Smart monitoring for the *Amur tiger* & *leopard*.

From multi-feature individual ID to sky-air-ground integrated habitat mapping.

●PANTHERA TIGRIS ALTAICA

PRESENTED BY

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DATASET

2000 — 2025 25 years of field data

JIANG LAB · NORTHEAST FORESTRY UNIVERSITY

- CONTEXT · PETERSBURG 2010 → 2019 JOINT STATEMENT

Four questions we couldn't answer with *traditional methods.*

Q1 · IDENTITY

Who is this individual?

- ID
- sex
- age
- body condition
  - —non-invasively, from image data

Q2 · SIGNAL

What do 3.5M frames say?

- Auto-triage
- species ID
- behavior recognition at scale

Q3 · DIET

What is the prey eating?

- Ungulate scat
- epidermal cell microscopy beyond visual ID

Q4 · HABITAT

Can we read the forest in 3D?

- UAV thermal
- LiDAR
- hyperspectral
- satellite
- —fused

We has built a long-term field monitoring network

14 Years of monitoring
>1,900 km²

12 Years of monitoring
>800 km²

14 Years of monitoring
>400 km²

14 Years of monitoring
>400 km²

10 Years of monitoring
>350 km²

We has built a long-term field monitoring network

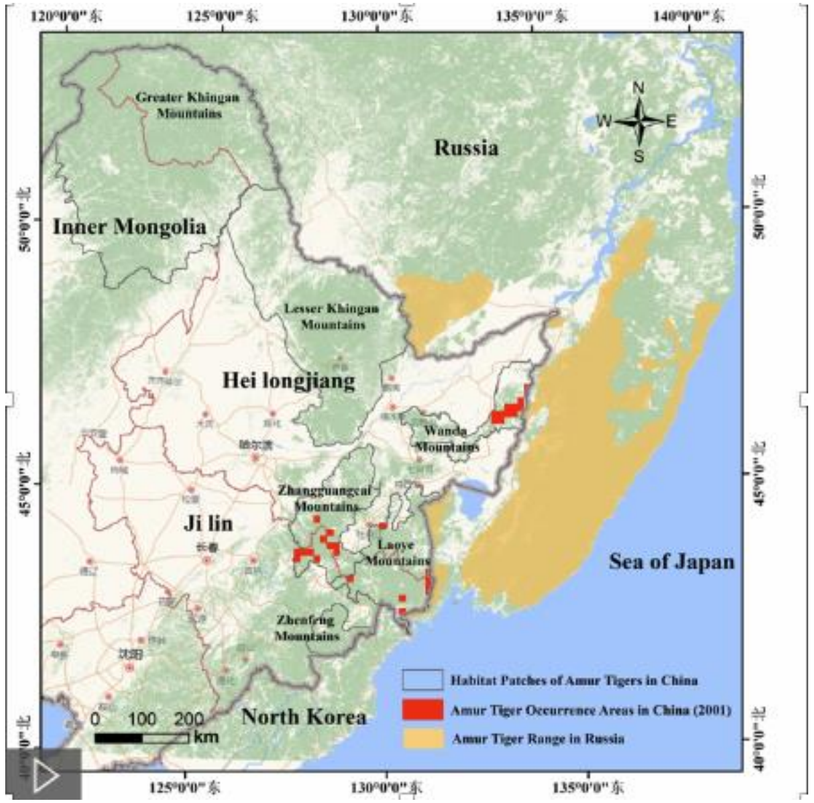
Existing databases

- ✓ National wild Amur tiger and leopard monitoring database, 2000–2026
- ✓ Heilongjiang provincial Amur tiger camera-trap database, 2025–2026
- ✓ Shanxi provincial North Chinese leopard camera-trap database, 2023–2025
- ✓ Hebei provincial North Chinese leopard camera-trap database, 2021–2025

Five data modules

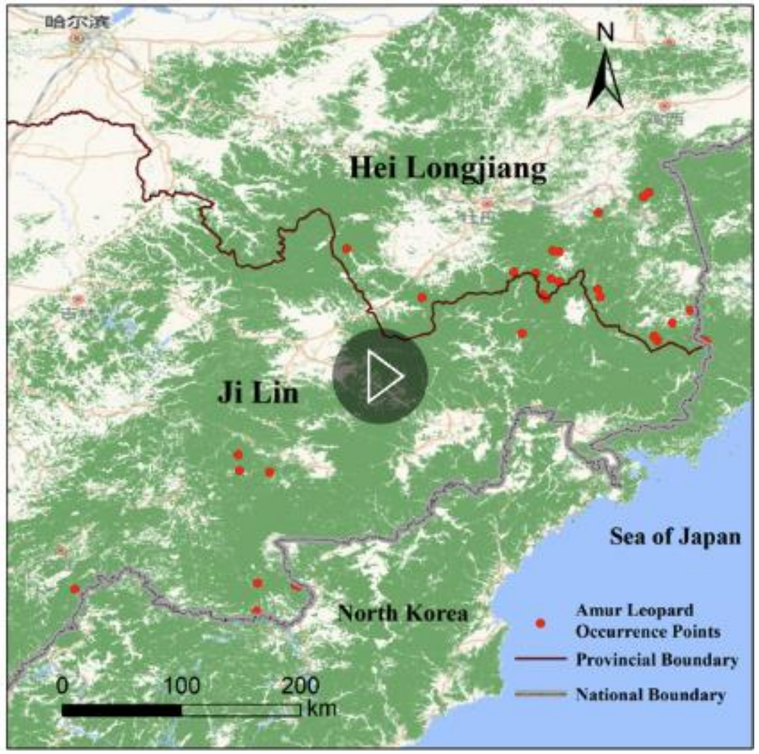
- Stripe-image library
- Distribution dynamics database
- Footprint-image library
- Genetic information database
- Ungulate prey density database

We has built a long-term field monitoring network



Distribution Changes of the

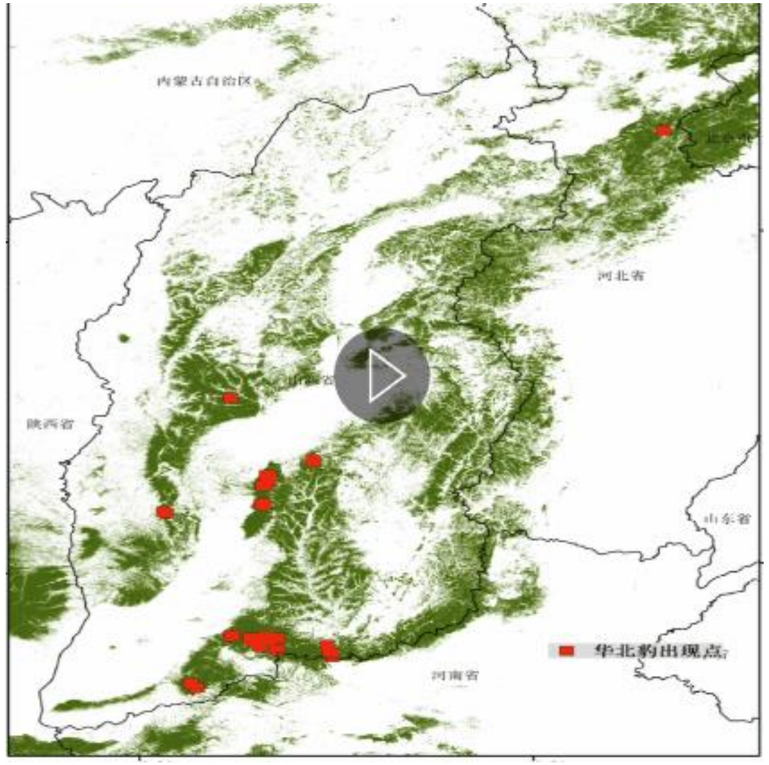
Amur Tiger from 1999 to 2025



Distribution Changes of the

Amur leopard from 2000 to 2023

We has built a long-term field monitoring network



Distribution Changes of the

North China Leopard from 1999 to 2025

Distribution Changes of the

Moose from 2000 to 2023

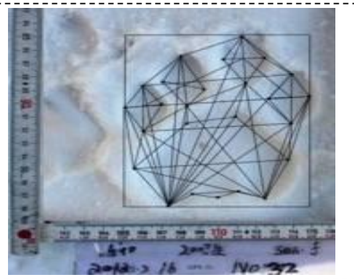
• SMART-MONITORING 01–03 · INDIVIDUAL RECOGNITION

Three signals fused to *95% individual ID.*

- Pattern fails under bad light and partial occlusion.
- Gait silhouette doesn't.
- Footprints extend ID into camera-blind zones.

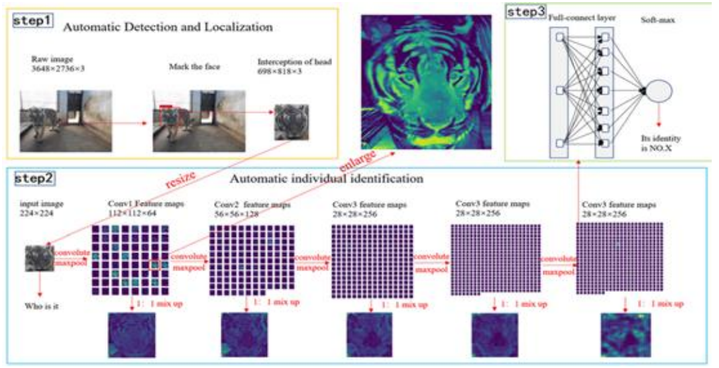
ACCURACY — SEMI-CAPTIVE TRIAL

Method · Mask R-CNN silhouette → ResNet-18 fusion · CN patent 112906511B



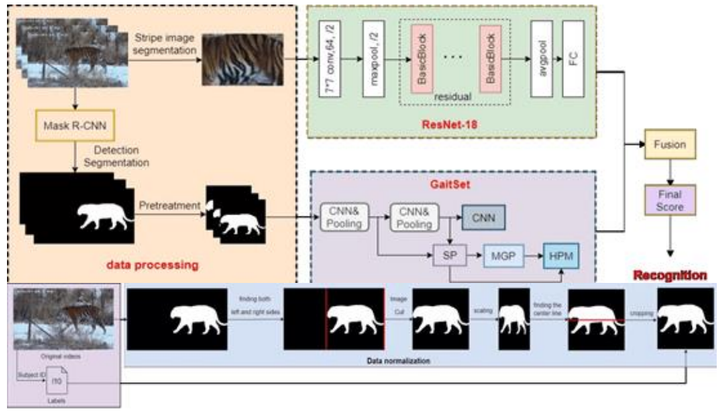
01 · FOOTPRINT

Geometric profile — ID + sex
>95%



02 · COAT PATTERN

Multi-region CNN
— ~90%



03 · GAIT SILHOUETTE

Robust to lighting
occlusion

• SMART-MONITORING 04–05 · NON-INVASIVE VITALS

You can't weigh a tiger. *So we weigh its picture.*

Body mass from four image-derived descriptors — lateral silhouette, central side profile, ellipse fit, rectangle fit — reconstructed in 2D and 3D. Age from dual-channel features of face + nose pad.

±1 yr

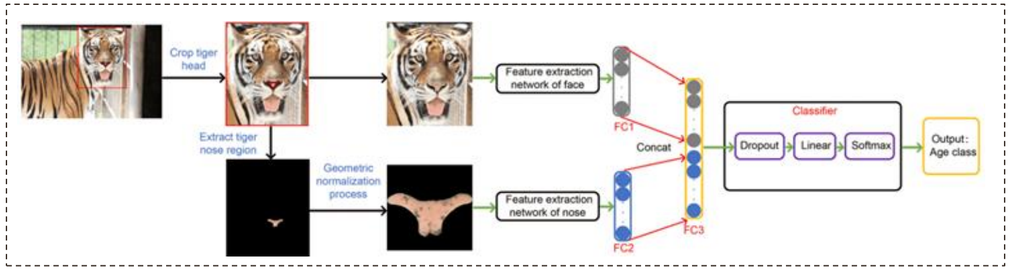
AGE PREDICTION ERROR BAND

89.02% CLASSIFIER ACCURACY

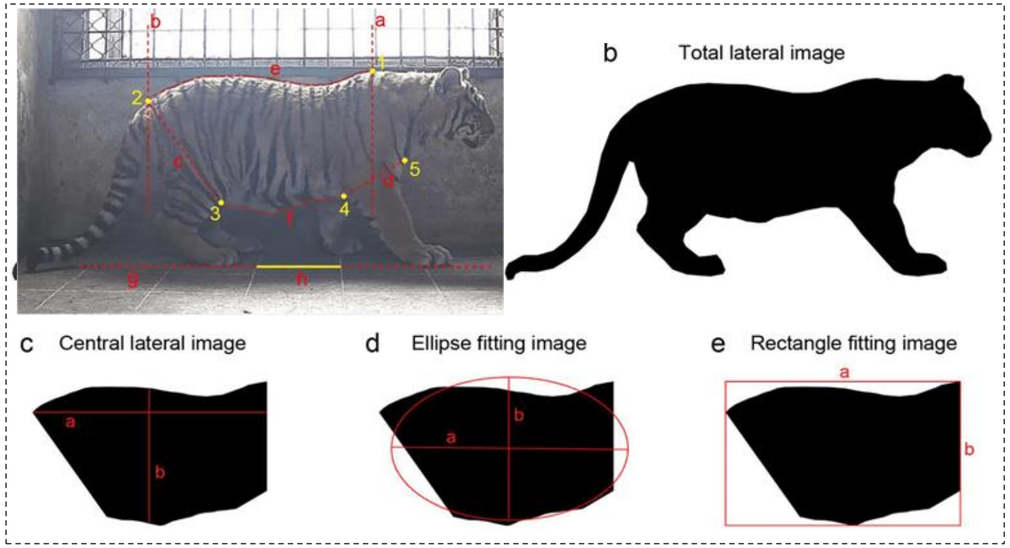
4 fits

BODY-WEIGHT DESCRIPTORS

FUSED SILHOUETTE · SIDE · ELLIPSE · RECT



Age from dual-channel features of face + nose pad.



Four different types of images were used to extract the physical features of the tiger.

• SMART-MONITORING 06–07 · FROM PRESENCE TO ACTION

From *“a tiger was here”* to *“a tiger killed here.”*

Static species ID is the baseline. On top of that we run a spatiotemporal deep network that recognises five discrete behaviors across four target species.

DATASET

3.5 M

IR FRAMES COLLECTED NE + N. CHINA

LABELED

1M +

HUMAN-ANNOTATED 28 SPECIES

AUTO-TRIAGE

95 %

BLANK FRAMES AUTO-DISCARDED

THROUGHPUT

1 TB

PROCESSED PER DAY END-TO-END

BEHAVIORS Recognition — MAP > 90%

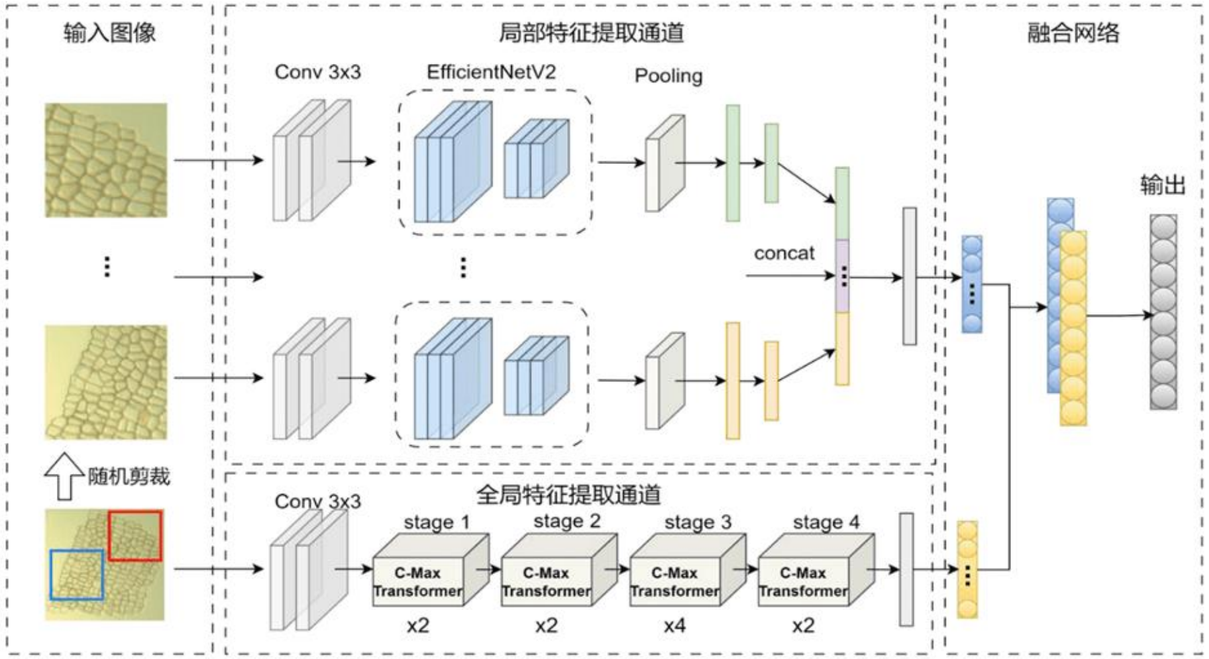
eat · *jump* · *stand* · *lie* · *walk*

tiger · leopard · roe deer · sika deer

- SMART-MONITORING 08 · MICROSCOPIC FORAGE ID

We read diet from *plant cells in scat.*

Electron-microscopy images of epidermal cell fragments, classified by EfficientNetV2 + Transformer global-feature channel. If we know what the deer ate, we know where the deer will be — and where the tigers can hunt.



91.2%

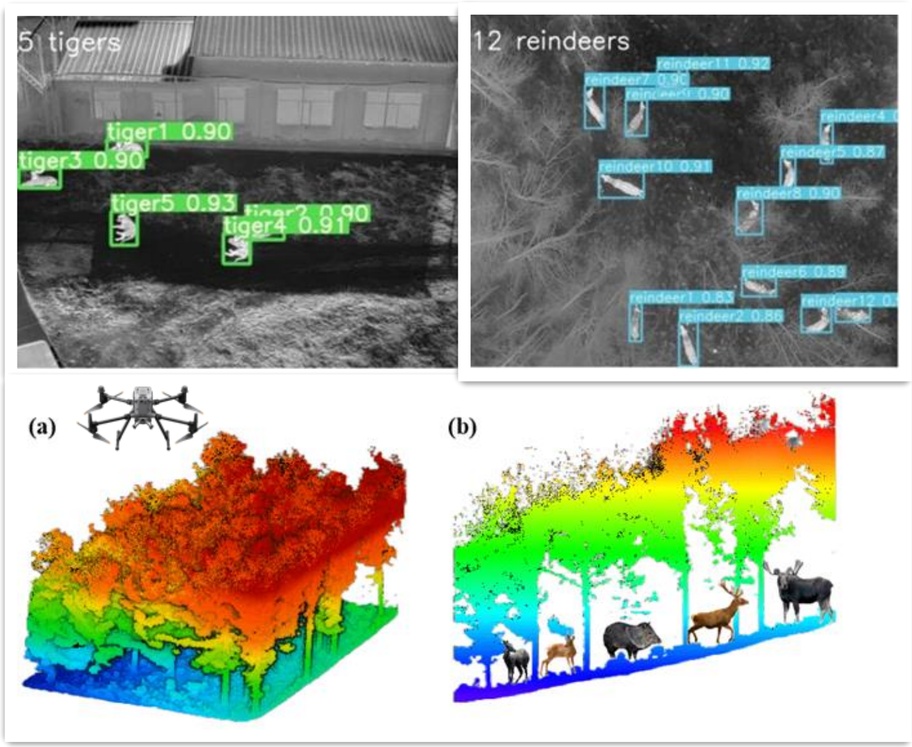
SPECIES-LEVEL ACCURACY ON PLANT EPIDERMAL FRAGMENTS

- SMART-MONITORING 09–10 · INTEGRATED REMOTE SENSING

Four sensors, one *3D habitat model.*

Each layer measures something the others can't. Fused together they give us the spatial relationship between tigers, prey, and the forest structure that actually decides where cats can survive.

SATELLITE		macro landscape · food-plant cover · yearly composites
HYPERSPECTRAL		forage plant species ID · fine-grained spectra
LiDAR		canopy · understory · sight-line 3D structure
UAV THERMAL		autonomous transects · on-board edge detection
↓ FUSED		*spatial model · tiger × prey × habitat factors*



25 yrs

The long top-predator dataset in *Northeast Asia.*

Ten technical advances converge into one platform, backed by five operational databases.

2000 — 2025

DB 01

Flank pattern image bank

high-resolution camera network

DB 02

Distribution dynamics

macro info-network monitoring

DB 03

Footprint image bank

digital geometric ID

DB 04

Genetic database

scat molecular + microstructure

DB 05

Prey density index

transects + UAV survey fused

- PROVINCE-WIDE CAMERA SAMPLING

· 165 sampling units

· 32,250 km²

One sampling unit = one female tiger‘s *daily range*.

4 km^2

EACH CAMERA

49 camera

EACH UNIT

196 km^2

EACH UNIT

8,085 camera

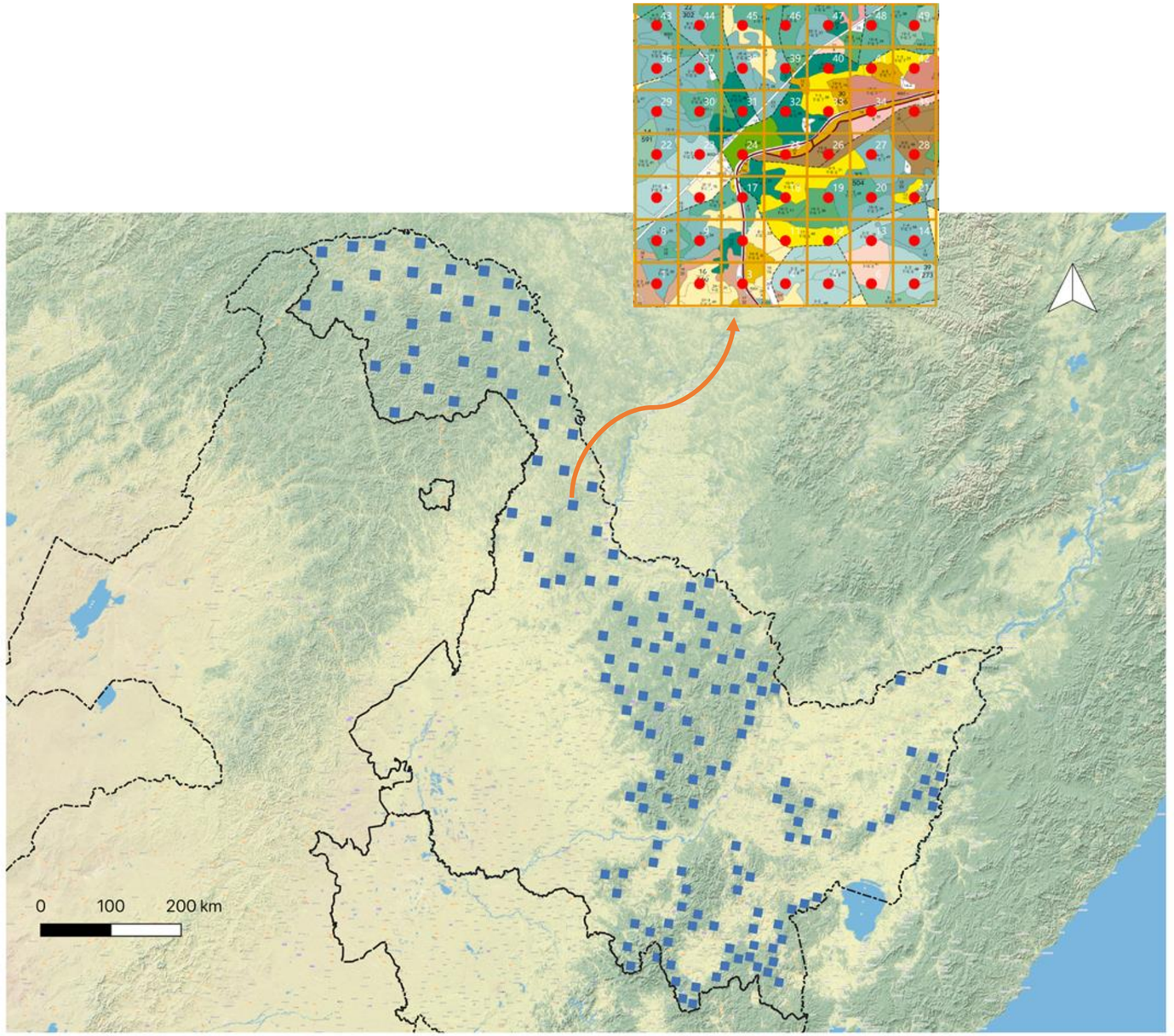
TOTAL

15%

FOREST SAMPLING INTENSITY

3 village

CONFLICT EARLY - WARNING PILOTS



WHAT 25 YEARS OF MONITORING TELL US

How many cats can *this landscape* actually hold?

Camera, prey-density and habitat layers feed a spatially-explicit carrying-capacity model. No single forest patch is large enough on its own — recovery is a transboundary metapopulation question.

SCENARIO A · NE ASIA METAPOPULATION

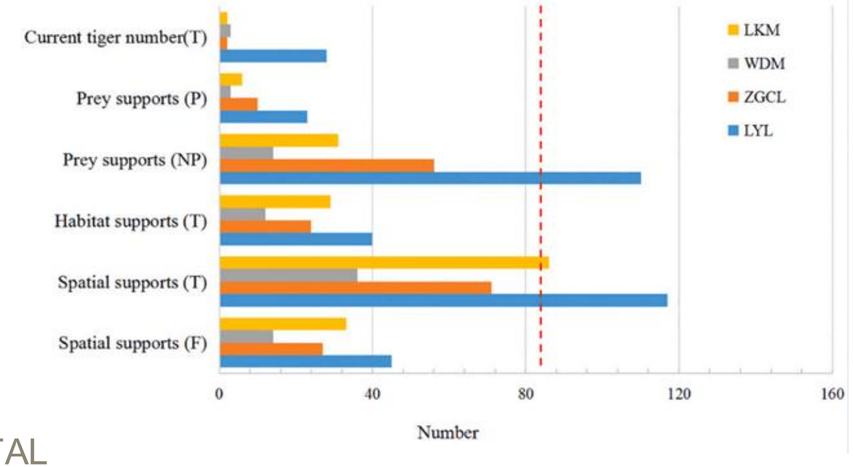
Four habitat patches across China

119

BREEDING ♀ TIGERS

310

TIGERS · TOTAL POP CEILING

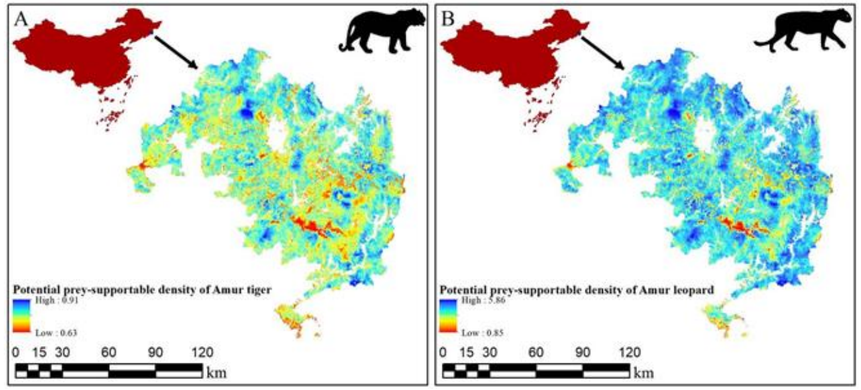


→ NO SINGLE PATCH IS SUFFICIENT ALONE.

SCENARIO B · NE TIGER & LEOPARD NATIONAL PARK

Recovery potential by spatial area, current prey population, and environmental carrying capacity

	SPATIALLY-SUPPORTABLE POPULATION0	PREY-SUPPORTABLE POPULATION	POTENTIAL PREY-SUPPORTABLE POPULATION
TIGER	55	90	101
LEOPARD	95	356	572

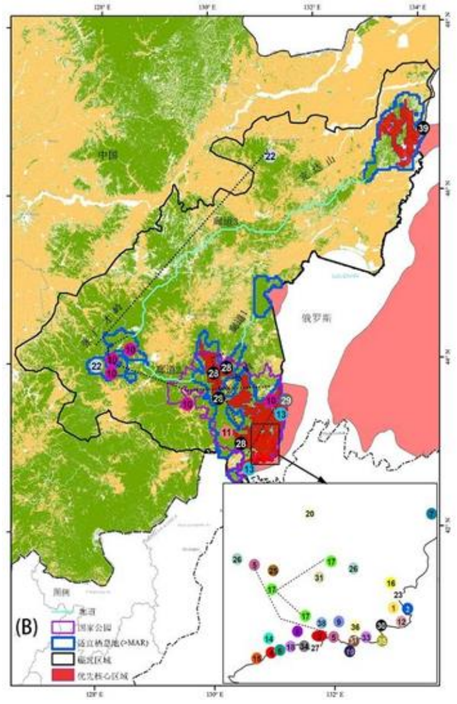


FROM MONITORING TO MAPS THAT MANAGERS USE

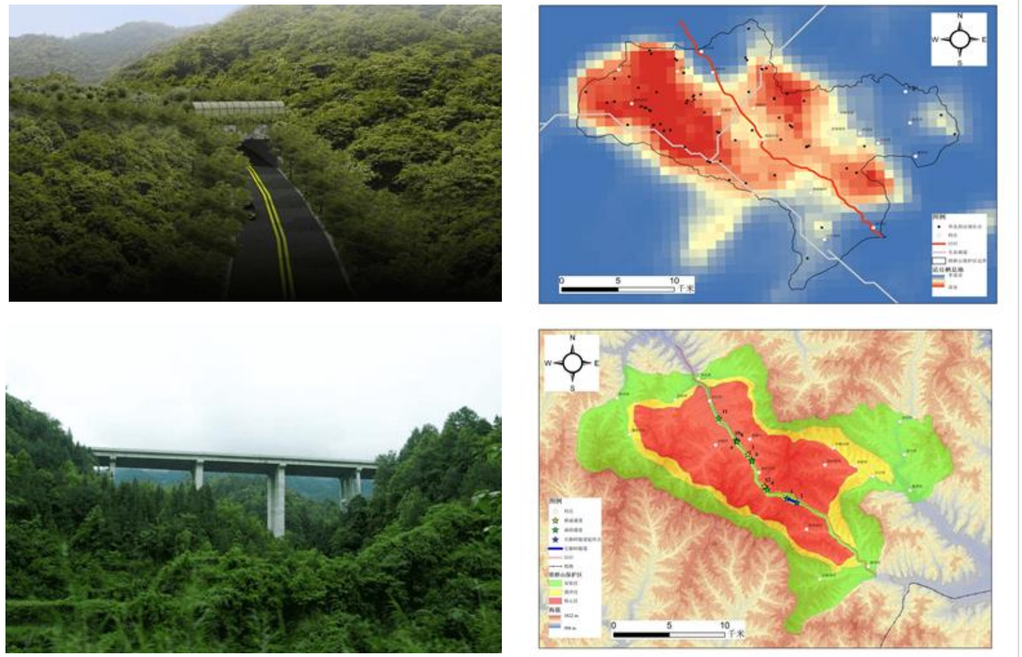
Where to *protect*, where to *connect*

The process of determining suitable habitats and corridors through the hierarchical priority protection area model

INPUT · GROUND Prey-survey transect distribution map.	INPUT · CAMERA Province-wide camera-trap location grid.
MODEL Hierarchical priority-area model → suitable habitat & corridor zones.	OUTPUT Ranked map → corridor design specs.



PRIORITY HABITAT + CORRIDOR NETWORK



EXAMPLES OF CORRIDOR DESIGN

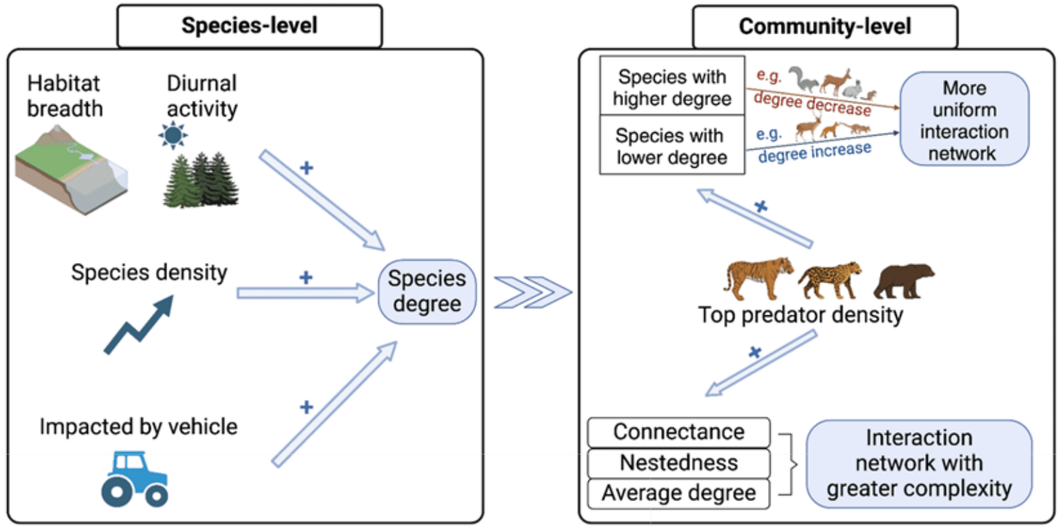
DEPLOYED · NE TIGER & LEOPARD NATIONAL PARK Corridor optimization · Hunchun bureau corridor design.	DEPLOYED · SHANXI HESHUN COUNTY N. Chinese leopard corridor — highway retrofit crossing structure.

ECOSPHERE 2021

BEYOND THE TIGER

The same camera grid measures *community structure.*

Our long-term camera grid is also a large mammal-community datasets in temperate forests.



FINDING 01

Top predators raise network connectance.

Areas with top predators show higher nestedness, connectance and average degree in species-interaction networks.

FINDING 02

Effects come from *fear* , not kills.

Indirect cascades — risk avoidance — may rearrange the distribution of species interactions within the forest.

FINDING 03

Vertical structure stabilises the community.

Trophic richness + cross-trophic compensation drive long-term stability — more than horizontal diversity alone.

JOURNAL OF ANIMAL ECOLOGY 2022 · STOTEN 2023 · PROCEEDINGS B 2024

CLOSING THE LOOP

Re-introduce *prey*.

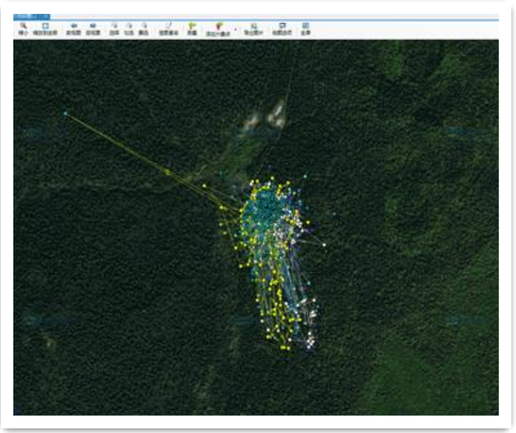
Sika deer (*Cervus nippon*) — a primary tiger prey — are being rebuilt as a founder population. Each batch is rewilded, then re-acquired by the same camera grid and behavior model that monitors the predators.

B 01	16	Training start 2022·MAR·23	RELEASED 2022·JUN·05
B 02	16	Training start 2022·AUG·05	RELEASED 2022·OCT·21
B 03	15	Training start 2023·SEP·05	RELEASED 2023·OCT·31
B 04	10	Training start 2024·AUG·22	RELEASED 2024·OCT·31

CUMULATIVE RELEASES

57 DEER

FOUR REWILDED BATCHES · 2022 – 2024



Our foundation can support a joint cross-border monitoring network

Our existing monitoring foundation can support:

1. Unified field design

Comparable camera-trap units and survey protocols

2. Shared data platform

Joint storage and analysis of images, individual IDs and distribution records

3. Cross-border individual library

“One tiger, one file” across national borders

4. Joint population assessment

Annual reports and co-authored scientific outputs

5. Conservation applications

Migration tracking, corridor identification, conflict early warning and disease-risk monitoring

THANK YOU FOR YOUR ATTENTION

Thank You.

Northeast Forestry University
Feline Research Center, NFGA

Heilongjiang Provincial Joint Key Laboratory
for Sino-Russian Cooperation on Amur Tiger Conservation and Restoration

WE LOOK FORWARD TO

deep cooperation.

2026