)

GIS MODELS

- Least-cost path models of animal movements (detection data helps)

NO DATA

- Expert-opinion models (modeling habitat & movement)
- Rapid assessments (stakeholder meetings; e.g., Nepal Railway)
- Local knowledge

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PLANNING WILDLIFE CROSSING MITIGATION

SPACING OF CROSSINGS

- How far apart?
- What interval for spacing?

Biophysical factors determine spacing:

- Terrain
- Habitat type
- Human disturbance


Aaron Laur

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TRUE OR FALSE?

The discipline of road ecology began over 20 years ago as a means to examine how roads impact the environment. Road ecology encompasses biotic (ecological) as well as abiotic (chemical and physical) impacts.

TRUE

The discipline of road ecology began over 20 years ago as a means to examine how roads impact the environment. Road ecology encompasses biotic (ecological) as well as abiotic (chemical and physical) impacts.

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3. INFORMING ROAD MITIGATION PROJECTS

PRE-CONSTRUCTION DATA

IMPACTS TO WILDLIFE:

- Mortality – vehicle cause
- Movements - disrupted

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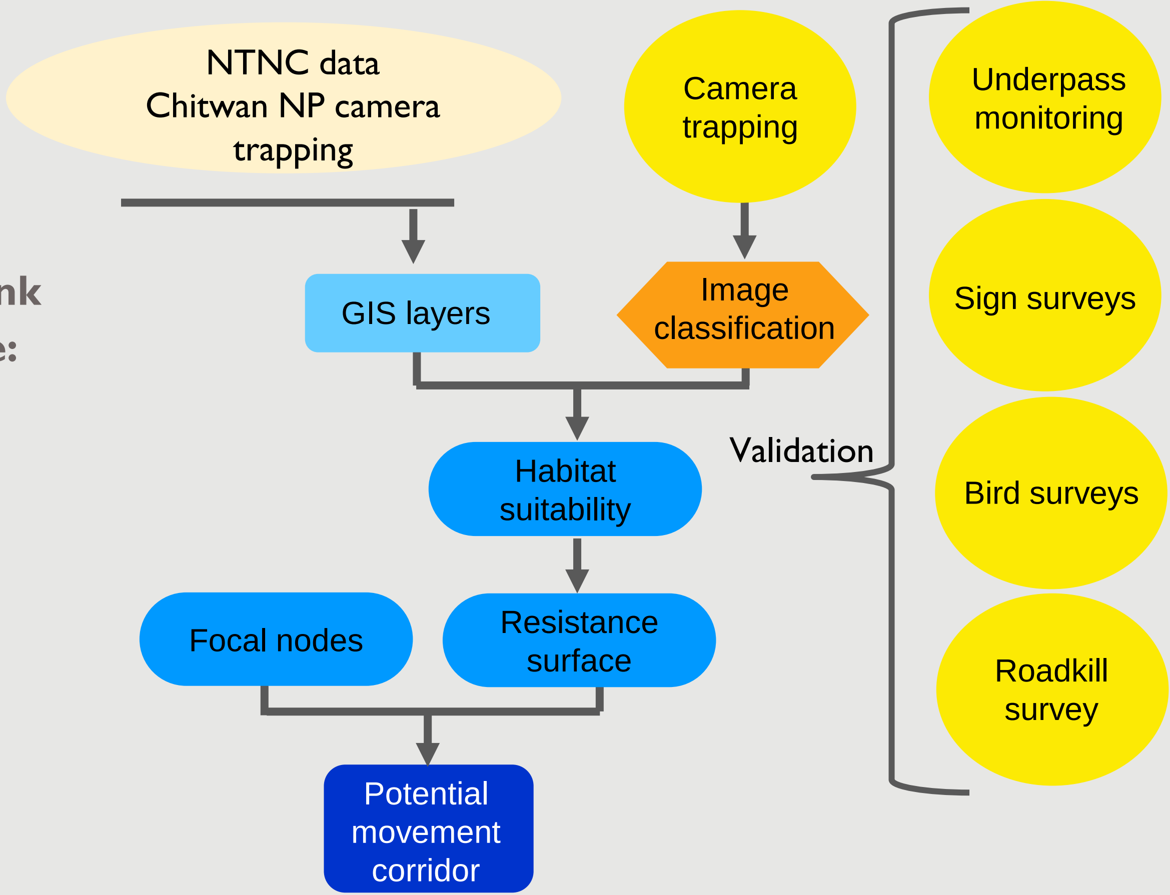
DATA COLLECTION METHODS

Asian Development Bank (ADB) Project Example: NHP Road, Nepal



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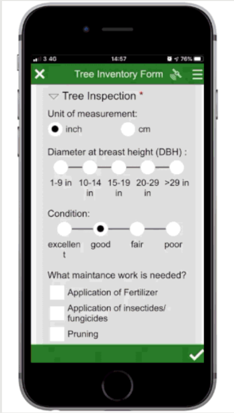
FIELD DATA COLLECTION

Notebooks (paper, pencil)

Voice Recorder

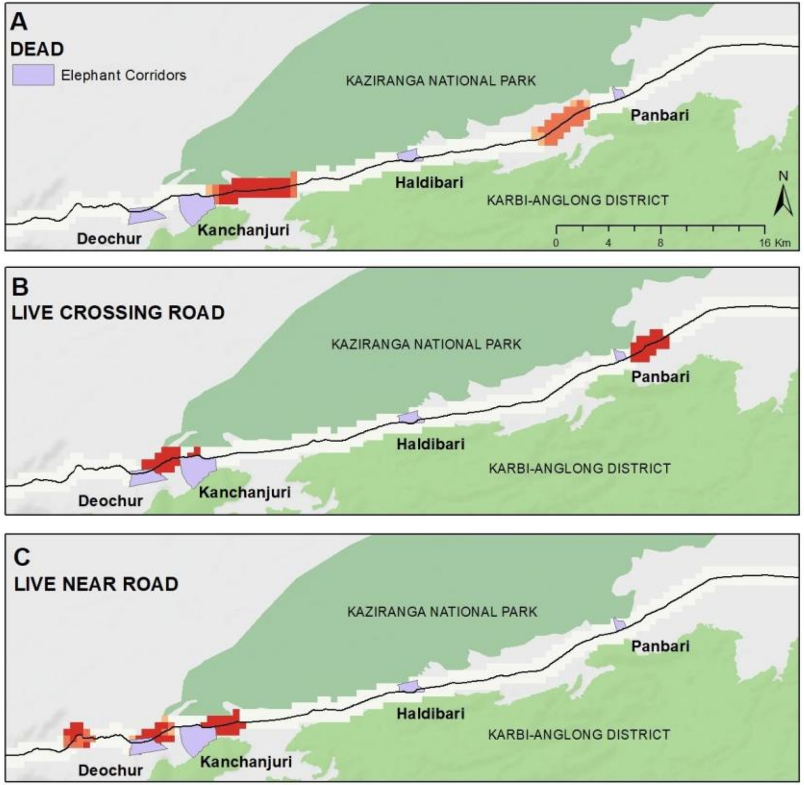
PDA – Personal Data Assistant



Smartphone App (next part of module)

CASE STUDY - NH-37

Kaziranga National Park
Assam, India



Service Layer Credits: Sources: Esri, USGS, NOAA

DATA OUTPUTS

2 Main Types of Data

1. Road-kill hot spots/clusters
- Species occurrence
- Location
- Severity of Impact

2. Species Occurrence (Camera/Sign surveys)
- Distribution
- Corridors
- Modelling Connectivity

These data types can be "layered" to inform key sites

MOVEMENT/CONNECTIVITY

Models Used

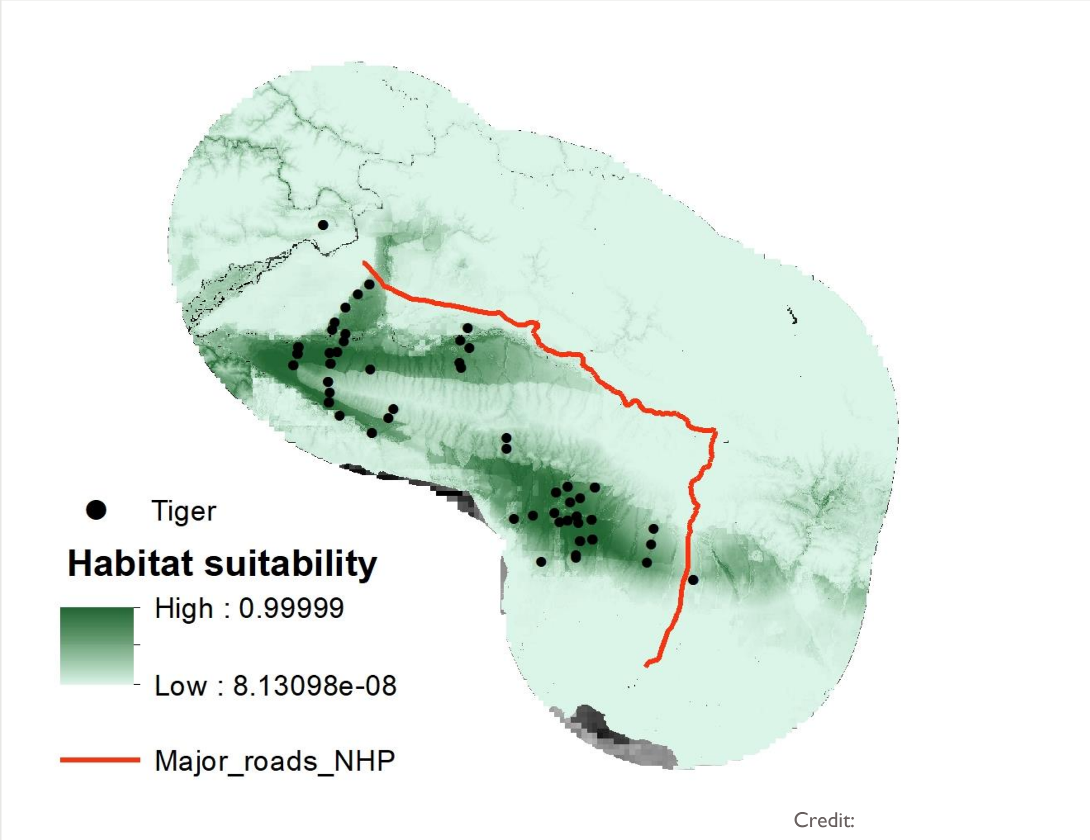
<u>Identify:</u>

Critical habitats

Movement corridors

LI–Wildlife conflict areas

Narayanghat-Hetauda-Pathlaiya Road near Chitwan NP, Nepal



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TRUE OR FALSE?

Planning the location of wildlife crossings requires good data on where species occur and where are most vulnerable to roads in terms of mortality (road-kill) and population connectivity.

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TRUE

Planning the location of wildlife crossings requires good data on where species occur and where are most vulnerable to roads in terms of mortality (road-kill) and population connectivity.

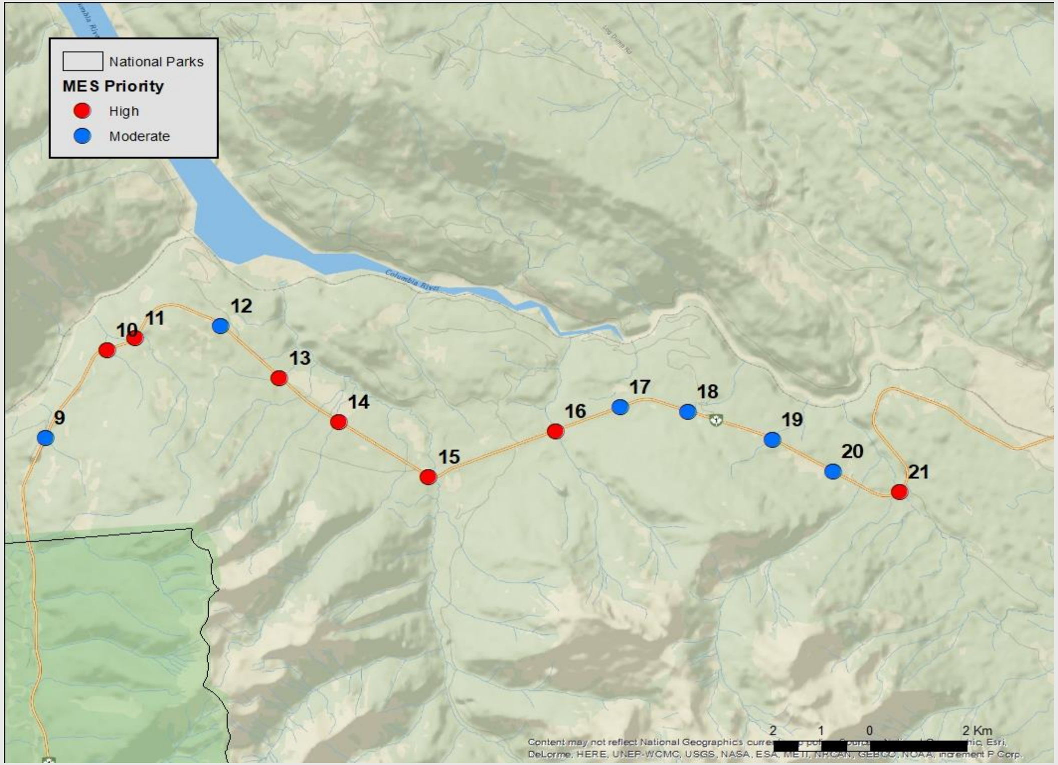
MERGING AND SYNTHESIS

LOCATIONS ("candidate")

1. Locations identified

1. Prioritization of sites*

**Not all sites have same conservation value*



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MERGING AND SYNTHESIS

Prioritization of locations
Primary – Secondary – Tertiary

Criteria (and scoring):
- Land security
- Connectivity
- Constructability
- Roadkill Severity

"Layering" of mitigation recommendations

1. Large/iconic species (conservation concern)
2. Arboreal/canopy dwellers
3. Small/medium terrestrial vertebrates

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4. DESIGN OF WILDLIFE CROSSINGS

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DESIGN

OVERPASS DESIGN

1. Landscape bridge/tunnel
2. Wildlife overpass
3. Multi-use overpass
4. Canopy crossing

UNDERPASS DESIGN

5. Viaduct/flyover
6. Large mammal underpass
7. Multi-use underpass
8. Underpass with water flow
9. Small/medium-sized mammal underpass
10. Modified culvert design
11. Herptile tunnel

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TUNNEL

CONSIDERATIONS

FEW

– Habitat Intact
- Human use/disturbance
- Habitat changes

WILDLIFE OVERPASSES

Wildlife Community

CONSIDERATIONS

- Dimensions
- Vegetation
- Soil
- Screening
- Human use

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FLYOVER - VIADUCT

Wildlife Community

CONSIDERATIONS

FEW –

– Habitat Intact
- Human use/disturbance
- Habitat changes

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WILDLIFE UNDERPASSES

CONSIDERATIONS

- Dimensions
- Vegetation
- Soil
- Screening
- Human use

Large & medium-sized fauna

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CONNECTIVITY AND COVER: SMALL MAMMALS

Linking wetland habitats

Providing habitat elements within – structural cover

ARBOREAL CROSSING STRUCTURES

"The least understood passages"

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USE OF EXISTING STRUCTURES – "RETROFITS"

- Very low cost
- Natural travel corridor
- Modify to enhance use
- Compliment a corridor network

Riparian crossing structure with travel path

WILDLIFE CROSSING STRUCTURES: PLANNING AND COSTS

- New road project
- Existing road upgrade – lower costs
  - Unpaved to paved
  - Added lane expansion



There are many designs used to get animals safely across roads. What are some of the main factors used to determine the most appropriate design? (more than one choice may apply).

a) Species habitat requirements
b) The design with the lowest cost
c) The design most used by engineers on past projects.
d) Terrain and type of habitat the crossing is planned.
e) None of the above.

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ANSWERS HIGHLIGHTED IN YELLOW

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4. MONITORING

THE CASE FOR WILDLIFE CROSSINGS

METHODS FOR MONITORING MITIGATION MEASURES

Cameras

Track beds

Hair/DNA sampling

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EVALUATION OF PERFORMANCE

ARE THEY FUNCTIONAL?

ARE THEY MEETING THE DESIRED OBJECTIVE?

- Increasing animal movements
- Reducing mortality

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EVALUATION OF PERFORMANCE

30 YEARS OF WILDLIFE CROSSING STUDIES:

Individual-level studies:

- What species?
- How frequently are the crossings being used?

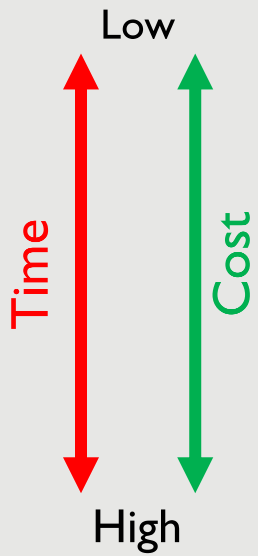
Demographic benefits?

- Lacking

Population-level/genetic benefits?

- Lacking

CRITERIA FOR MEASURING PERFORMANCE



1. Movement within populations
2. Biological requirements met, genetic interchange
3. Dispersal of subadults, recolonization
4. Population redistribution with environmental change
5. Long-term maintenance of metapopulation, community stability, and ecosystem processes

<u>Levels of biological organization</u>
Individuals
Species-populations
Communities-ecosystems

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BASIC PRINCIPLES

- Movements are associated with topographic features & habitat
- Design and manage for multiple species
- Agencies need to coordinate in short- and long-term
- Structures must be integrated into larger network

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MAINTENANCE OF WILDLIFE CROSSING STRUCTURES

1. **Funding and annual budgets**
2. Keep passages open and clear of debris: Regular inspections
3. Reduce/Eliminate human activity (poaching), disturbance, garbage dumps
4. Canopy crossings: Regular inspections
5. Substrate (soil base) preserved within underpasses
6. Fencing & gates: Inspect and repair as needed
7. Overpass: Routine inspections as for bridges

WILDLIFE CROSSINGS IN ASIA – LOOKING FORWARD

1. LITERATURE REVIEW: Few studies to date
2. GROWING NUMBER OF CROSSING PROJECTS
3. INCREASED KNOWLEDGE – Designs & performance
4. ENSURE FUNDING FOR EVALUATIONS
5. KNOWLEDGE BASE: Build and adapt future projects;
6. REVISE TECHNICAL GUIDELINES: Share "Lessons learned"

SUMMARY

1. Crossing structures: **A key strategy** for wildlife conservation.
2. Crossing structures need to **connect to a larger corridor network.**
3. Scale is important: **Project and Landscape** level.
4. Planning needs to look **beyond highway corridor**
5. **Research & monitoring** is critical to inform design.
6. **Technical guidelines** are needed.
7. **Construction costs are reduced** if part of larger project.
8. **National scale assessment** will allow for prioritization of projects.

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What are some criteria that have been used to determine that wildlife crossings are functional?

a) Wildlife tracks have been seen passing through the wildlife crossing
b) Breeding males and females are detected using the crossing
c) Population-level benefits such as gene flow is documented.
d) Ecosystem processes, such as predator-prey relationships, are restored because of the crossing.
e) All of the above.

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ANSWER IS HIGHLIGHTED IN YELLOW

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THANK YOU

Photo: WCS-Mongolia.

CONTACT:

Anthony P. Clevenger: apclevenger@gmail.com

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AGENDA MOD 5 - PART 2

1. **GIS AND THE ITERATIVE SPATIAL ANALYSIS FRAMEWORK**
2. **DATA CONSIDERATIONS AND TOOLS**
3. **MODERN TOOLS ENABLE INCREASED EFFICIENCY, COLLABORATION, AND TRANSPARENCY**

1. GIS AND THE ITERATIVE SPATIAL ANALYSIS FRAMEWORK

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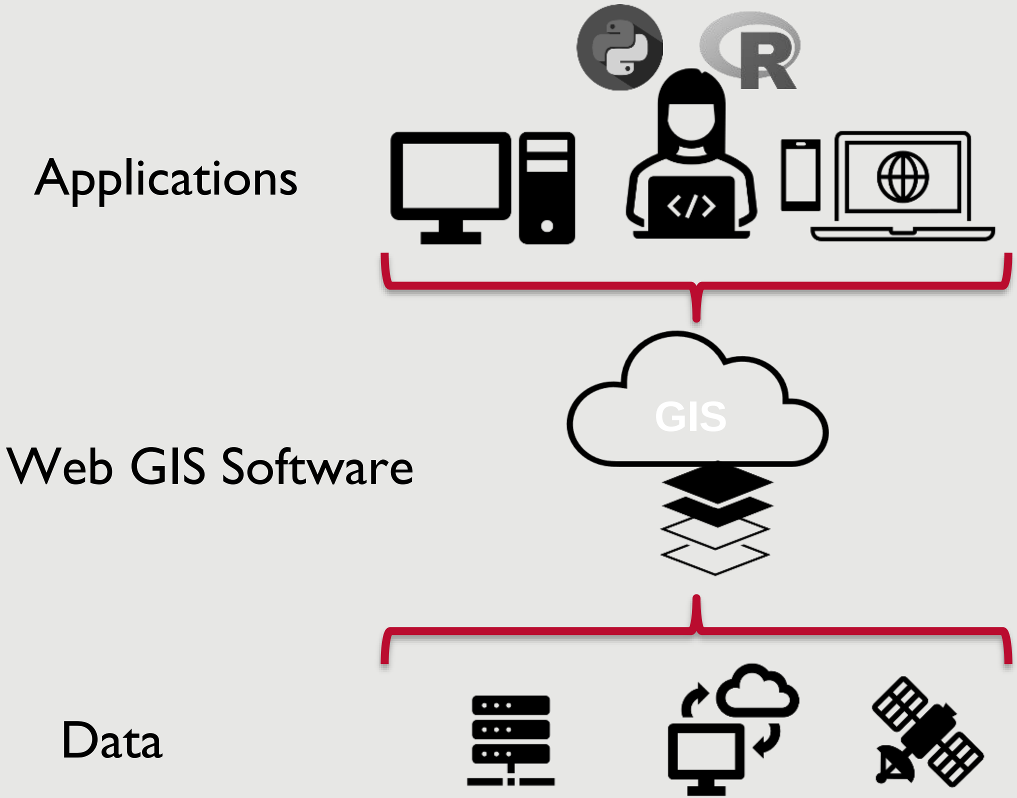
WHAT IS WEB GIS?

- System of connected servers, software, and applications
- Provides for integration and collaboration



WEB GIS IS MORE THAN A DATABASE

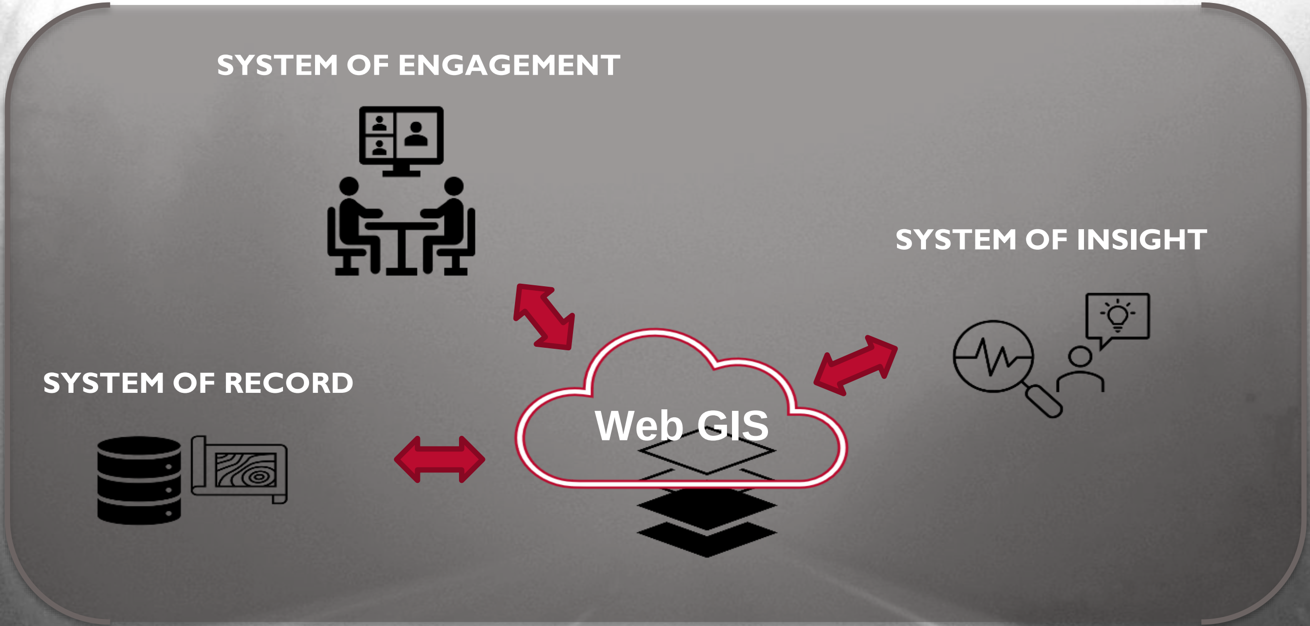


Photo: Ben Dorsey, Adapted from: esri.com

ITERATIVE SPATIAL ANALYSIS FRAMEWORK

Data gathering and synthesis

Planning and Design

Mapping and Visualization

Decision Making

Analysis and Modelling

Action

ITERATIVE SPATIAL ANALYSIS FRAMEWORK

Data gathering and synthesis

What data do we need?
What data exist?
What data do we need to collect?

Planning and Design

Mapping and Visualization

Decision Making

Analysis and Modelling

Action

ITERATIVE SPATIAL ANALYSIS FRAMEWORK

Data gathering and synthesis

Planning and Design

Mapping and Visualization

Enables Rapid QA/QC
Extent and Resolution?
Current, Consistent and Complete?

Decision Making

Analysis and Modelling

Action

ITERATIVE SPATIAL ANALYSIS FRAMEWORK

Data gathering and synthesis

Planning and Design

Mapping and Visualization

Decision Making

Analysis and Modelling

Balanced data?
Technical aberrations?
Model power and performance?

Action

ITERATIVE SPATIAL ANALYSIS FRAMEWORK

Data gathering and synthesis

Planning and Design

Study duration & Sample size
Initial results and communication
With stakeholders

Mapping and Visualization

Decision Making

Analysis and Modelling

Action

ITERATIVE SPATIAL ANALYSIS FRAMEWORK

Data gathering and synthesis

Planning and Design

Mapping and Visualization

Decision Making

Project stage based

Early: Sampling scale & Survey locations

Mid: Project tracking, interm reporting

Late: Mitigation locations & solutions

Analysis and Modelling

Action

ITERATIVE SPATIAL ANALYSIS FRAMEWORK

Data gathering and synthesis

Planning and Design

Mapping and Visualization

Decision Making

Analysis and Modelling

Action

Implement decisions
Final reporting

Q1. Why would the process of data collection, analysis, and reporting be repeated in a LI project? (Choose all that apply)?

- ❑ a. The project changed in design, extent or scope.
- ❑ b. New data became available or was located during the project.
- ❑ c. The data and reporting needs vary for each stage of a project.
- ❑ d. To ensure the findings hold true across multiple scales or analysis methodologies.
- ❑ e. All of the above.

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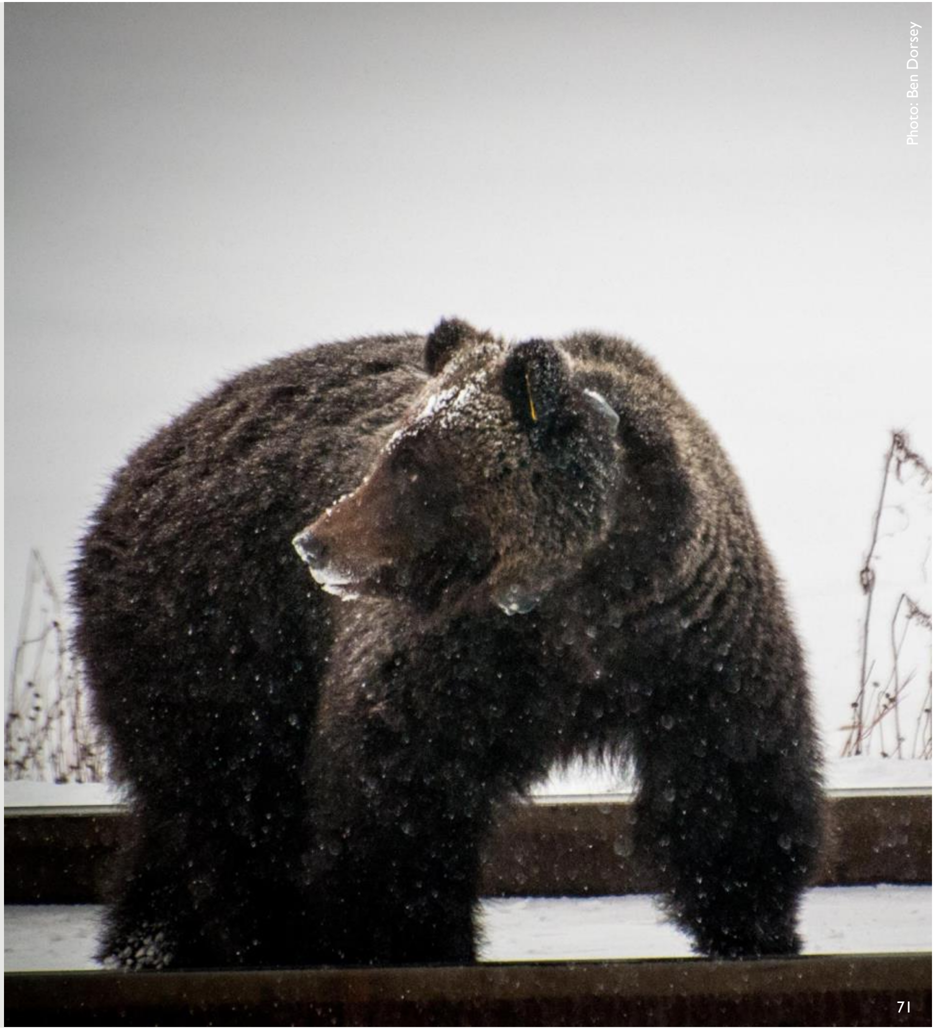
- ✔ e. **All of the above.**

WEB GIS
FOSS AND SAAS

- Web GIS software comes in two general licensing forms
- SAAS – costs $ upfront, rapid setup and easy to implement
- FOSS – costs may be hidden, requires different technical skills, possibly longer setup time.



DEMO A SAAS WEB GIS

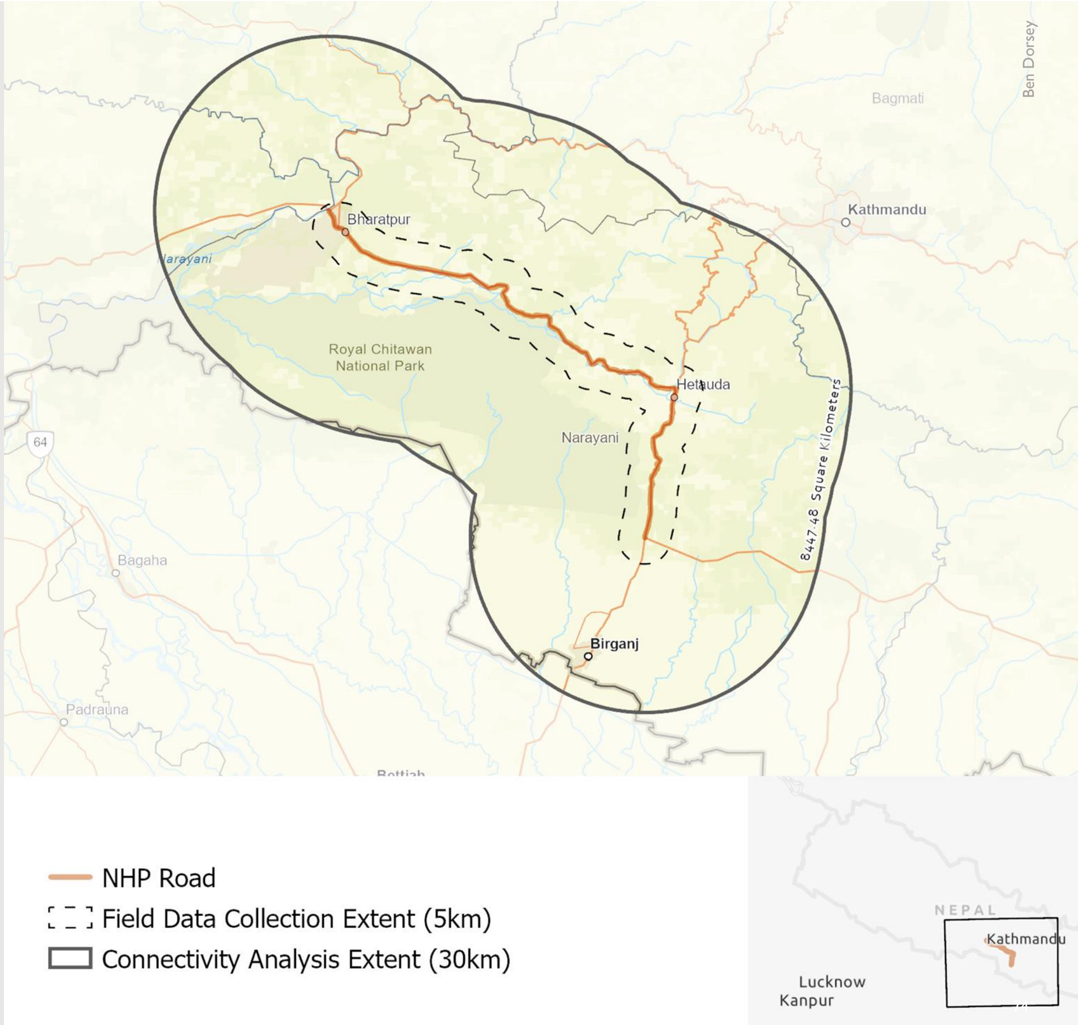
- **DATA COLLECTION**
  - MOBILE
  - SMART
  - SYNC
  - EFFICIENT
  - COST EFFECTIVE
  - STRUCTURED DATA
- **DESKTOP**
  - ANALYTICS
  - CARTOGRAPHY
  - TRADITIONAL TOOLS
- **WEB MAPS AND APPS**
  - COMMUNICATE
  - COLLABORATE
  - SHARE
  - PROTECTED

— 2. DATA CONSIDERATIONS AND TOOLS

Common data sets and assumptions
Considerations for collecting data
Rapid & efficient data collection methods and tools

COMMON DATASETS & CONSIDERATIONS

- Study area (extent)
- Multiple extents may be required



MORTALITY, OCCUPANCY & OCCURRENCE

- All are spatio-temporal information
- Scale and resolution of data matter
- Current realization function of history

- Mortality (road-kill)
  - Surveys and sampling are best
  - Unequal probability of detection

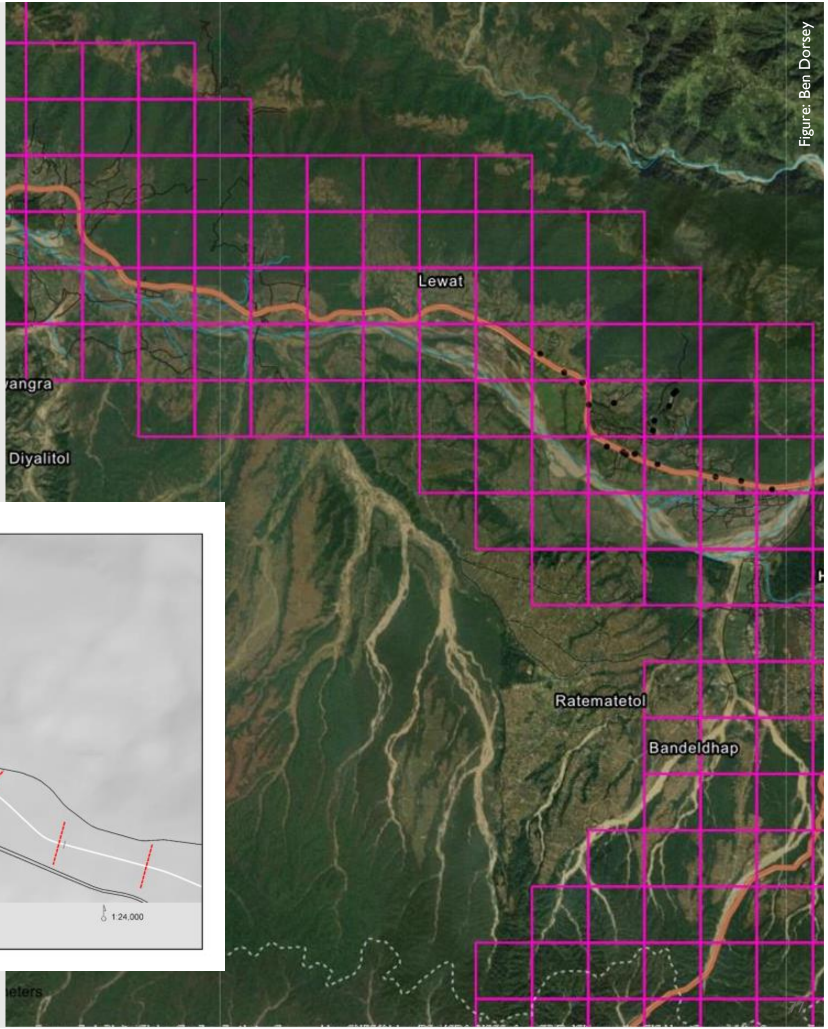
- Species Occupancy/Occurrence
  - Possibly undervalued in literature

DATA MAY VARY BY LI TYPE

- Railways and Power Utilities
  - May provide habitat and movement
  - Bird strike indicators and remote cameras

DATA COLLECTION METHODS AND TOOLS

- Transects (linear and perpendicular)
- Point sampling (along and on grid)
- Animal movement (GPS collaring)



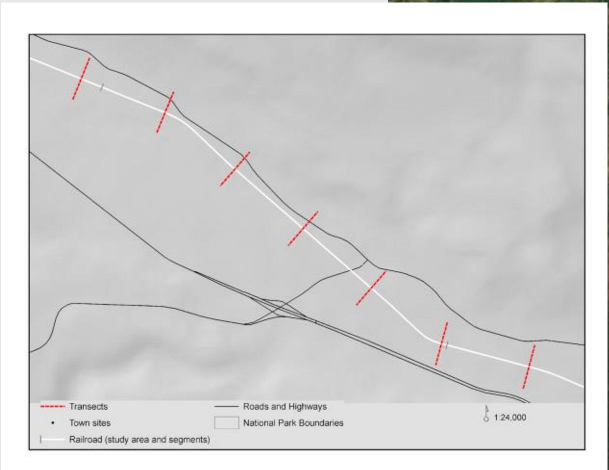


Figure: Ben Dorsey

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3. MODERN TOOLS ENABLE INCREASED EFFICIENCY, COLLABORATION, AND TRANSPARENCY

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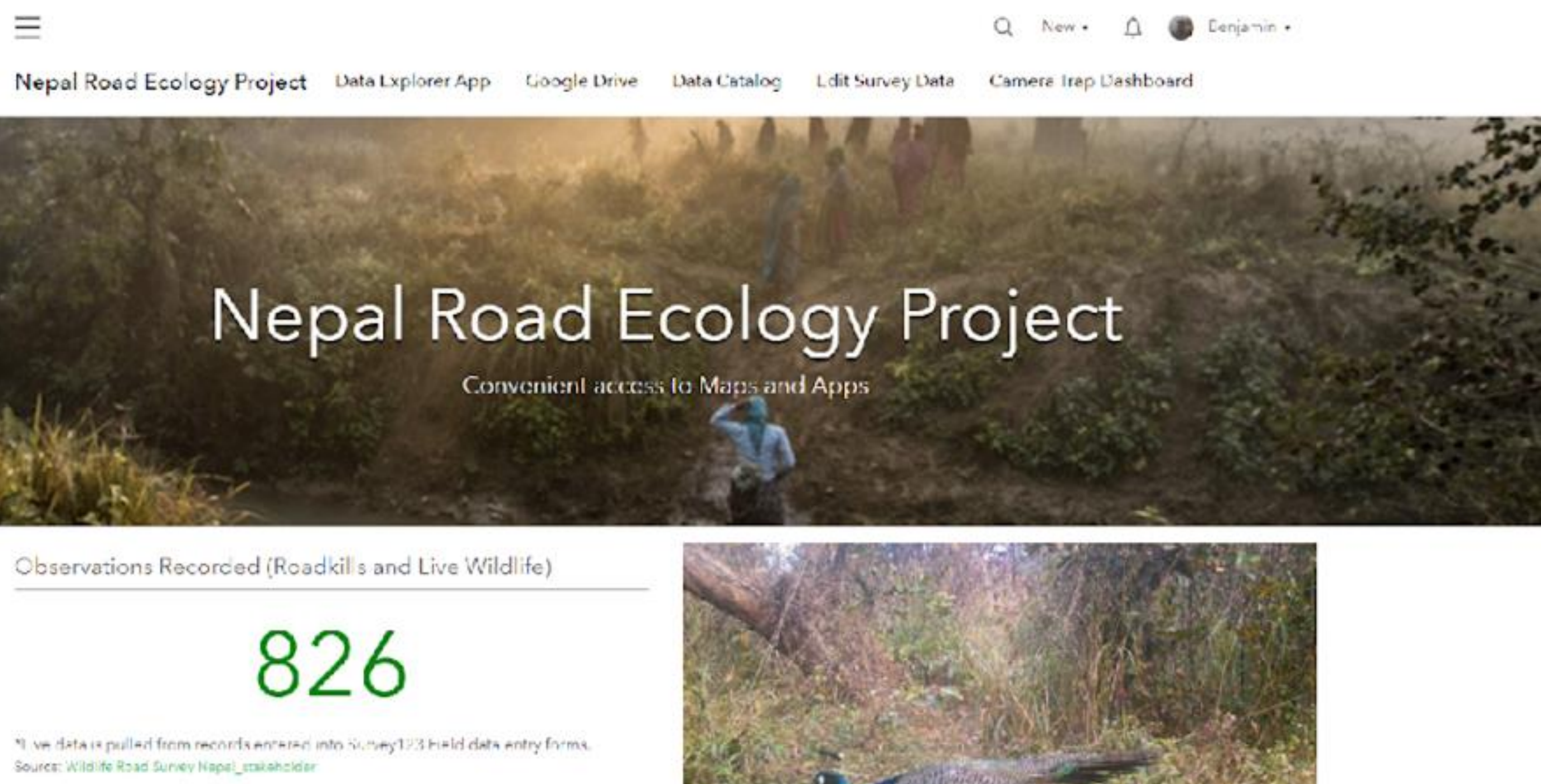
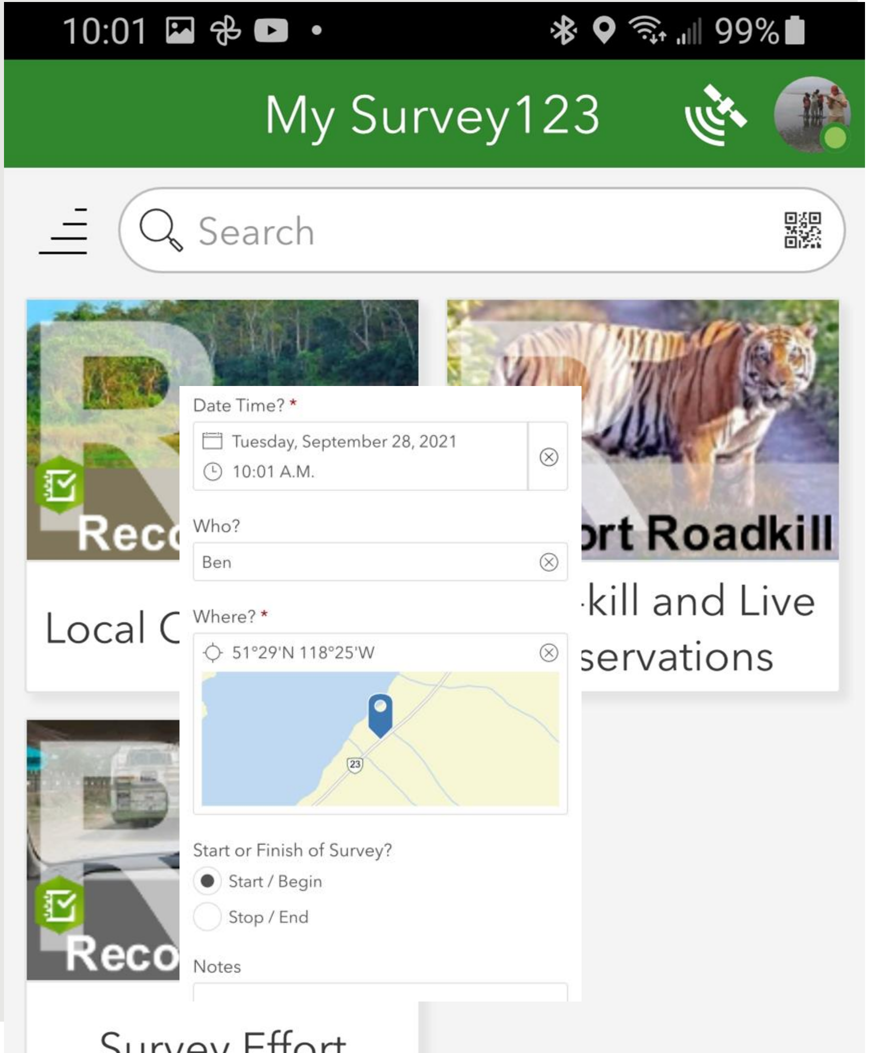
DEMO A WEB GIS LI PROJECT



DEMO - DATA COLLECTION

- Smart forms
- Multiple apps per project
- Automatically sync data
- Offline capabilities



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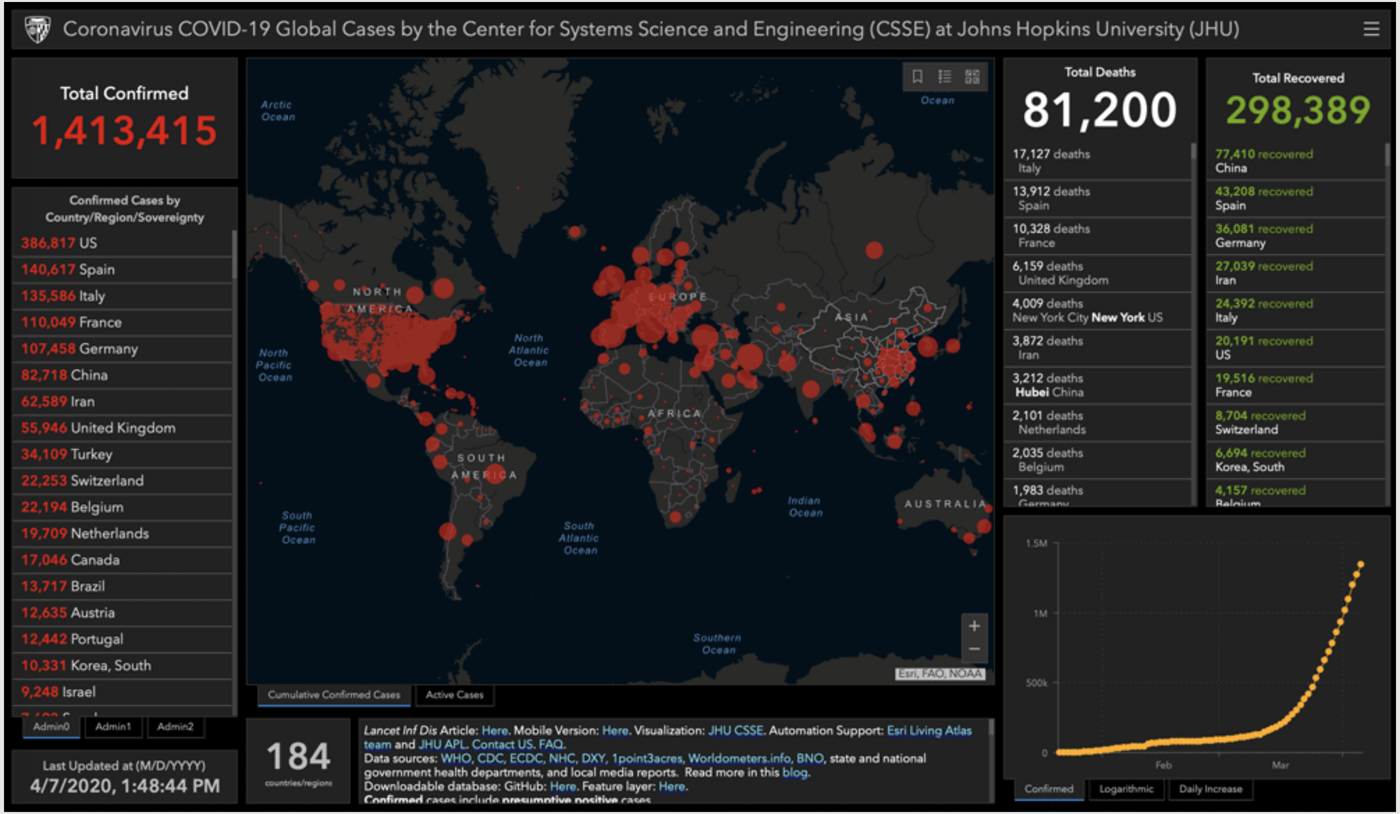
DEMO - DASHBOARDS



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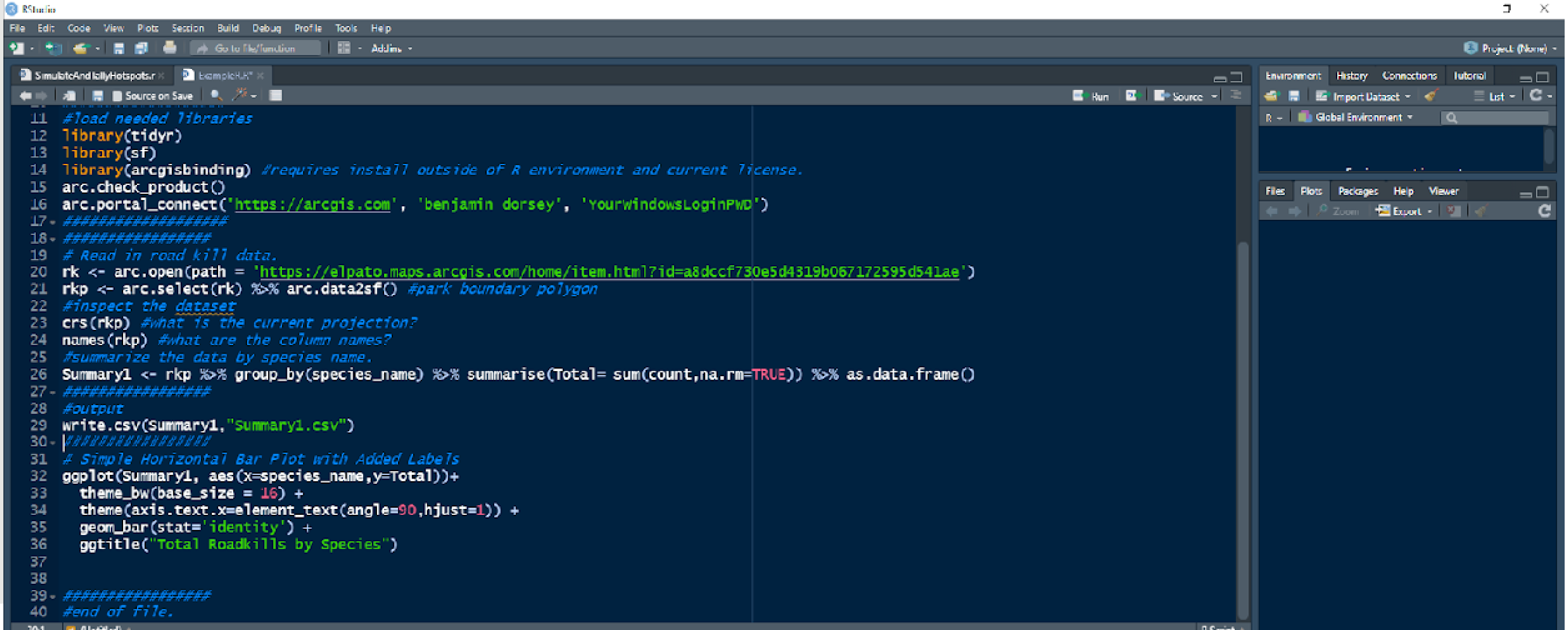
WEB GIS & ANALYSIS

- Transparent
- Reproducible



Q2. Within the two primary types of GIS data (raster and vector) what are five subtypes of GIS data?

- ❑ Raster (continuous and discrete), Vector (points, lines, and polygons)
- ❑ Raster (classified and raw), Vector (2D, CAD, dynamic segmentation)
- ❑ Raster (satellite and aerial photos), Vector (roads, land cover, road-kills)
- ❑ All of the above.

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Q3. Which statements are true about using web GIS? (Choose all that apply)

- ❑ Web GIS can increase project efficiency by improving data collection, QA/QC, and collaboration.
- ❑ Can be used by traditional GIS software programs such as QGIS and in desktop analysis programs such as R and Python.
- ❑ Data stored on a web GIS are less secure, more costly and require highly trained technical staff.
- ❑ A and B
- ❑ A and C
- ❑ B and C
- ❑ All of the above

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Q4. Data stored on a FOSS Web GIS are less secure than data stored on a SAAS GIS? (True or False)

Q4. Data stored on a FOSS Web GIS are less secure than data stored on a SAAS GIS?

False - All systems require management to ensure information and data are secure.

Q5. SAAS Web GIS tools are faster and less technical to set up. (True or False)

Q5. SAAS Web GIS tools are faster and less technical to set up. (True or False)

True – SAAS tools like ArcGIS Online are fast and easy to setup.

THANK YOU

CONTACT:

Anthony P. Clevenger: apclevenger@gmail.com

Ben Dorsey: bpdorsey@gmail.com

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Photo: WCS-Mongolia.