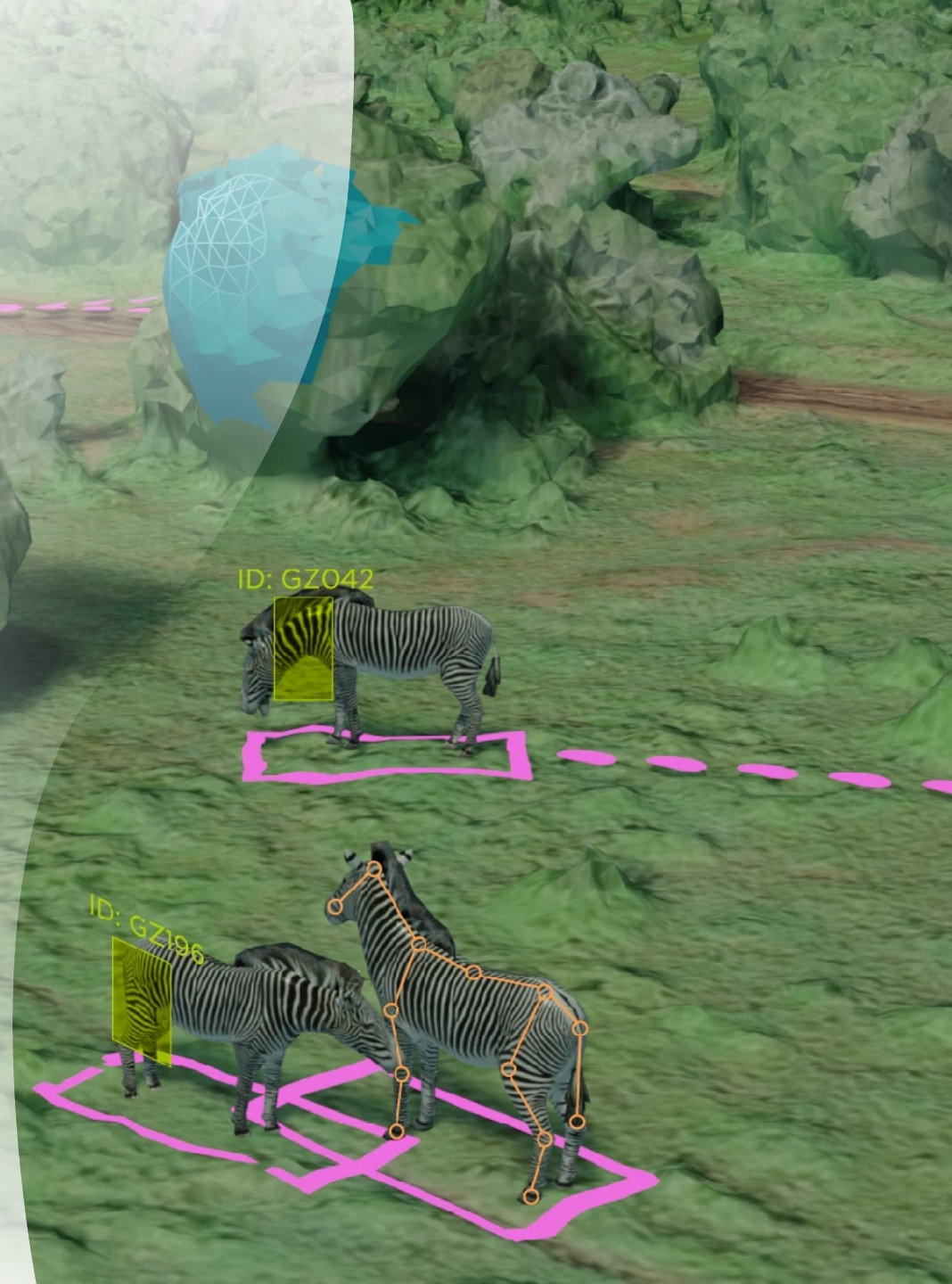
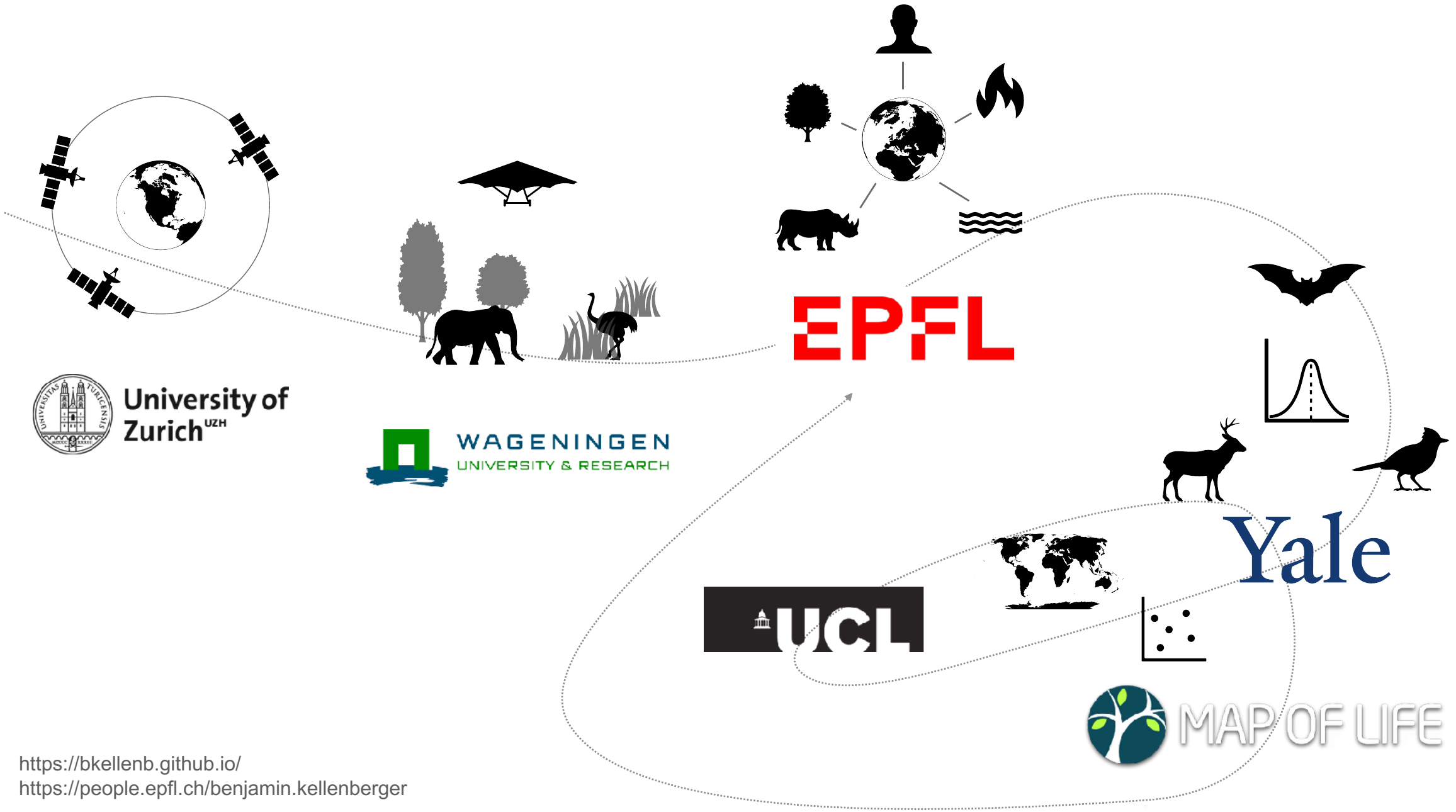
L’IA per la biodiversità e gli ecosistemi

Scuola estiva Climate Change AI
Settimana 5 · Settoriale IV



Benjamin Kellenberger | 2026-08-17



https://bkellenb.github.io/
https://people.epfl.ch/benjamin.kellenberger



D: che cos’è la «biodiversità»?

E come si misura?

> «La biodiversità sono tutte le diverse forme di vita che si trovano in un’area»
>
> – WWF, 2026

Misurare la biodiversità:

- numero di specie
- numero di individui per specie
- distribuzione delle specie
- interazioni: tipo (predazione, simbiosi, ecc.), frequenza
- dinamiche:
  - riproduzione
  - spostamenti di areale
- risposta ai cambiamenti:
  - clima
  - perdita di habitat
    - accaparramento di terre (ad es. disboscamento; conversione in terreni agricoli)
    - degrado del suolo
  - specie invasive
- ...

La biodiversità è complessa

Il sistema più complesso noto all'umanità: la Terra

Non lo capiremo mai fino in fondo

Ma abbiamo…

…conoscenze

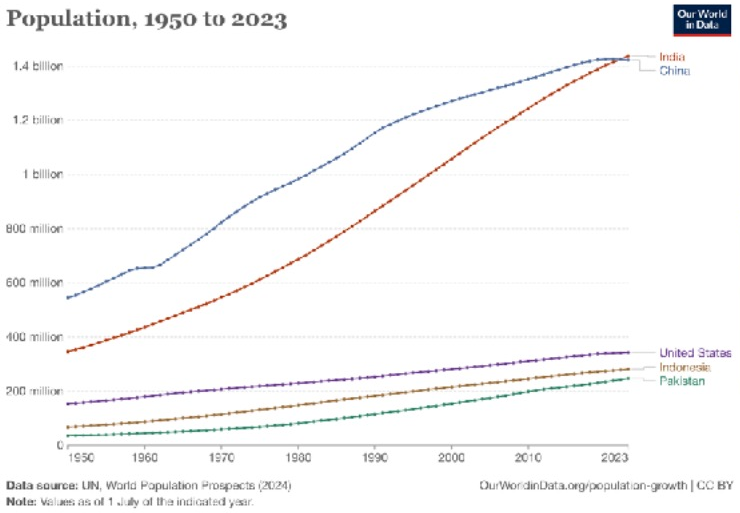
…saggezza

…osservazioni



Falena di Darwin (Xanthopan praedicta). Foto © Robert Clark

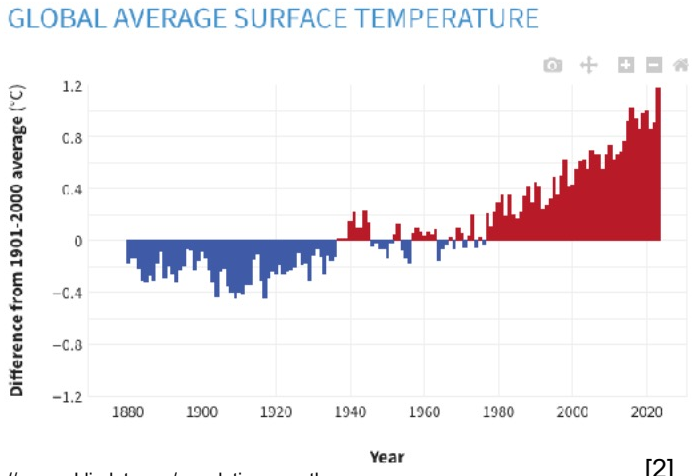
Sfide ambientali



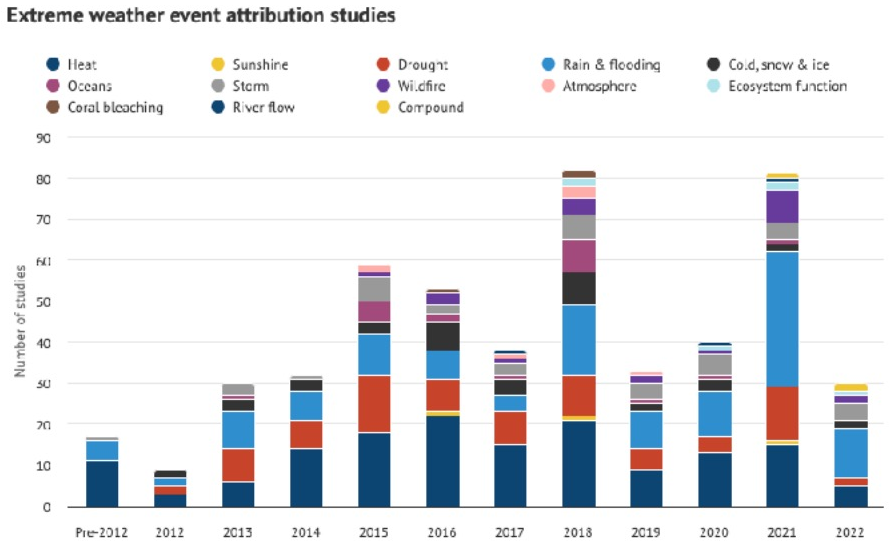
[1]



[3]



[2]



[4]



[5]

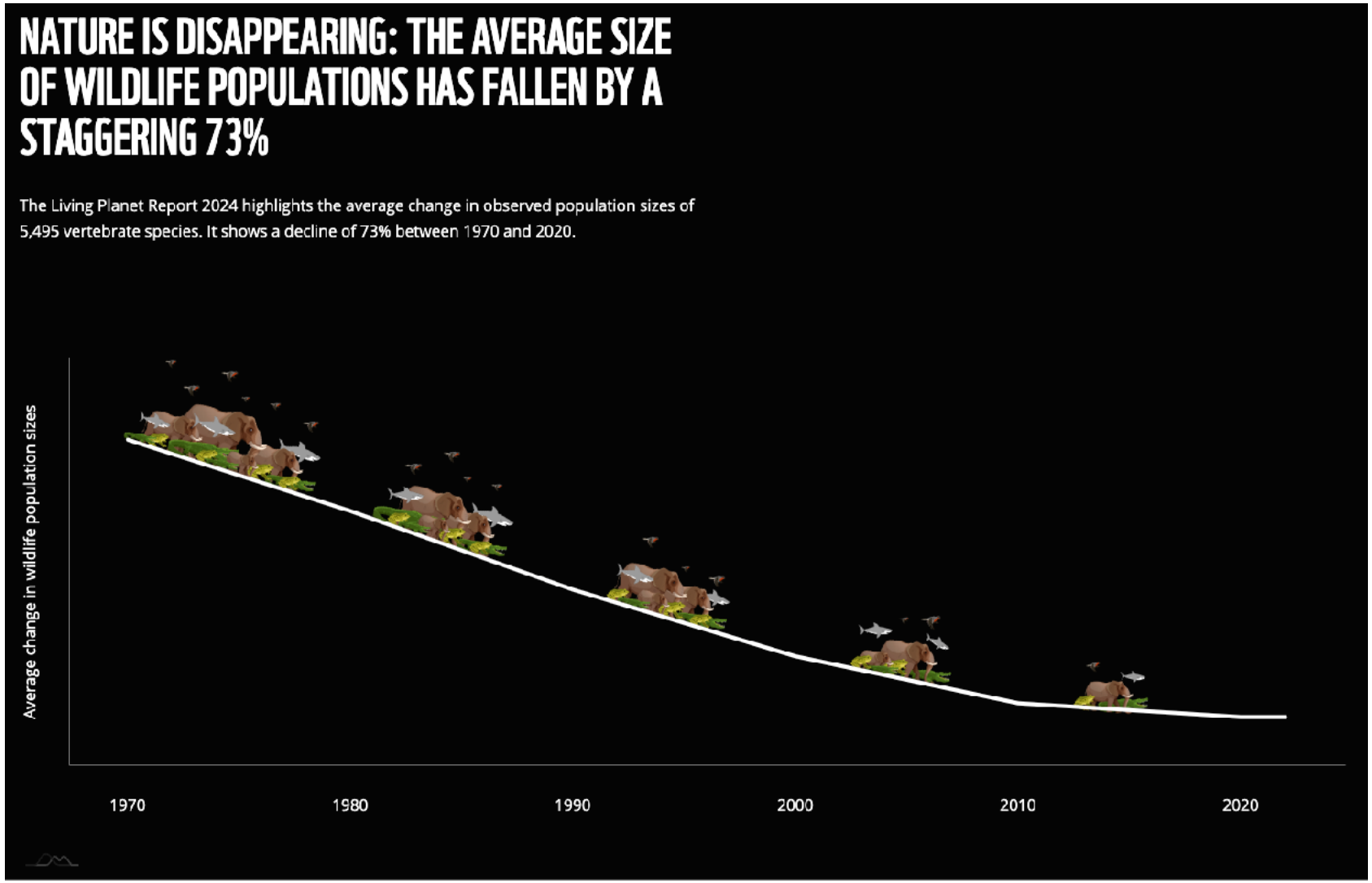


[6]

[1] https://ourworldindata.org/population-growth
[2] https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature
[3] https://www.flightradar24.com/
[4] https://www.carbonbrief.org/mapped-how-climate-change-affects-extreme-weather-around-the-world/
[5] https://www.theguardian.com/world/2024/oct/30/spain-floods-torrential-rain-deaths
[6] https://www.theguardian.com/world/2026/jul/27/france-and-spain-race-to-contain-huge-wildfires-before-fresh-heatwave-begins

Sfide per la biodiversità

Perdita di specie



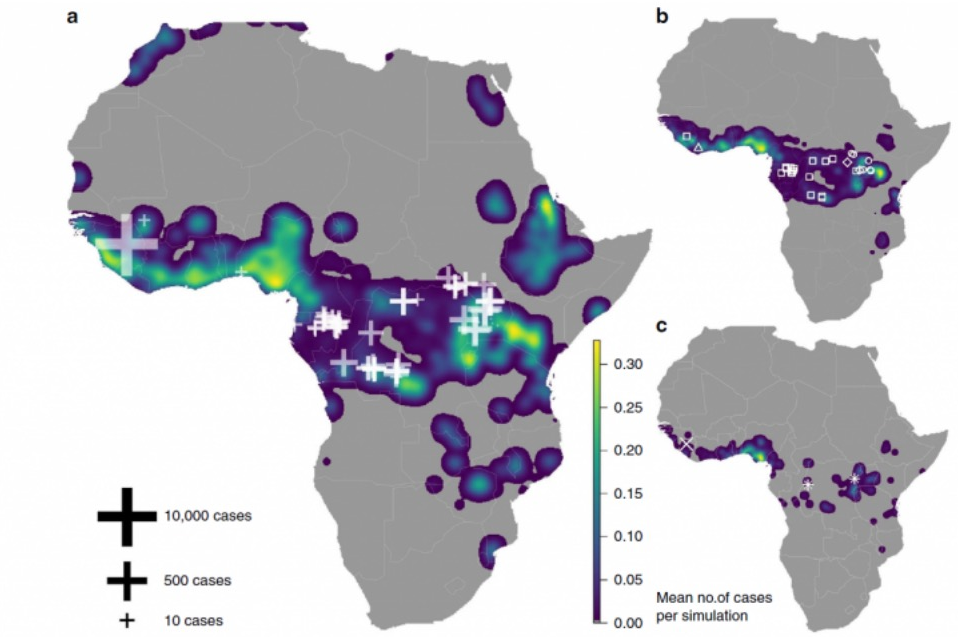
https://livingplanet.panda.org/

Sfide per la biodiversità

Invasioni biologiche



https://freerangestock.com/photos/65509/gypsy-moth-infestation.html



Redding et al., 2019: Impacts of environmental and socio-economic factors on emergence and epidemic potential of Ebola in Africa. Nature Communications 10, 4531. https://doi.org/10.1038/s41467-019-12499-6

Sfide per la biodiversità

Degrado e distruzione degli habitat



Photo © Harley Kingston



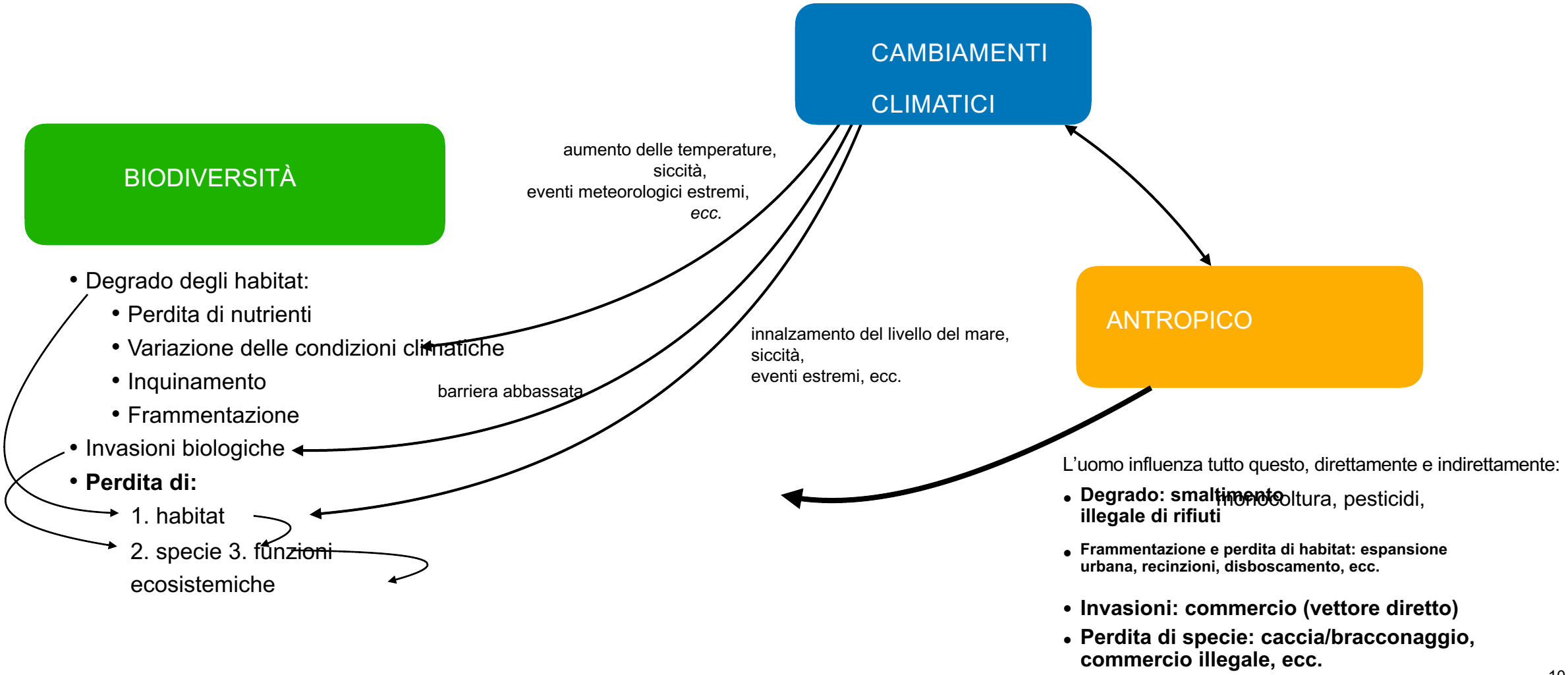
Photo © GRID-Arendal



Photo © The Ocean Agency / XL Catlin Seaview Survey / Richard Vevers

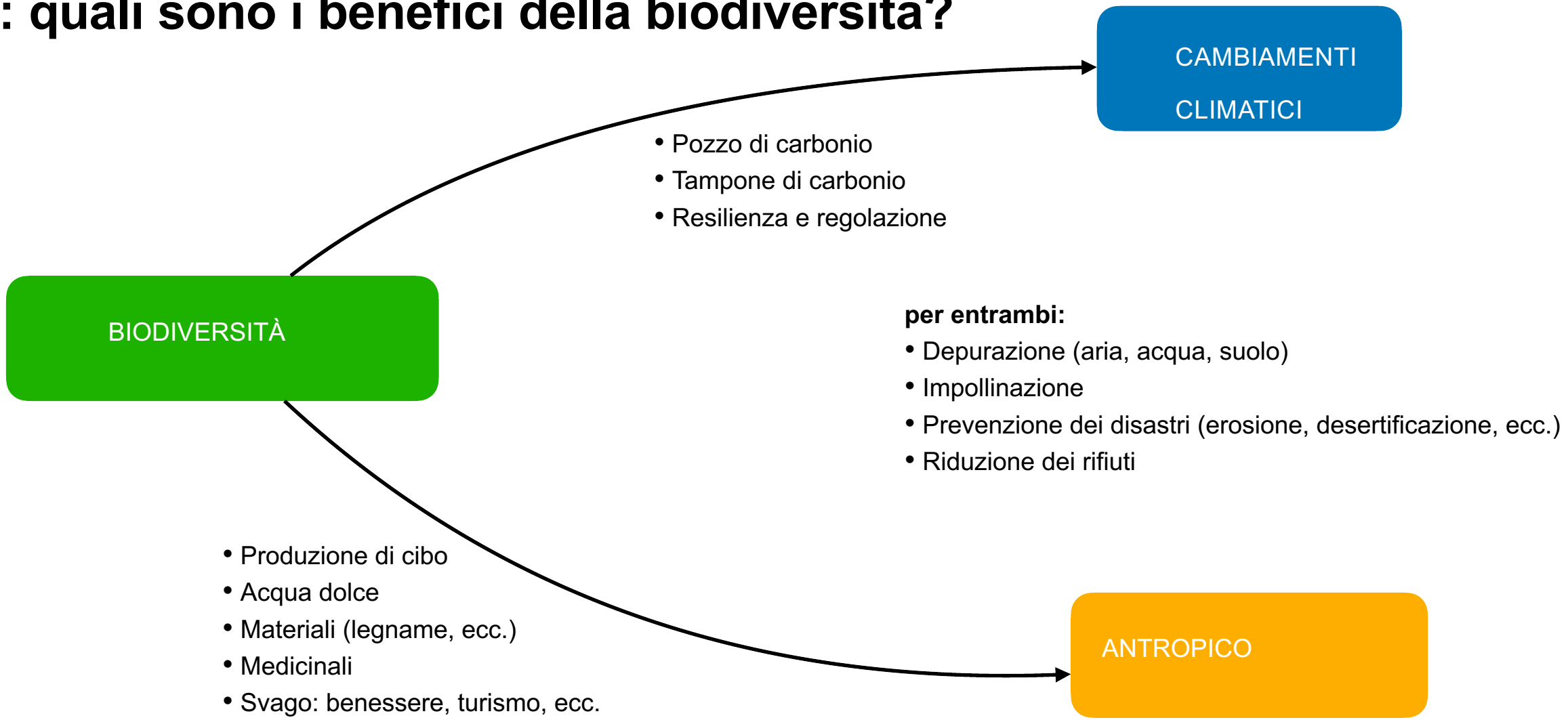
Sfide per la biodiversità

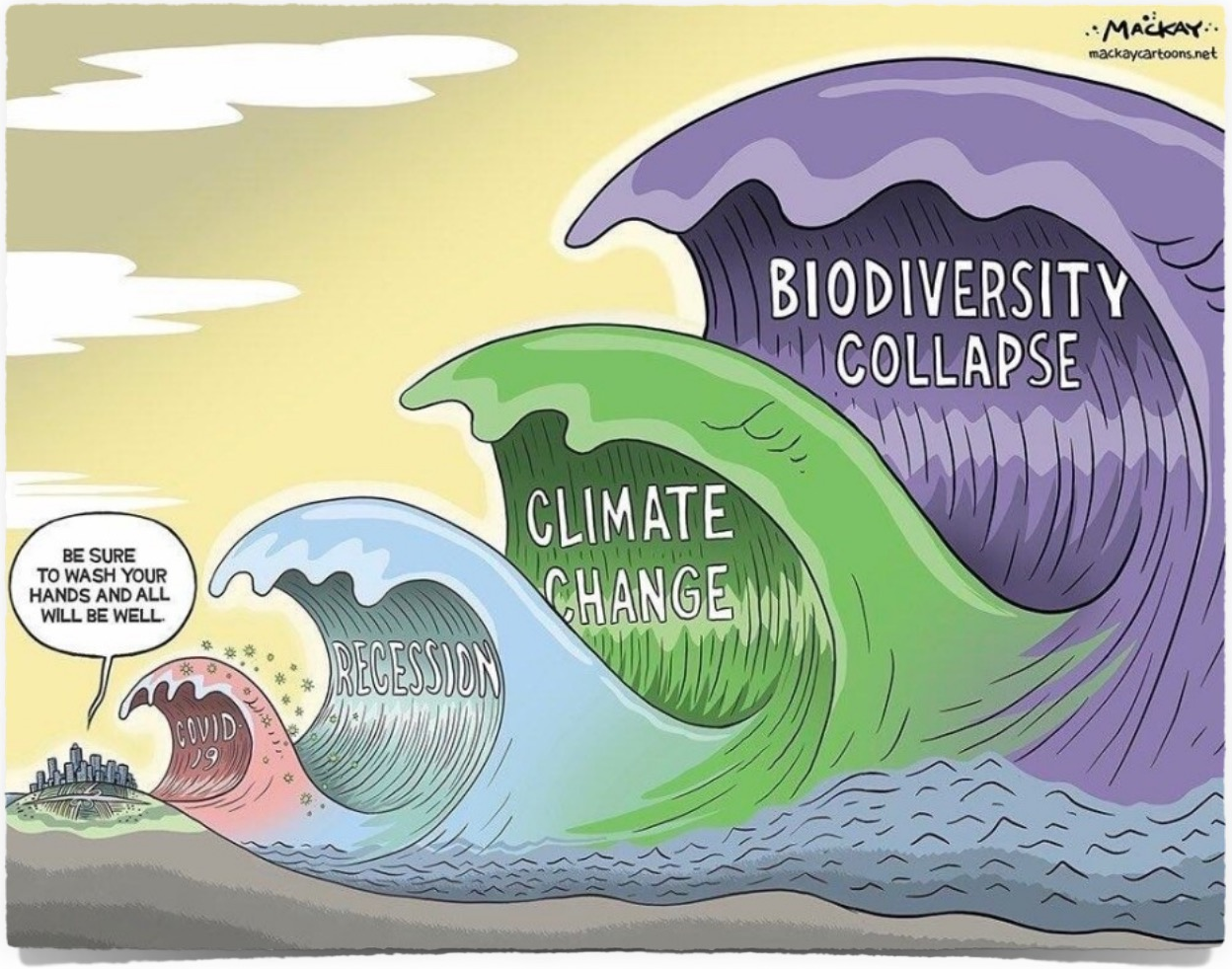
D: quali sono i fattori e i motori negativi?



Sfide per la biodiversità

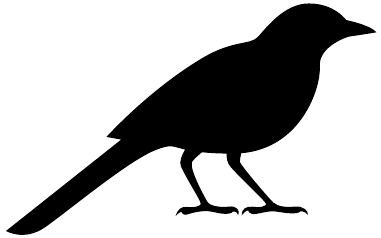
D: quali sono i benefici della biodiversità?





La biodiversità è vita. Senza di essa non saremmo qui.

IA e biodiversità

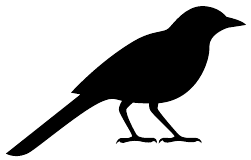


I. Come possiamo monitorare l’individuo?

IA e biodiversità

I. Monitorare l’individuo





Fototrappole

- Sviluppate per la caccia:
  - Sensori fotografici:
    - RGB (fotocamera standard)
    - Infrarosso termico (visione notturna)
  - Sensore di movimento: scatta solo in presenza di movimento (animale che passa)
  - Resistenti alle intemperie (in natura)
  - Mimetizzate (osservare senza disturbare)



Photo © Axel Fassio

Fototrappole



Photo © Axel Fassio



Immagini da Snapshot Kgalagadi (https://lila.science/datasets/snapshot-kgalagadi)

Fototrappole



Photo © Axel Fassio

Sfide



(1) Illumination



(2) Blur



(3) ROI Size



(4) Occlusion



(5) Camouflage



(6) Perspective

Beery, 2023

Fototrappole
con l'IA



Photo © Axel Fassio

«in piedi» «canguro»

«Joey il canguro»

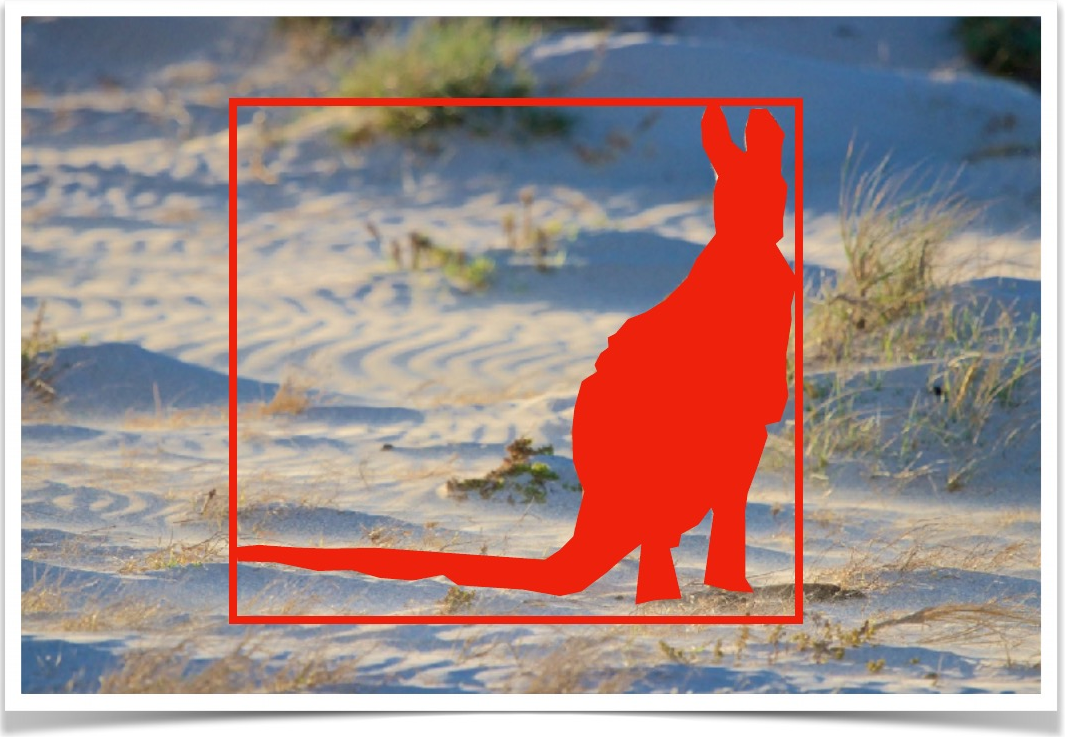


Photo © Benjamin Kellenberger

1. Classificazione delle specie
2. Classificazione del comportamento
3. Rilevamento
4. Identificazione individuale
5. Segmentazione delle istanze
    - Età
    - Sesso
    - Salute
    - etc.

Fototrappole
con l'IA



Photo © Axel Fassio

«grooming»

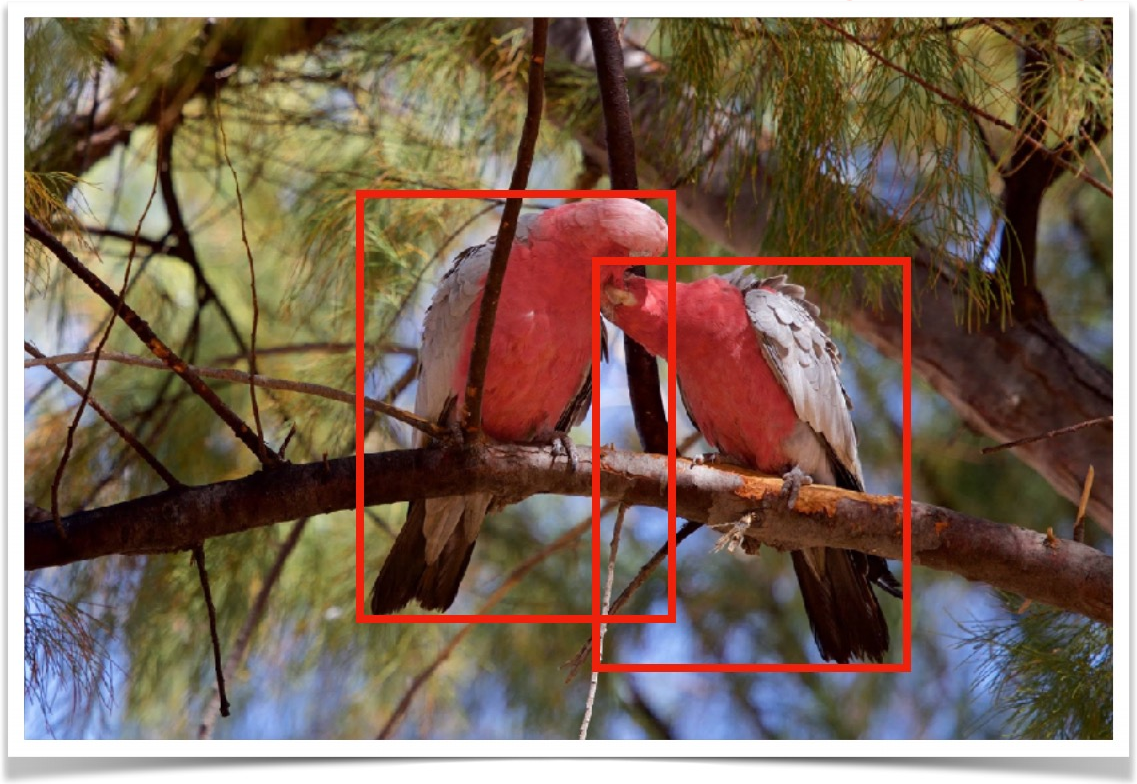


Photo © Benjamin Kellenberger

Interazioni ➔ comportamento collettivo

Fototrappole

MegaDetector: il modello di riferimento (Beery, 2023)

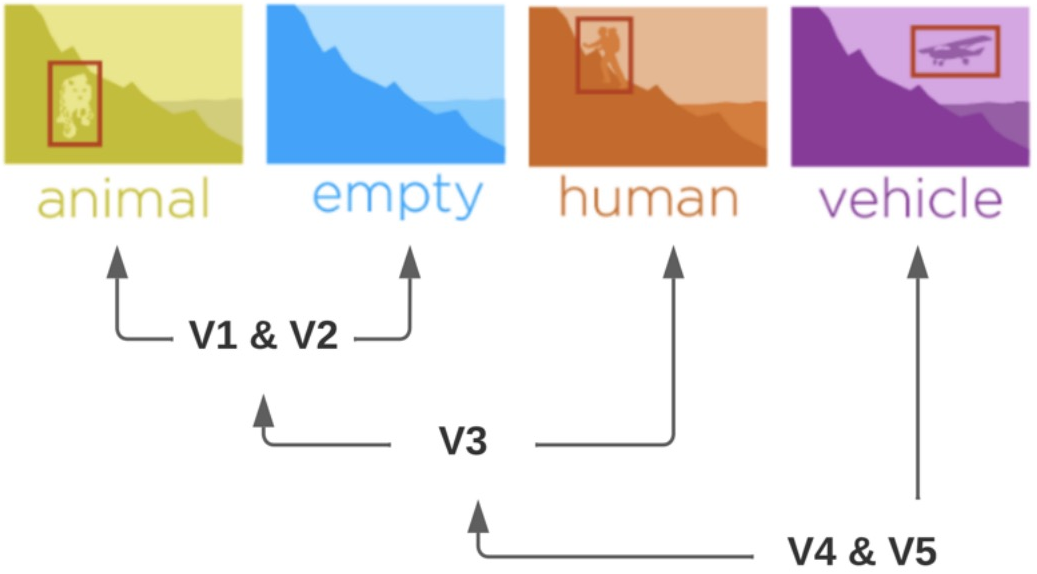


Photo © Axel Fassio

Lo standard di fatto per l'analisi automatizzata iniziale delle immagini delle fototrappole

2 rami attivi:

- https://microsoft.github.io/MegaDetector/
- https://github.com/agentmorris/MegaDetector



Fototrappole

MegaDetector: il modello di riferimento (Beery, 2023)



Photo © Axel Fassio

Facilissimo da usare!

Computer locale

```
pip install PytorchWildlife
```

```
from PytorchWildlife.models import detection as pw_detection

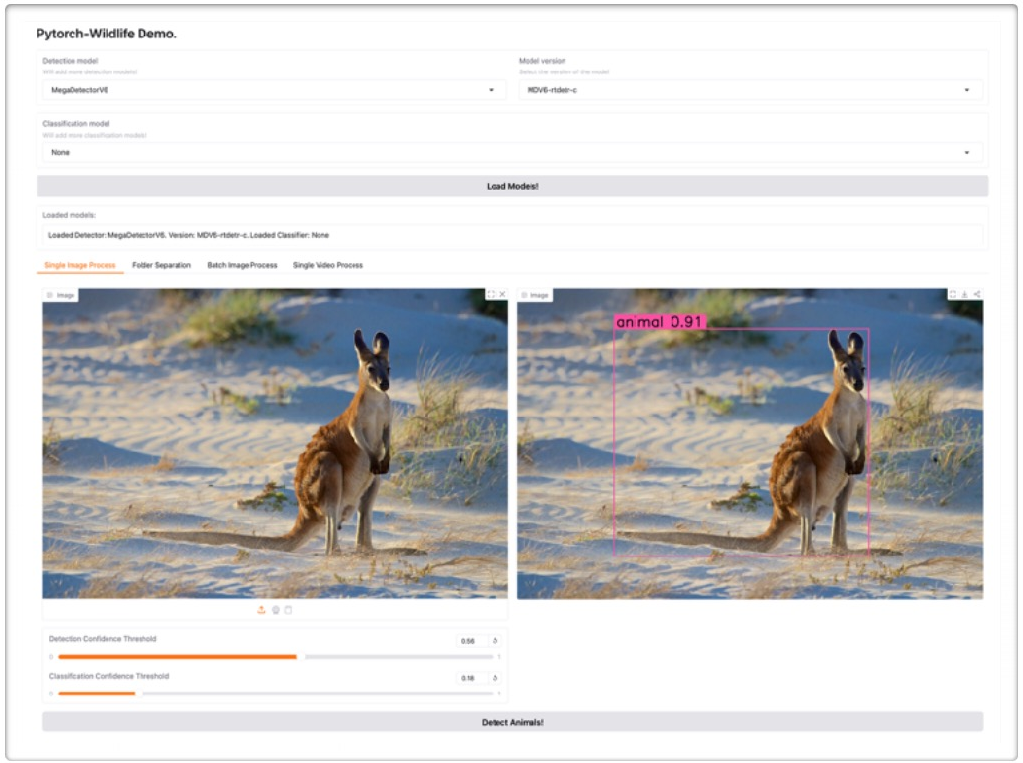
# Load MegaDetectorV6 (weights download automatically)
model = pw_detection.MegaDetectorV6()

# Detect in a single image
results = model.single_image_detection("path/to/camera_trap_image.jpg")

# Detect across a whole folder
results = model.batch_image_detection("path/to/image_folder/")
```

https://microsoft.github.io/MegaDetector/

Browser web

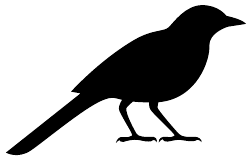


https://huggingface.co/spaces/ai-for-good-lab/pytorch-wildlife

IA e biodiversità

I. Monitorare l’individuo





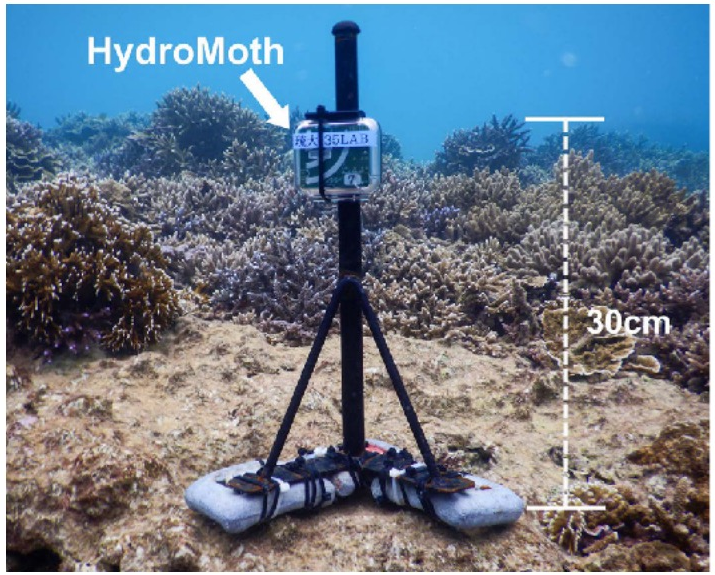


Registratori acustici

- Registrazione sonora continua



AudioMoth.
Foto: https://www.openacousticdevices.info/



HydroMoth.
Foto: Kimura et al., 2024

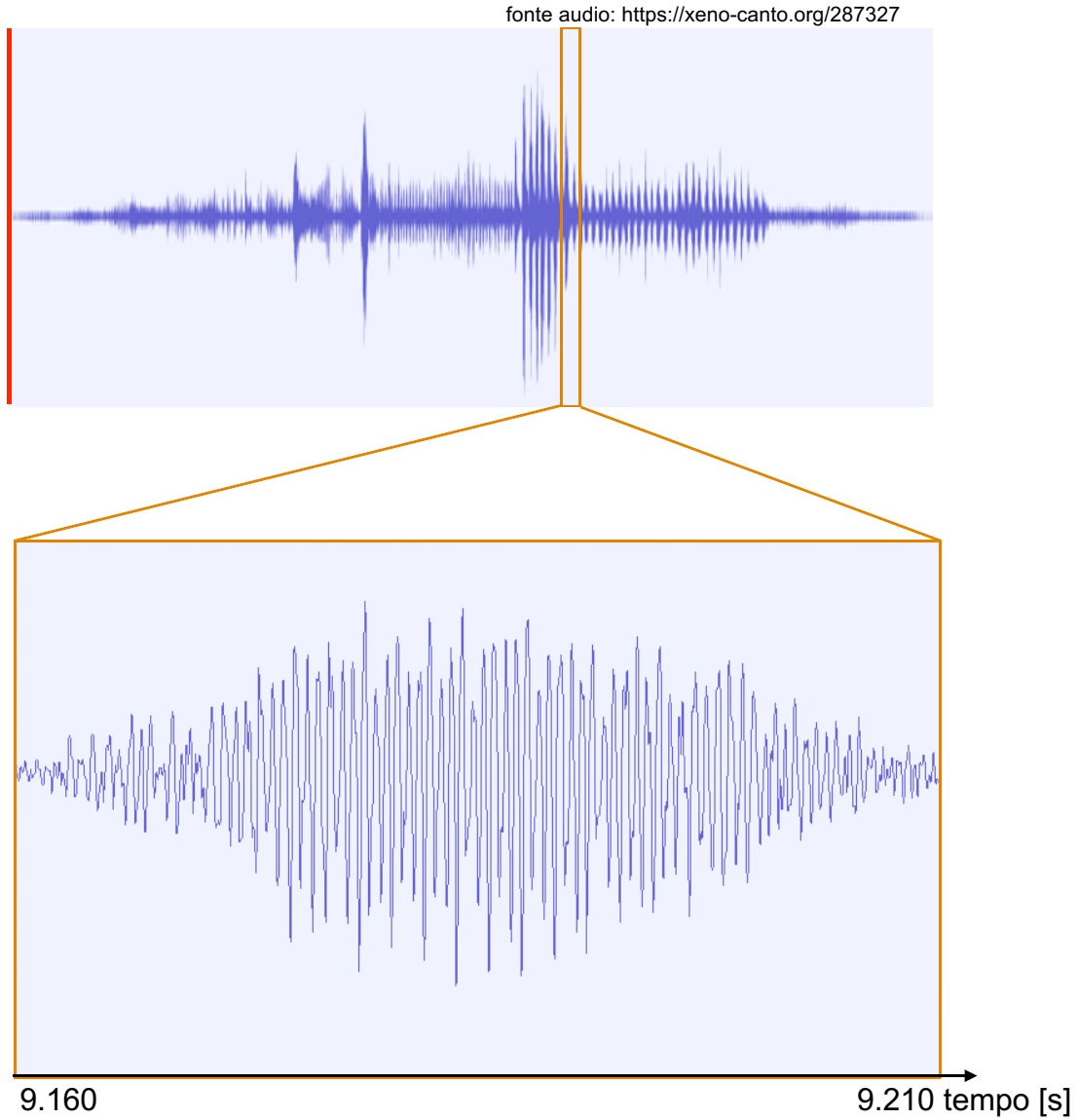
Registratori acustici

Kookaburra ridens
(Dacelo novaeguineae)

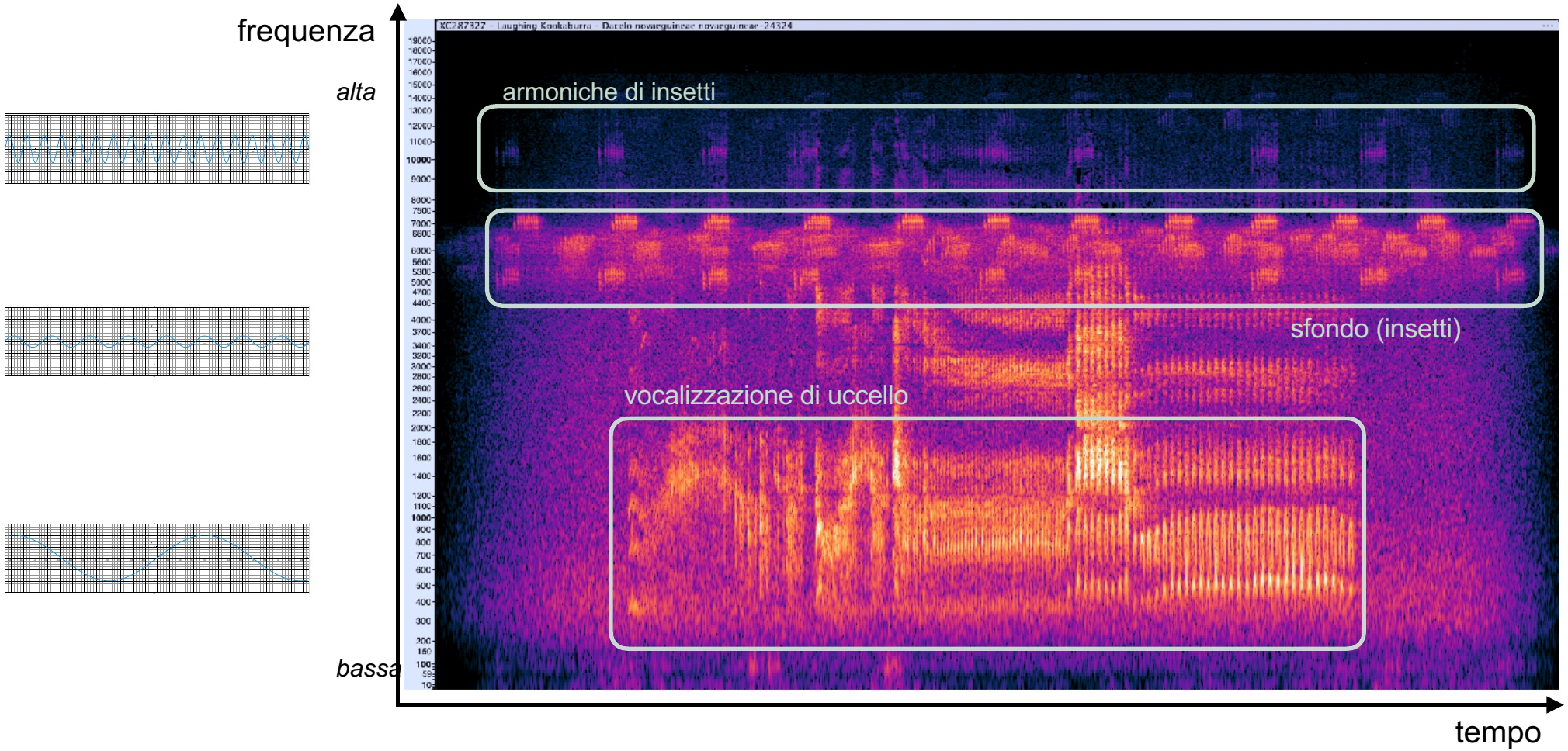


https://ebird.org/species/laukoo1





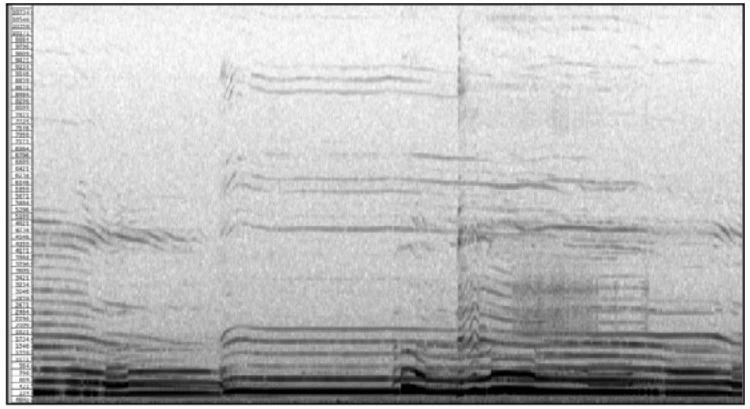
Spettrogrammi



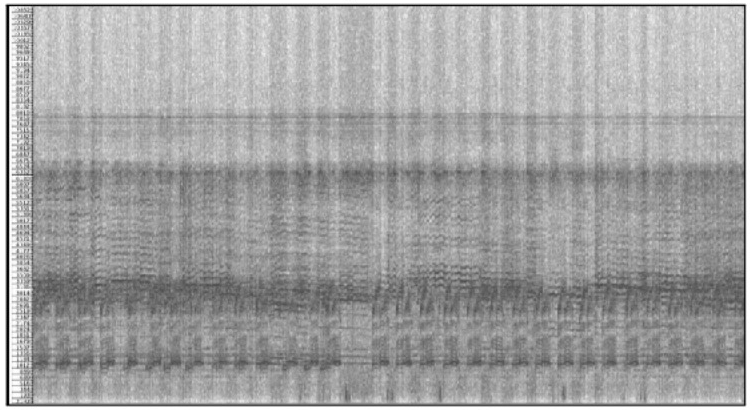
Spettrogrammi

Esempi:

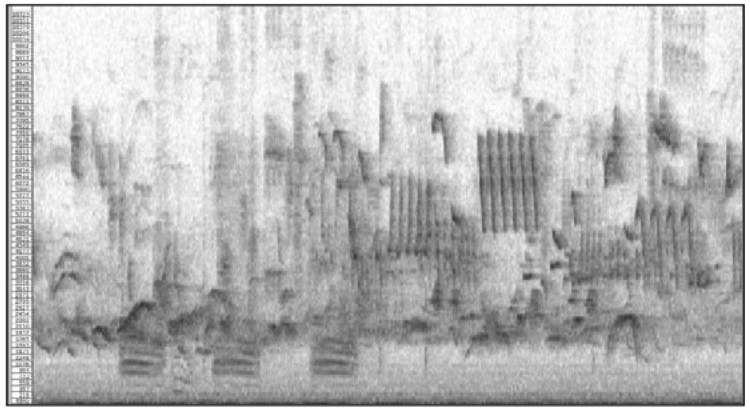
Small pack of wolves howling together



Frogs (lower pitch) and insects (higher)



"Dawn chorus" of many bird species



Risso's & Pacific White-sided dolphins

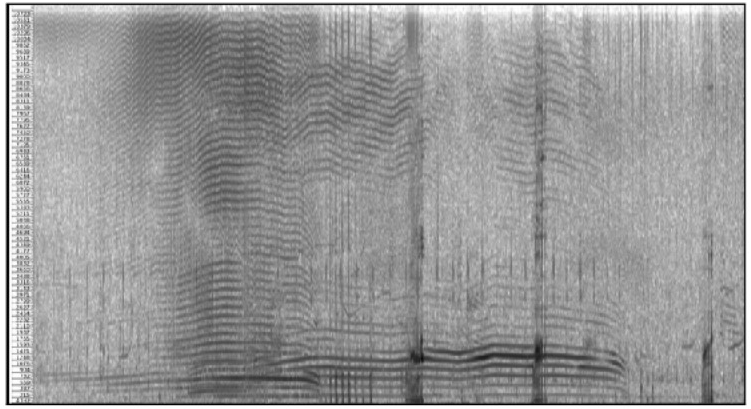
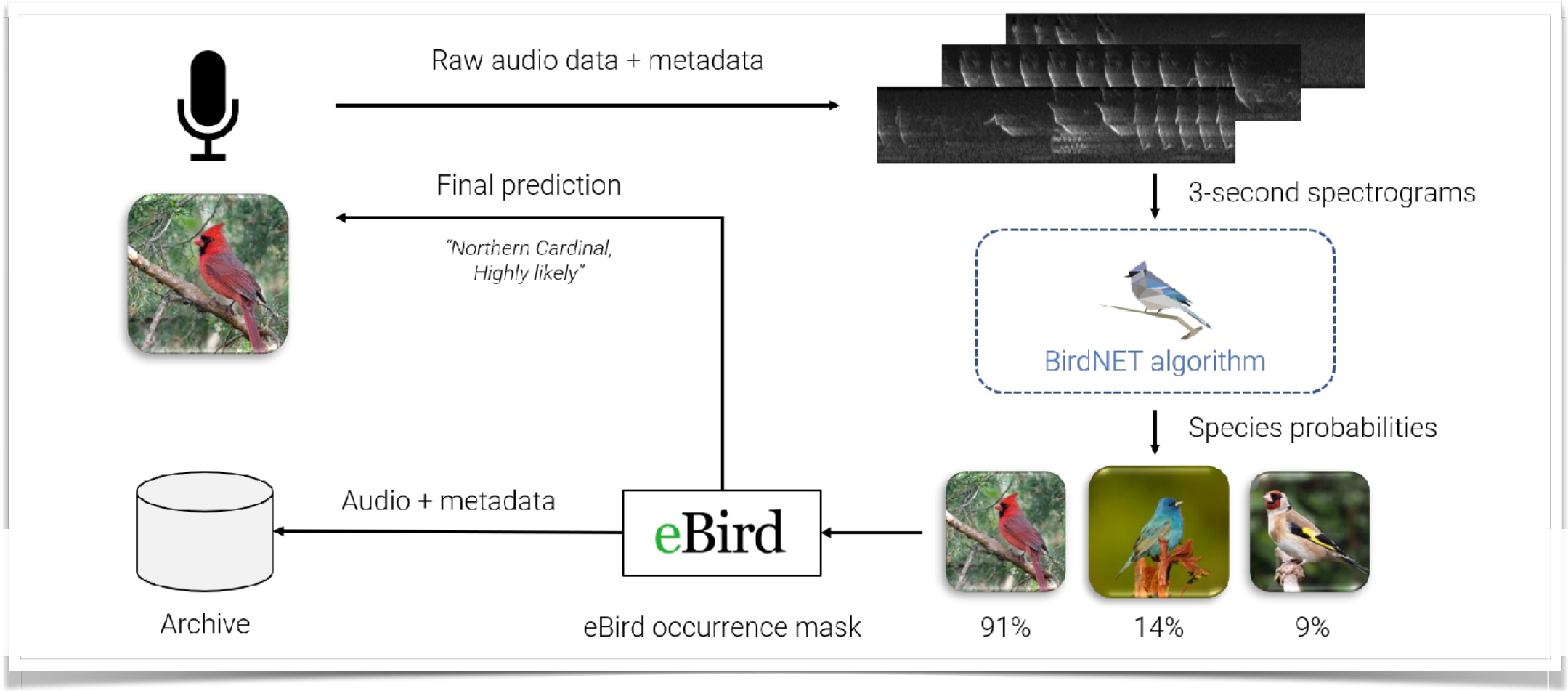


Immagine © Dan Stowell / Naturalis

Paesaggi sonori

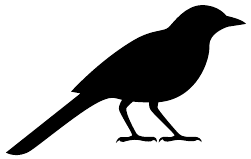
Modello di esempio: BirdNET (https://birdnet.cornell.edu/)



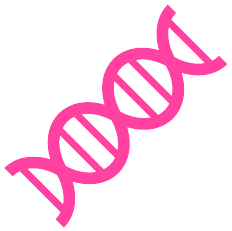
IA e biodiversità

I. Monitorare l’individuo

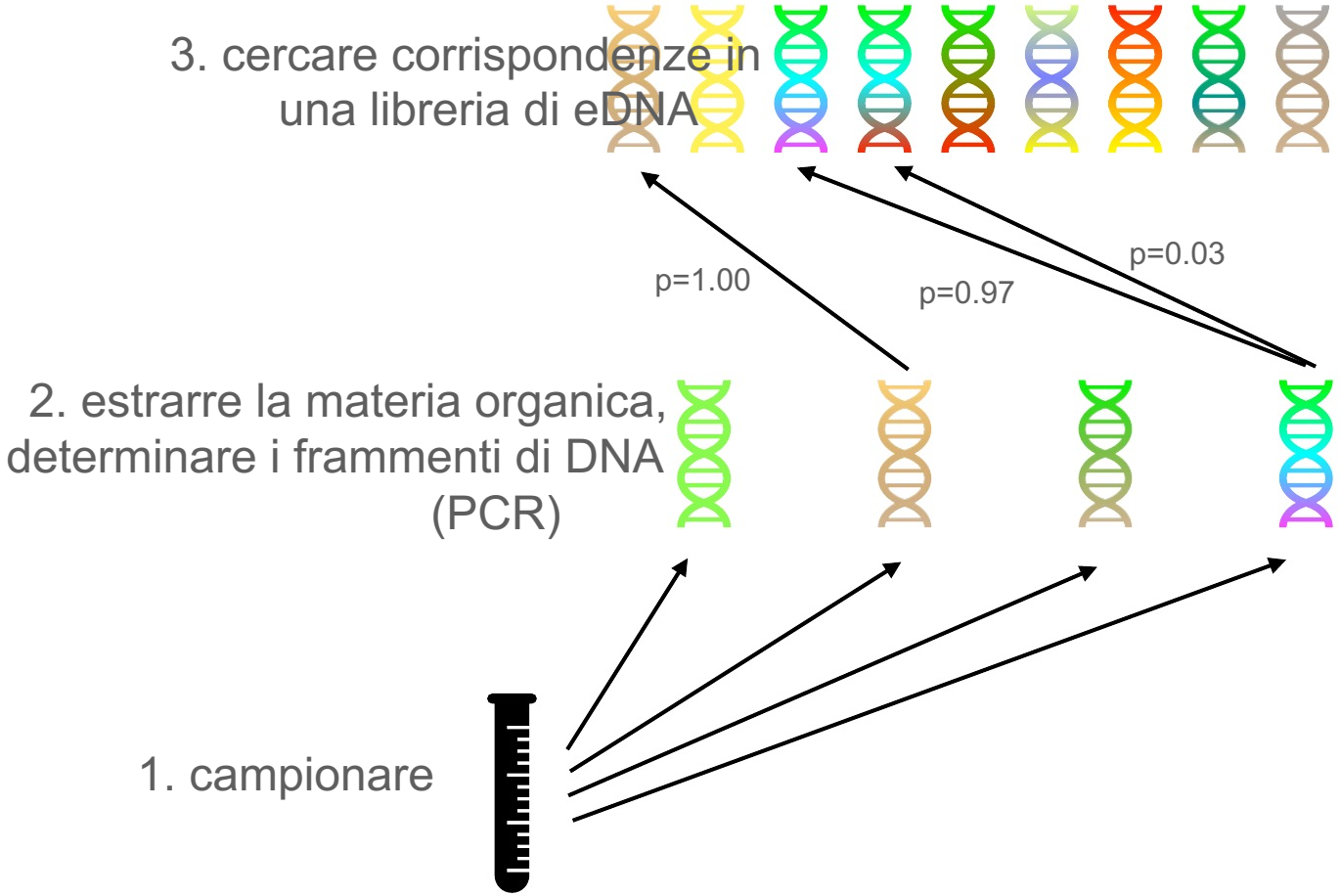








eDNA



aria

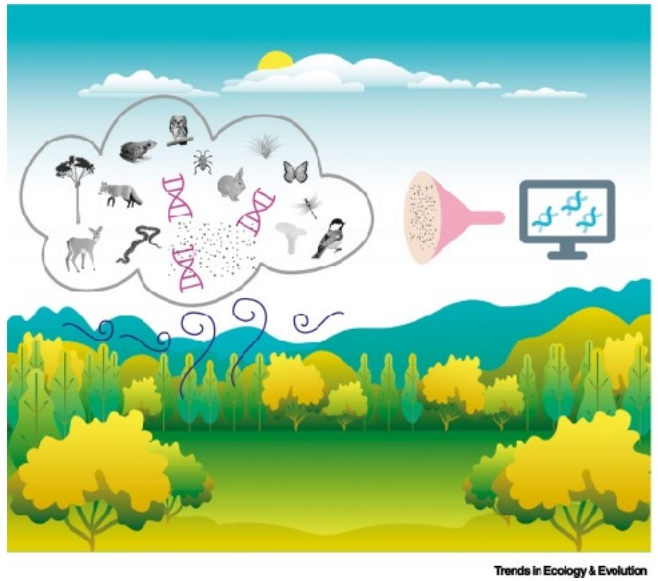


Immagine: Bohmann e Lynggaard, 2023

terrestre

acquatico

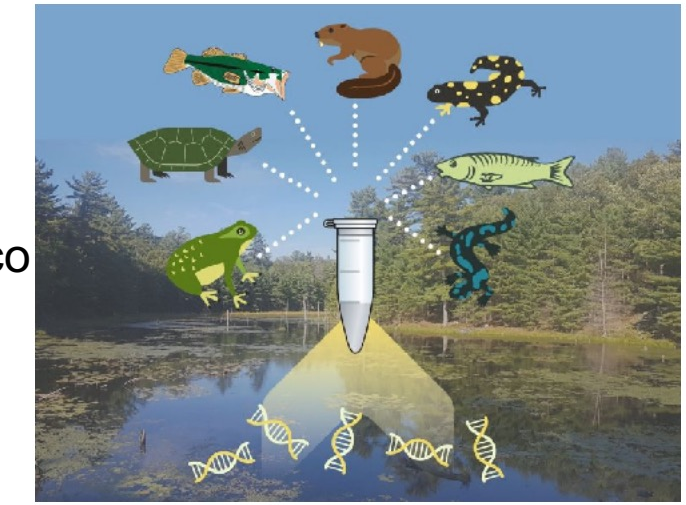
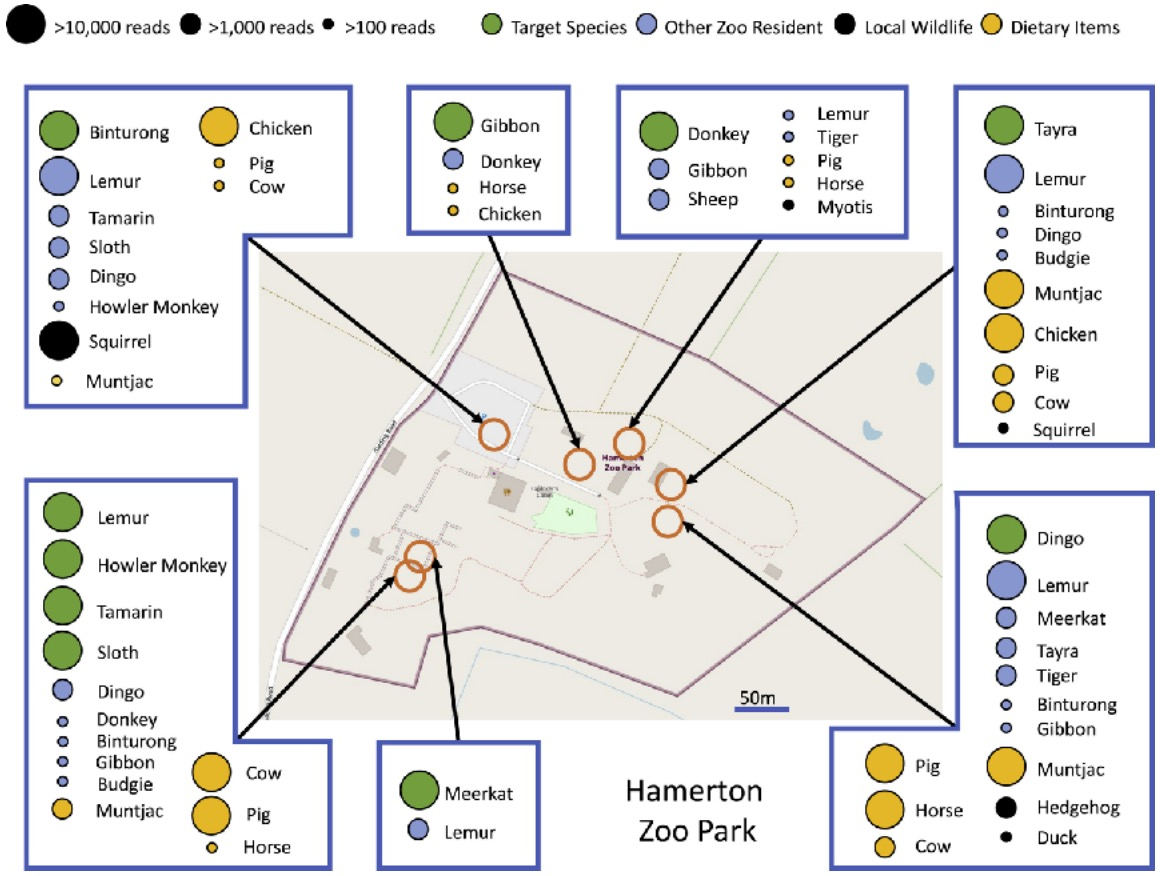
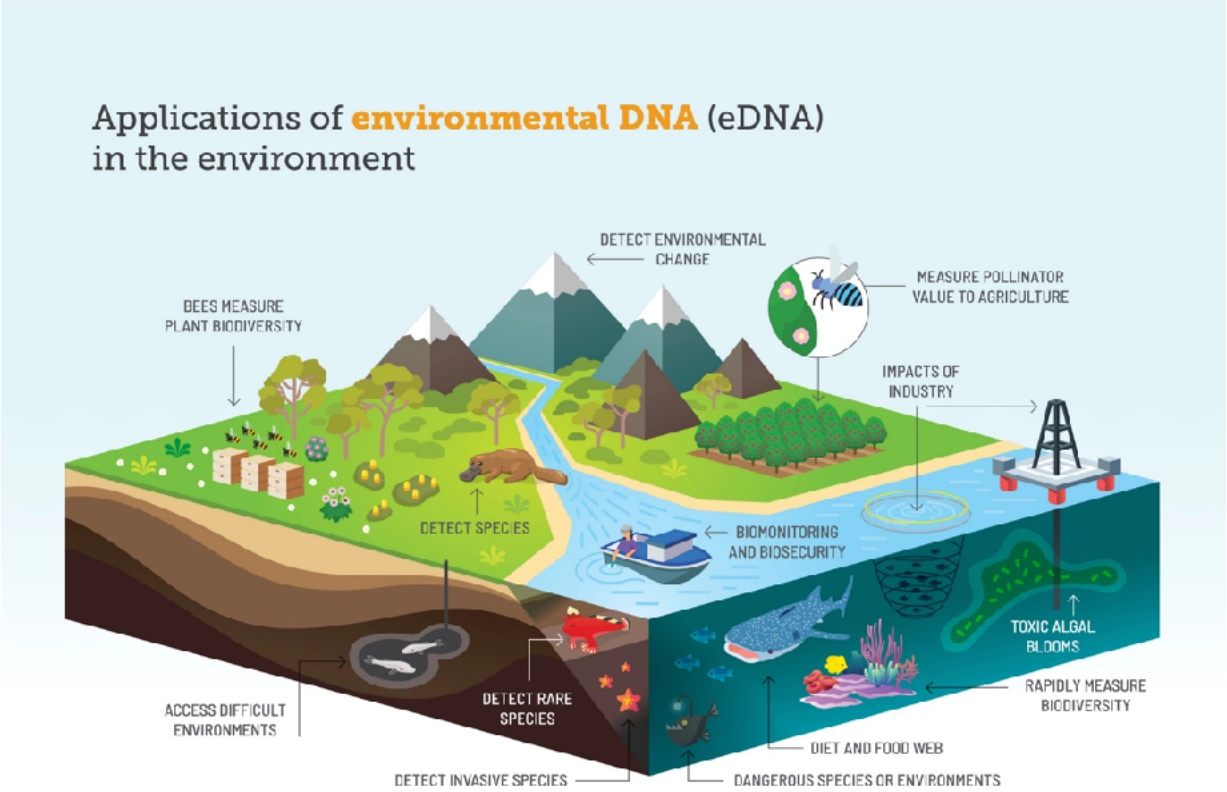


Immagine: https://stateofthebay.ca/

eDNA



[1]

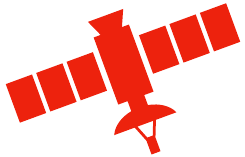


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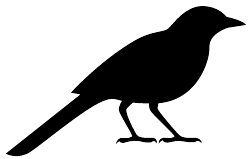
[1] Clare, E.L., Economou, C.K., Bennett, F.J., Dyer, C.E., Adams, K., McRobie, B., Drinkwater, R. and Littlefair, J.E., 2022. Measuring biodiversity from DNA in the air. Current Biology, 32(3), pp.693-700.
[2] Berry, O., Jarman, S., Bissett, A., Hope, M., Paeper, C., Bessey, C., Schwartz, M.K., Hale, J. and Bunce, M., 2021. Making environmental DNA (eDNA) biodiversity records globally accessible. Environmental DNA , 3 (4), pp.699-705.

IA e biodiversità

I. Monitorare l’individuo









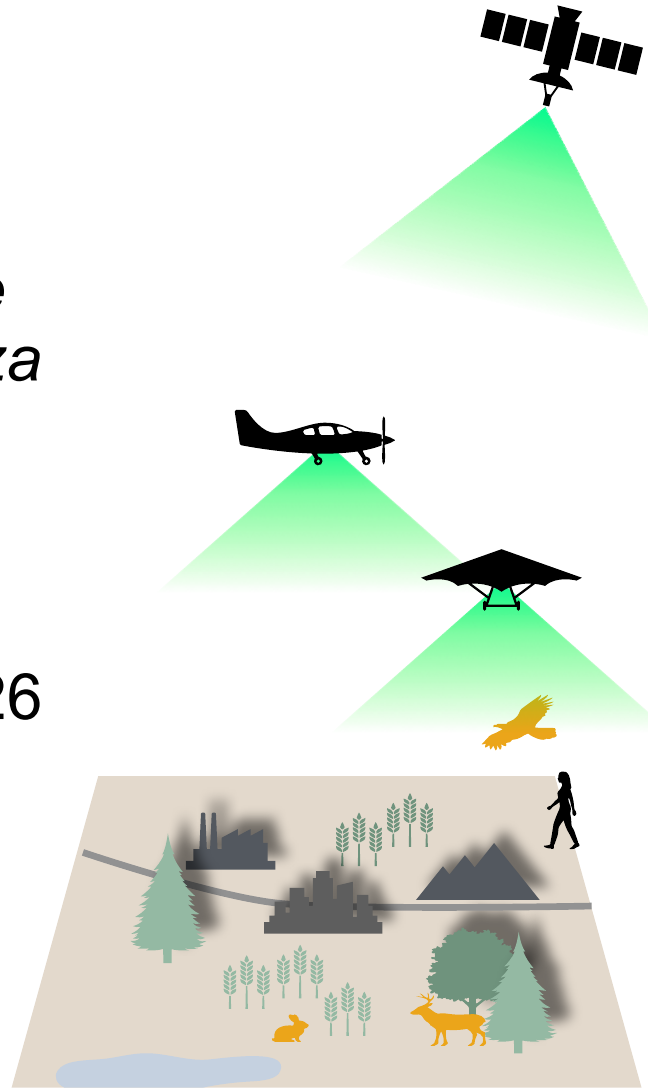


Telerilevamento

«Il telerilevamento è il processo di rilevare e monitorare le caratteristiche fisiche di un'area misurando a distanza la radiazione riflessa ed emessa (in genere da satellite o aereo)

USGS, 2026

Osservazione della Terra



spaziale (satellite, navetta, ISS, ecc.)

aereo (aeroplano, drone, pallone)

a terra (misure di campo)

Telerilevamento

Rilevamento aereo della fauna



Image © Friedrich Fedor Reinhard



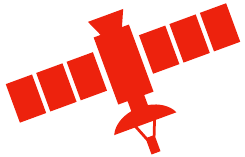
Q

Dove sono gli animali?

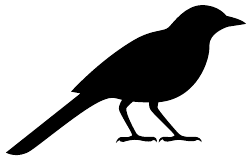


IA e biodiversità

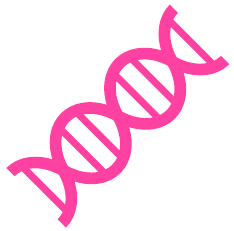
I. Monitorare l’individuo











Rete di osservazione della biodiversità



Tuia, Kellenberger, Beery, Costelloe et al., 2022

Compromessi tra sensori

Fototrappole



Registratori acustici



Telerilevamento satellitare



Videotrappole



eDNA



Telerilevamento da drone



Rilevamento della fauna

Cosa usare e quando

Telerilevamento satellitare
+ copertura fino a globale serie
+ temporali continue spesso più
+ bande spettrali gratuito (se
+ basta bassa risoluzione)

– bassa risoluzione
– nuvole
– niente video (tracciamento!)

Immagini da drone/UAV
+ risoluzione altissima
+ sicuro economico
+

– area ridotta
– non vede sotto gli alberi

Immagini da aereo
+ risoluzione molto alta
– costoso
– pericoloso

Fototrappole
+ serie temporali continue primo
+ piano: semanticamente ricco

– solo localizzazione puntuale

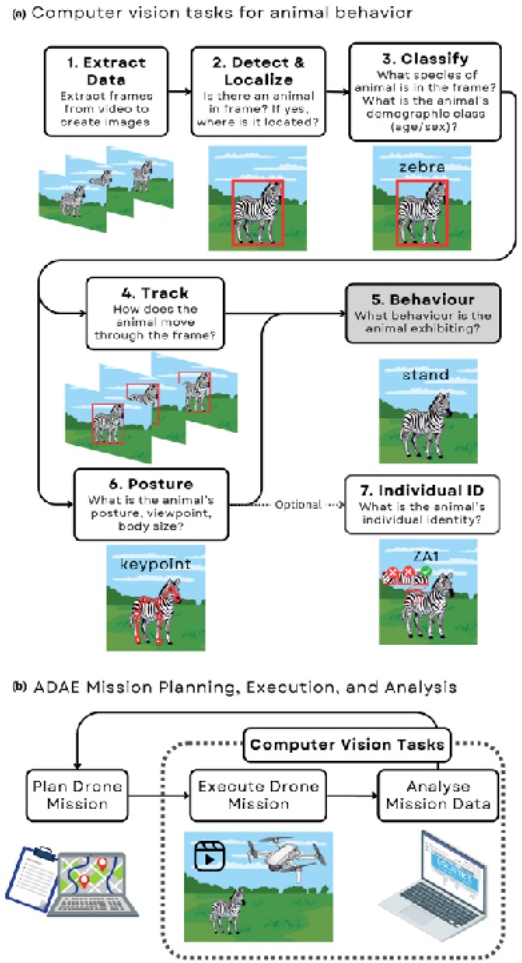
Rilievi sul campo
+ spesso unica fonte di dati storici può
+ vedere sotto la vegetazione
– puntuali
– potenzialmente ambigui

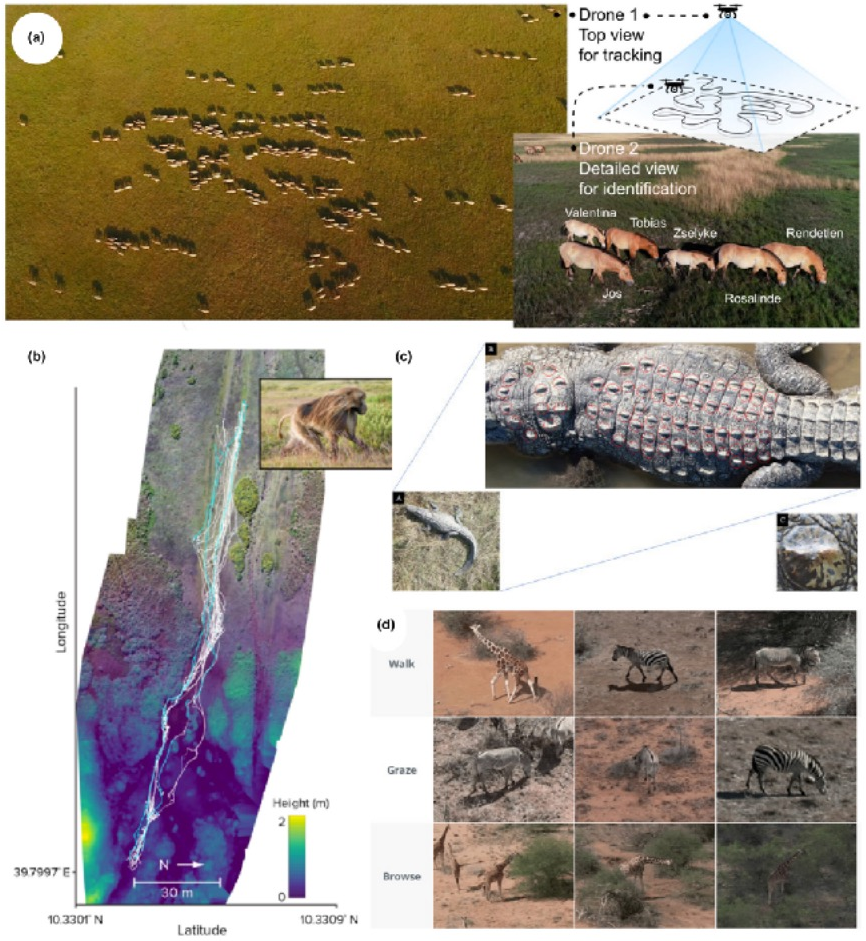


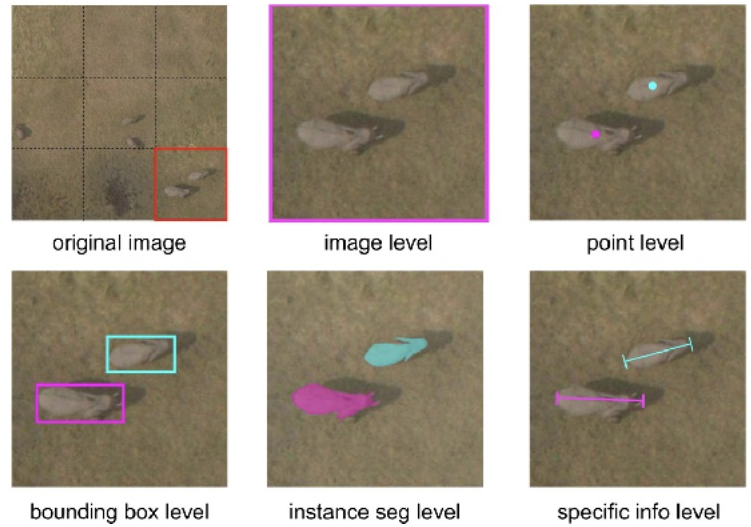
Image © Friedrich Fedor Reinhard

Conservazione della fauna

Oltre il rilevamento





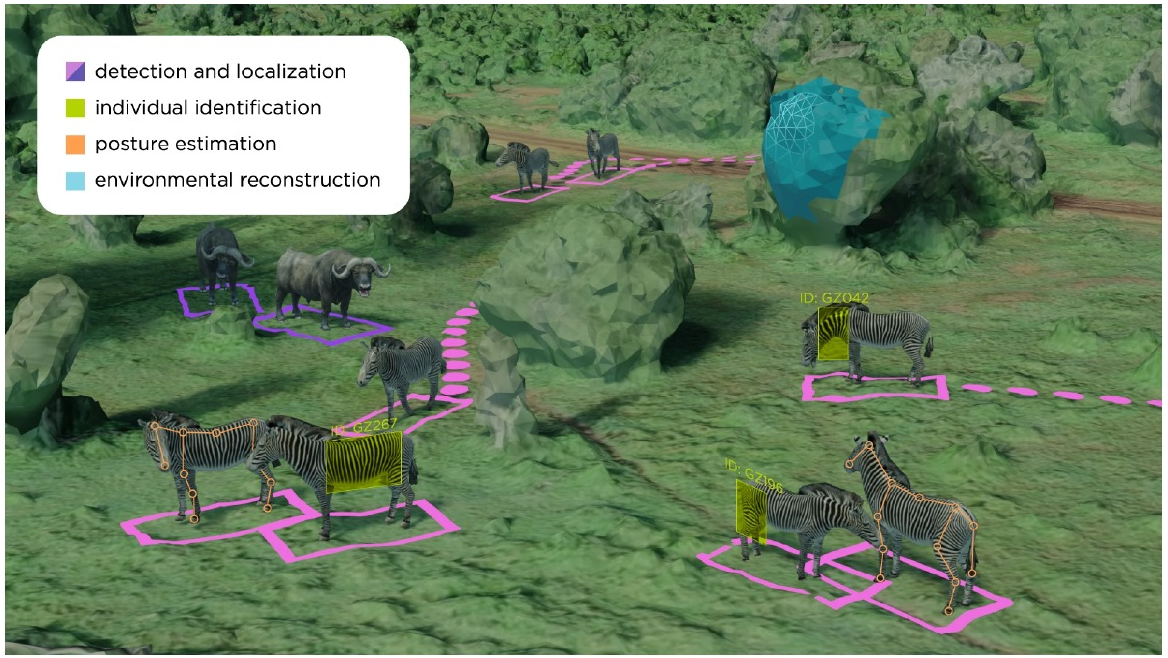


Kline et al., 2025

Conservazione della fauna

Oltre il rilevamento

- Censimenti della fauna: quanti animali (per specie)
- Distribuzione: dove si trovano (e perché)
- Salute animale
- Salute ambientale
- Prevenzione del bracconaggio
- etc.



Tuia, Kellenberger, Beery, Costelloe et al., 2022

➔ La scienza dei dati può aiutare in tutti questi casi!

IA e biodiversità

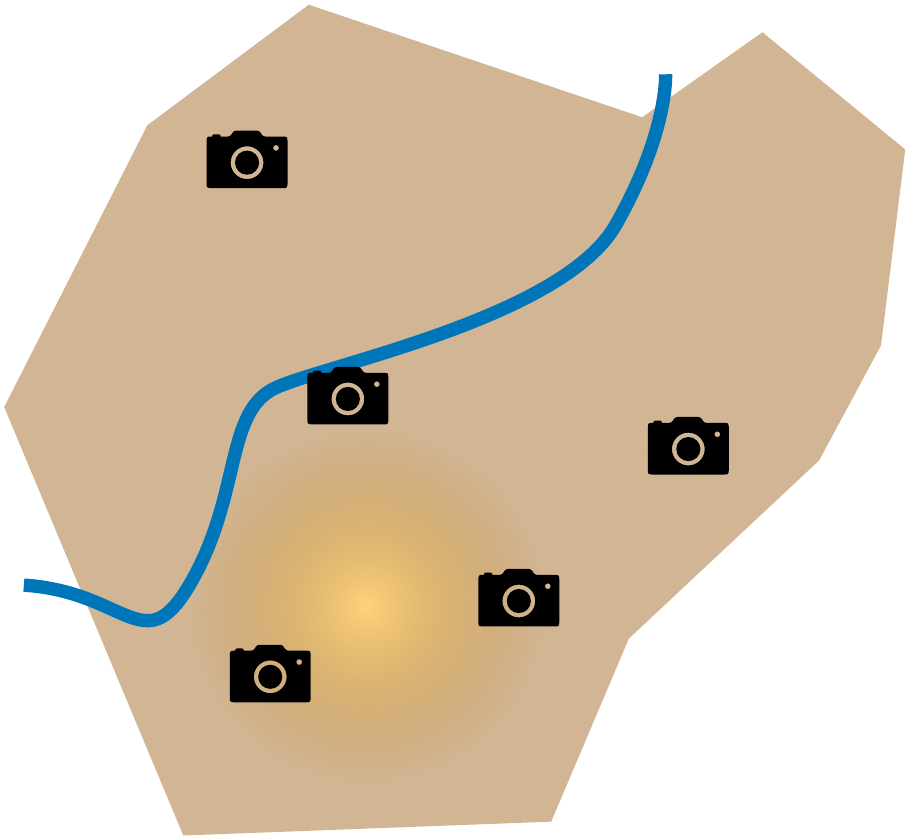
II. Dagli individui alle comunità

IA e biodiversità

II. Dagli individui alle comunità

rilievi con drone

rete di fototrappole

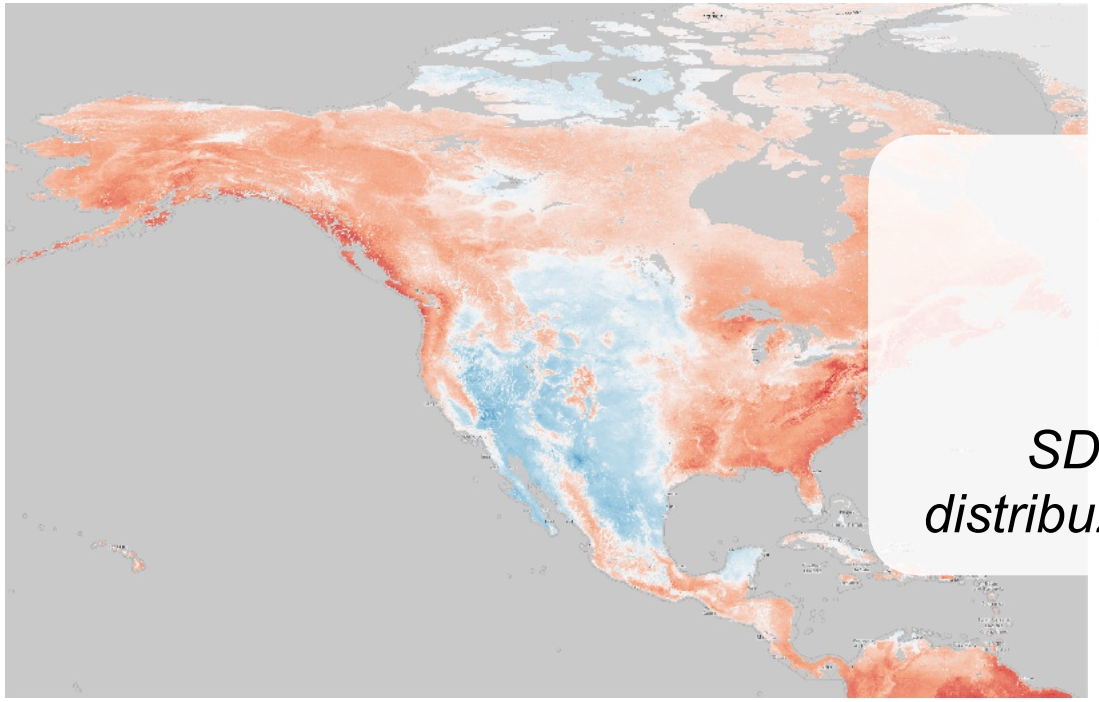


area di studio

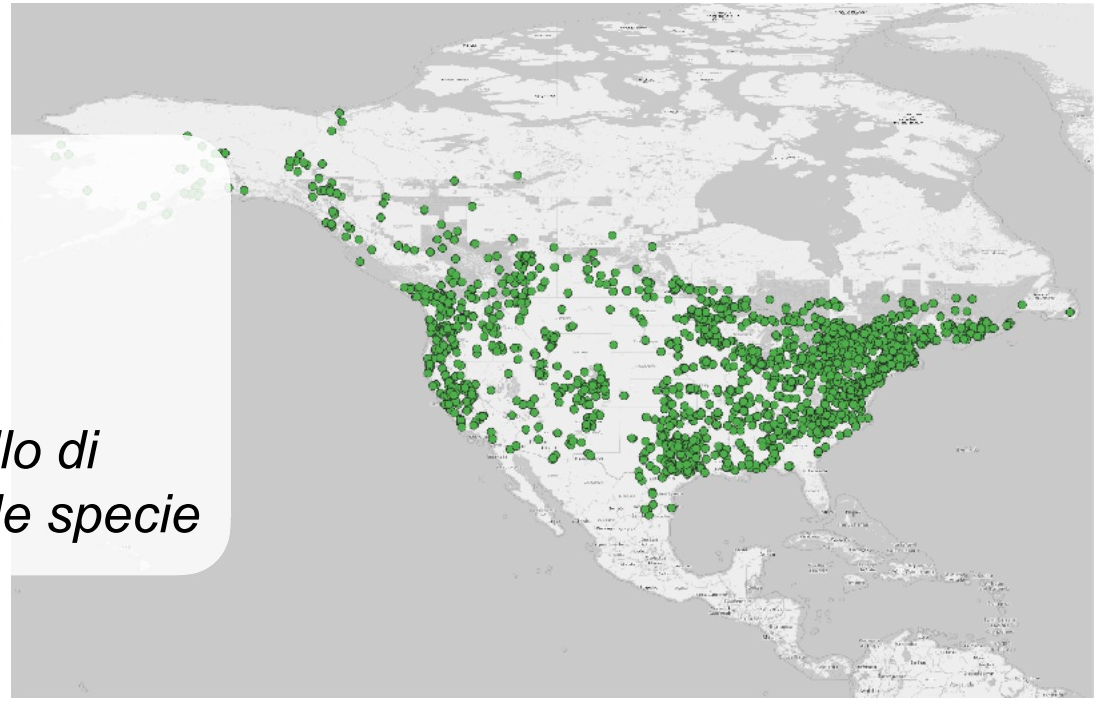
Dove sono presenti le specie?

E perché?

SDM: modellazione della distribuzione delle specie



SDM: modello di distribuzione delle specie



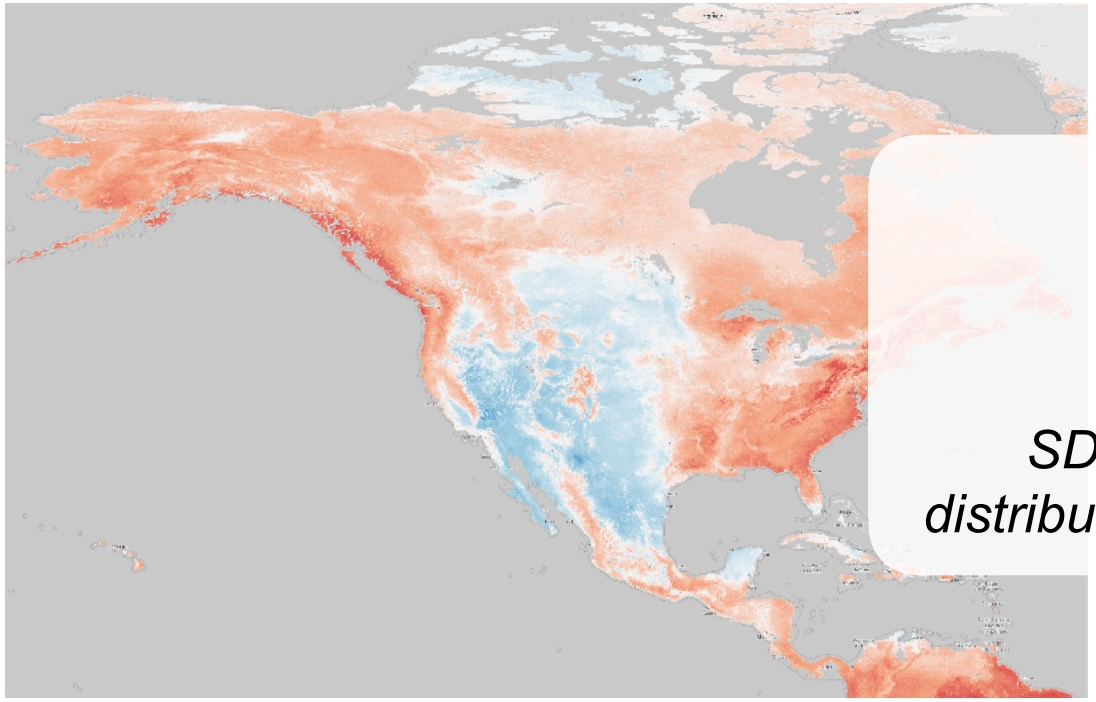
covariate ambientali

- temperatura annuale
- precipitazioni
- pH del suolo
- ...

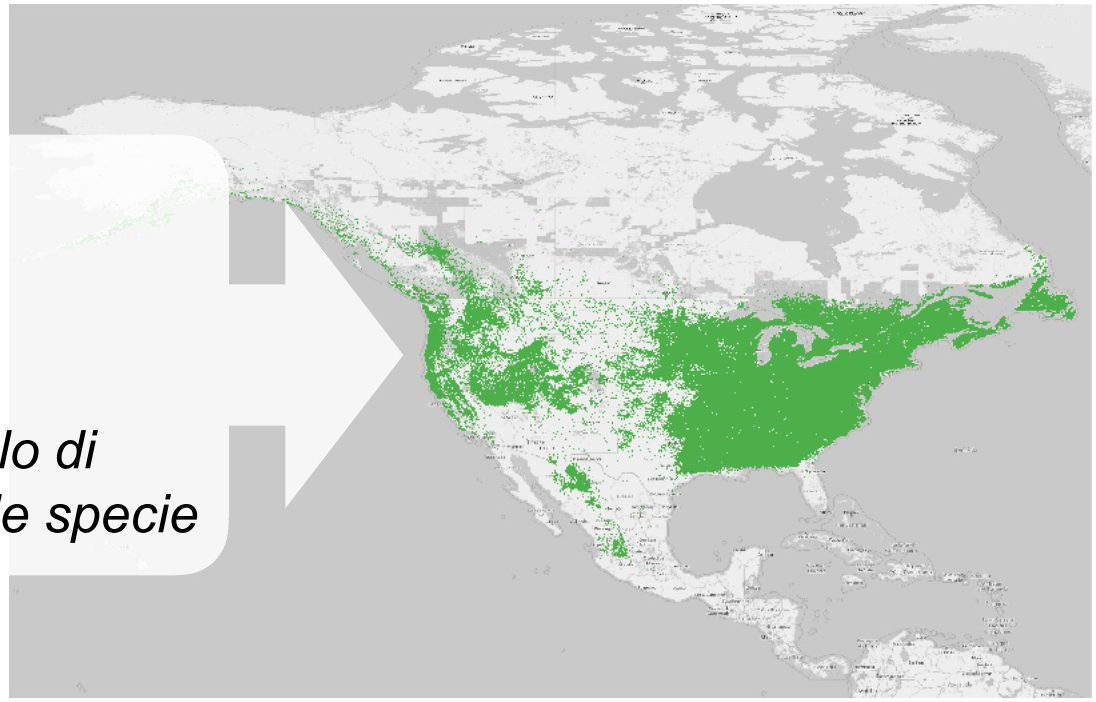
osservazioni di specie

- rilievi sul campo
- mappe di areale degli esperti
- iNaturalist, eBird, ecc.

SDM: modellazione della distribuzione delle specie



SDM: modello di distribuzione delle specie



covariate ambientali

- temperatura annuale
- precipitazioni
- pH del suolo
- ...

idoneità prevista

Ingredienti di un SDM

A. Osservazioni di specie

- Rilievi sul campo
- Piattaforme di citizen science:
  - iNaturalist (https://www.inaturalist.org/)
  - GBIF (https://gbif.org/)
  - eBird (https://ebird.org/)
  - etc.
- Sensori:
  - Fototrappole
  - Immagini aeree
  - registrazioni acustiche (geolocalizzate)



Ingredienti di un SDM

B. Descrittori ambientali



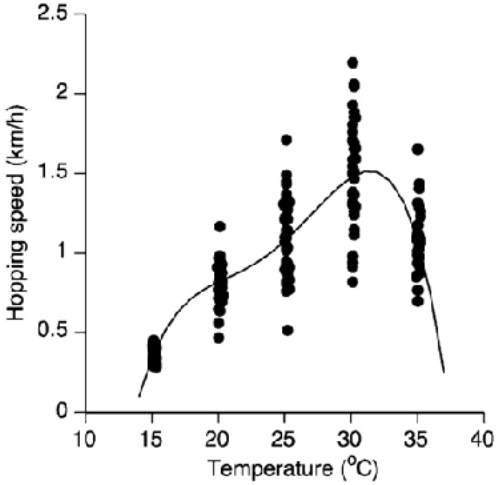
➔ Telerilevamento

Prodotti diffusi:

- climatici: CHELSA (https://www.chelsa-climate.org/)
- pedologici: SoilGrids (https://soilgrids.org/)
- quota:
  - ASTER GDEM (https://asterweb.jpl.nasa.gov/gdem.asp)
  - SRTM (https://www.earthdata.nasa.gov/data/instruments/srtm)
- produttività:
  - indici di vegetazione: ad es. MODIS EVI, Landsat NDVI, ecc.

Famiglie di SDM

A. Meccanicistici



Regole costruite a mano

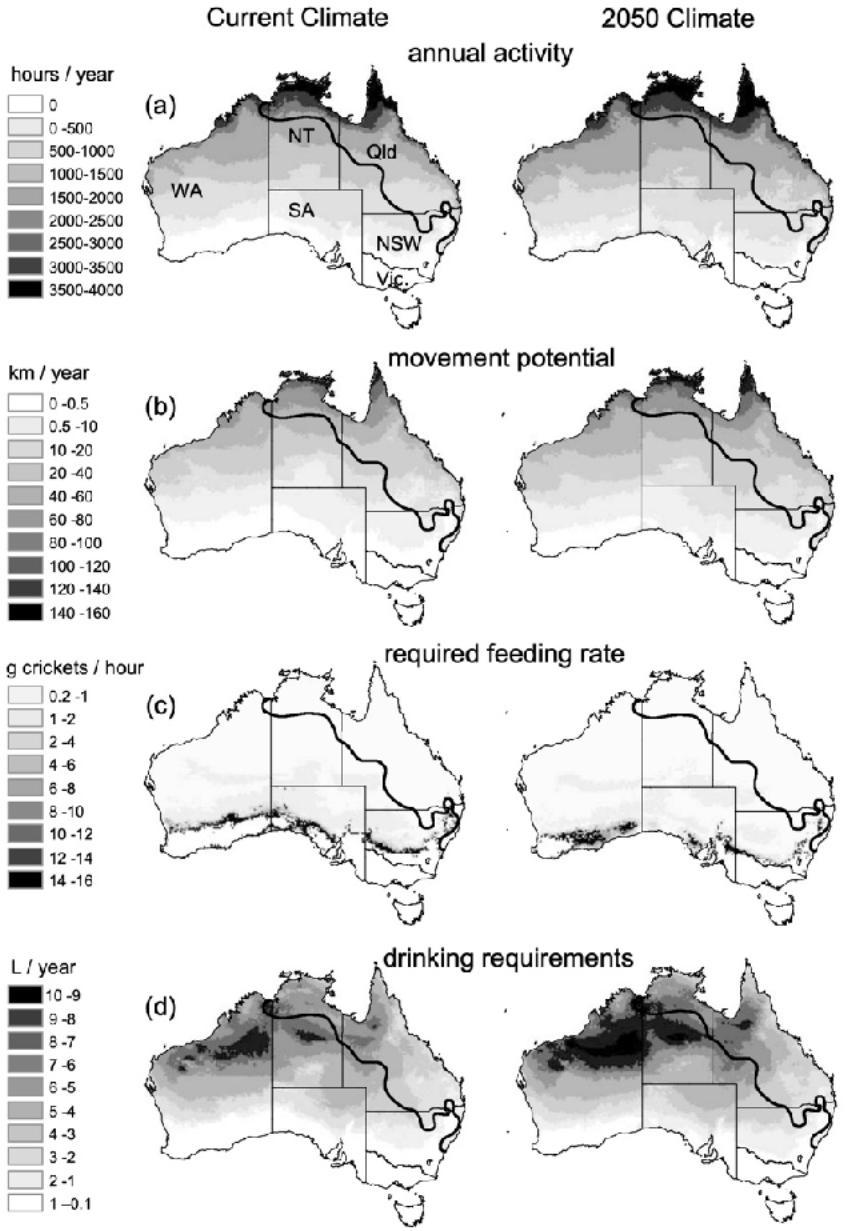
Esempio: Kearney et al. (2008):

$$Q_{solar} + Q_{IRin} + Q_{metab} = Q_{resp} + Q_{evap} + Q_{IRout} + Q_{conv} + Q_{cond} \quad (1)$$

Le regole (formule) possono derivare da osservazioni

+ Precisi, basati sulla conoscenza, trasparenti, robusti

– Molto difficili da formulare



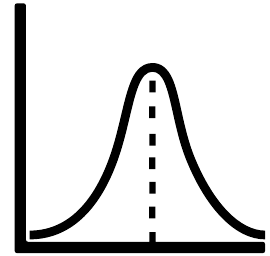
Famiglie di SDM

B. Correlativi

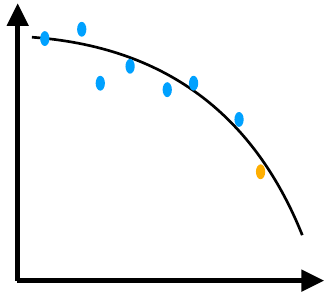
La grande maggioranza degli SDM

+ «Facili» da costruire; guidati dai dati

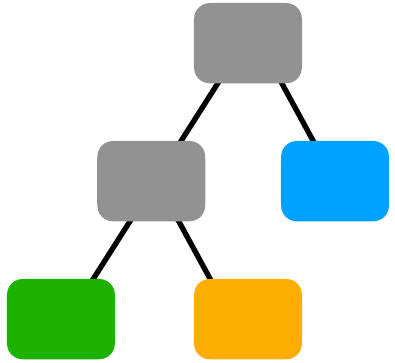
– Guidati dai dati: soggetti a bias, poco trasparenti



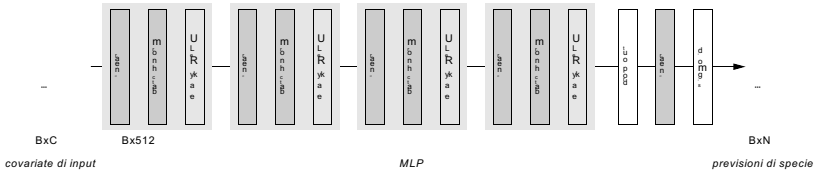
Massima entropia
(MaxEnt)



GLM, GAM, ecc.



Alberi decisionali; foreste casuali, BRT, ecc.



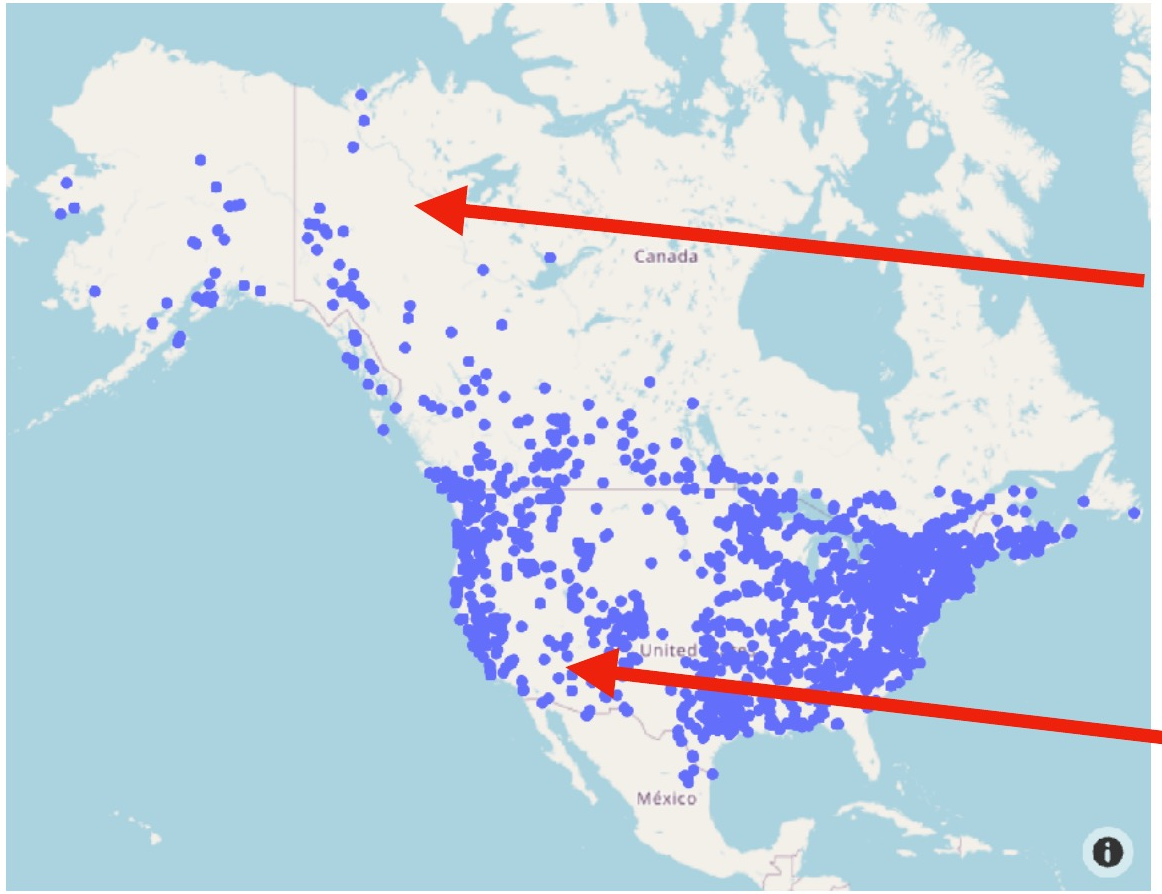
Deep learning

Sfide degli SDM

A. Osservazioni di specie

Castoro americano (Castor canadensis)







iNaturalist

osservazioni

mappa di areale degli esperti

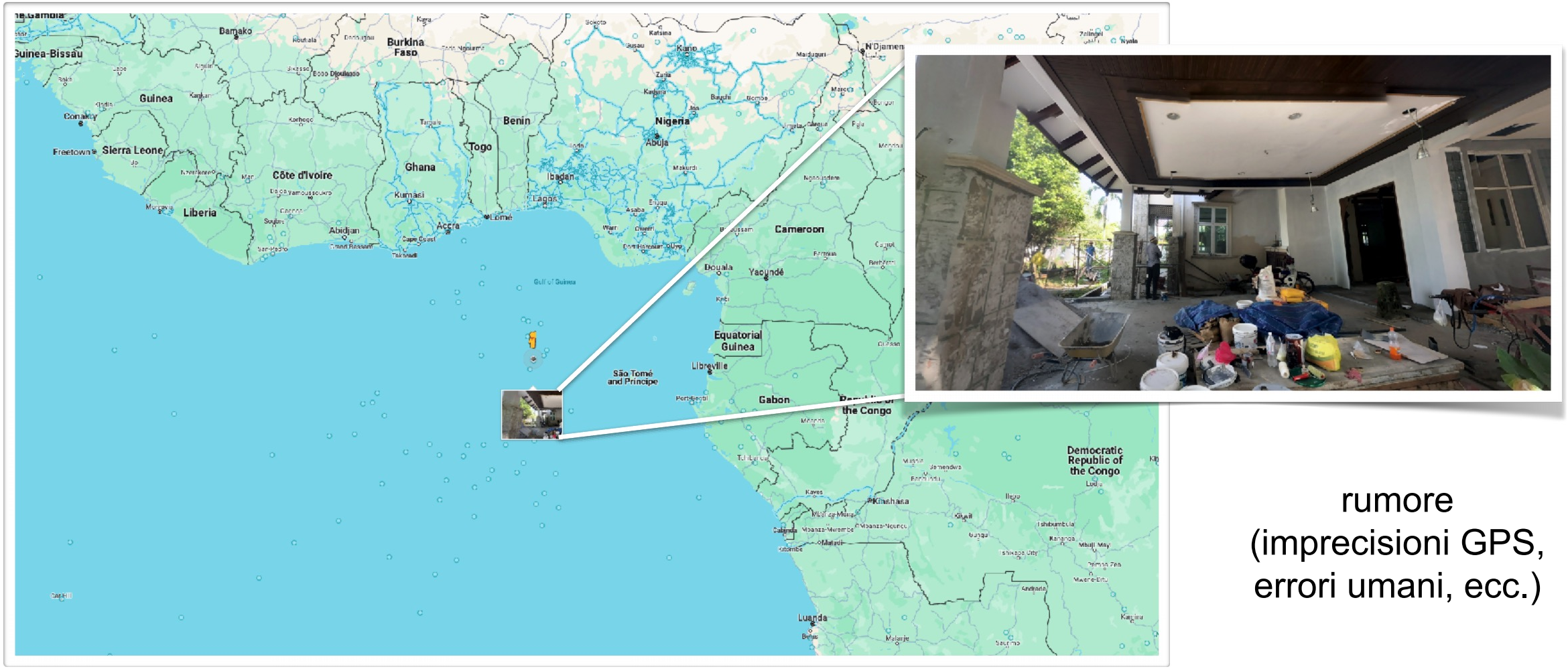
MOL MAP OF LIFE

Sfide degli SDM

A. Osservazioni di specie



Castoro americano (Castor canadensis)



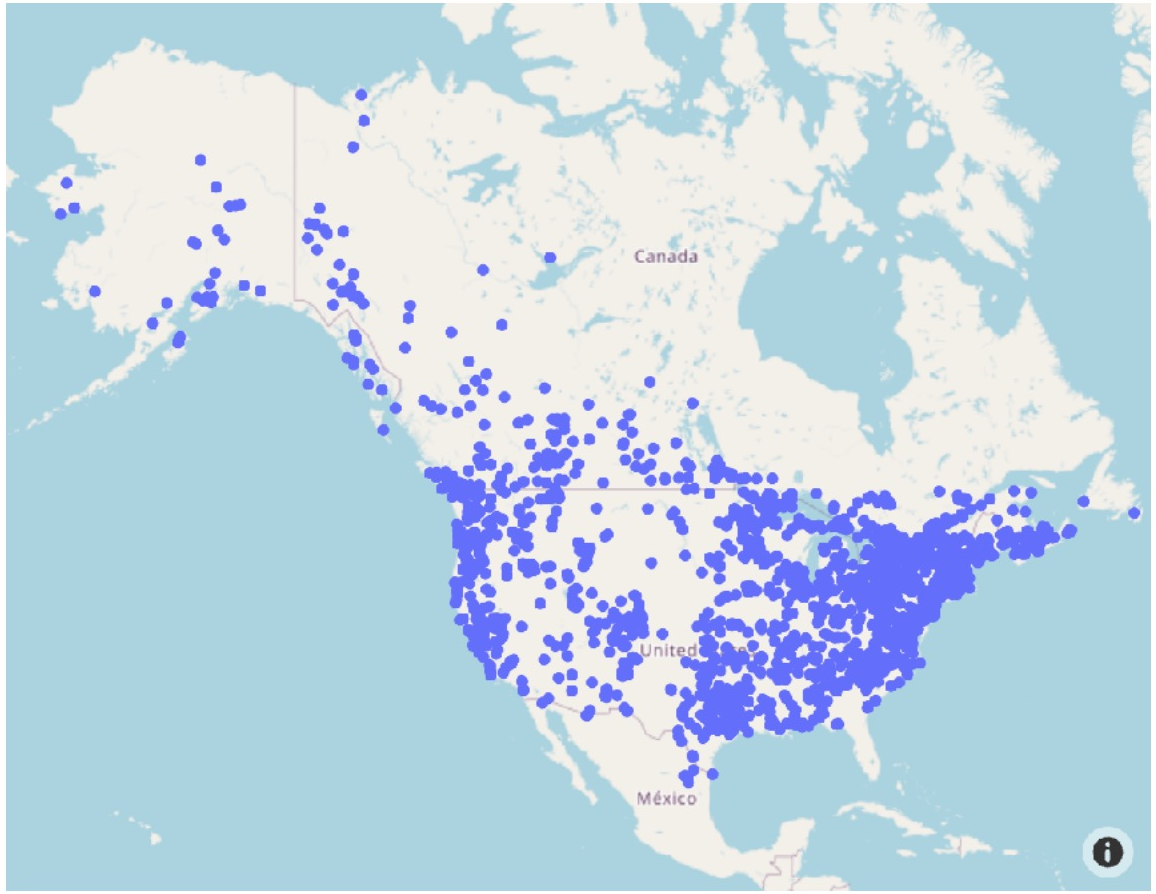
rumore
(imprecisioni GPS,
errori umani, ecc.)

Sfide degli SDM

A. Osservazioni di specie

Castoro americano (Castor canadensis)





iNaturalist

«Sappiamo» dove si trova la specie.

Ma dove non si trova?

Le assenze sono difficili da ottenere.

→ pseudo-assenze:

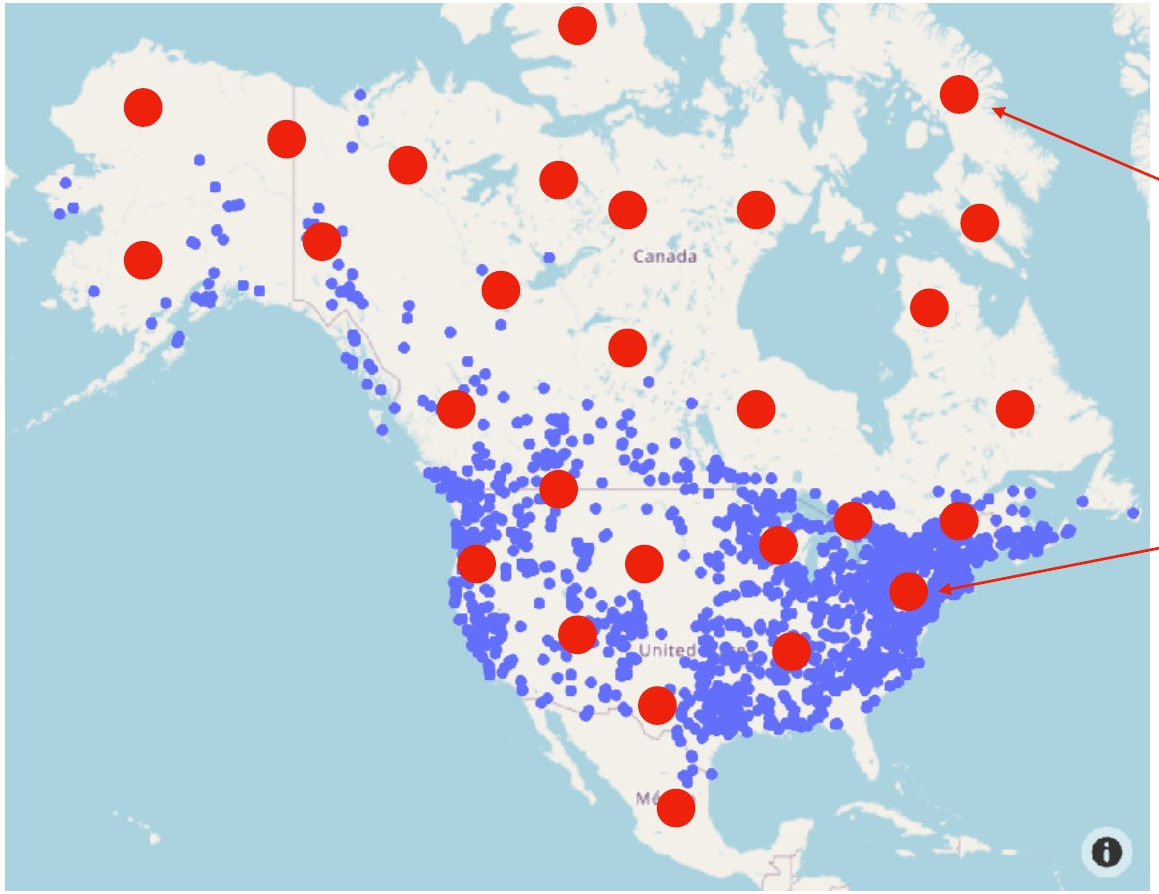
- Dove?
- Quante?
- Quanto affidabili?

Sfide degli SDM

A. Osservazioni di specie

Castoro americano (Castor canadensis)





iNaturalist

Casuale uniforme

a cosa servono punti come questo?

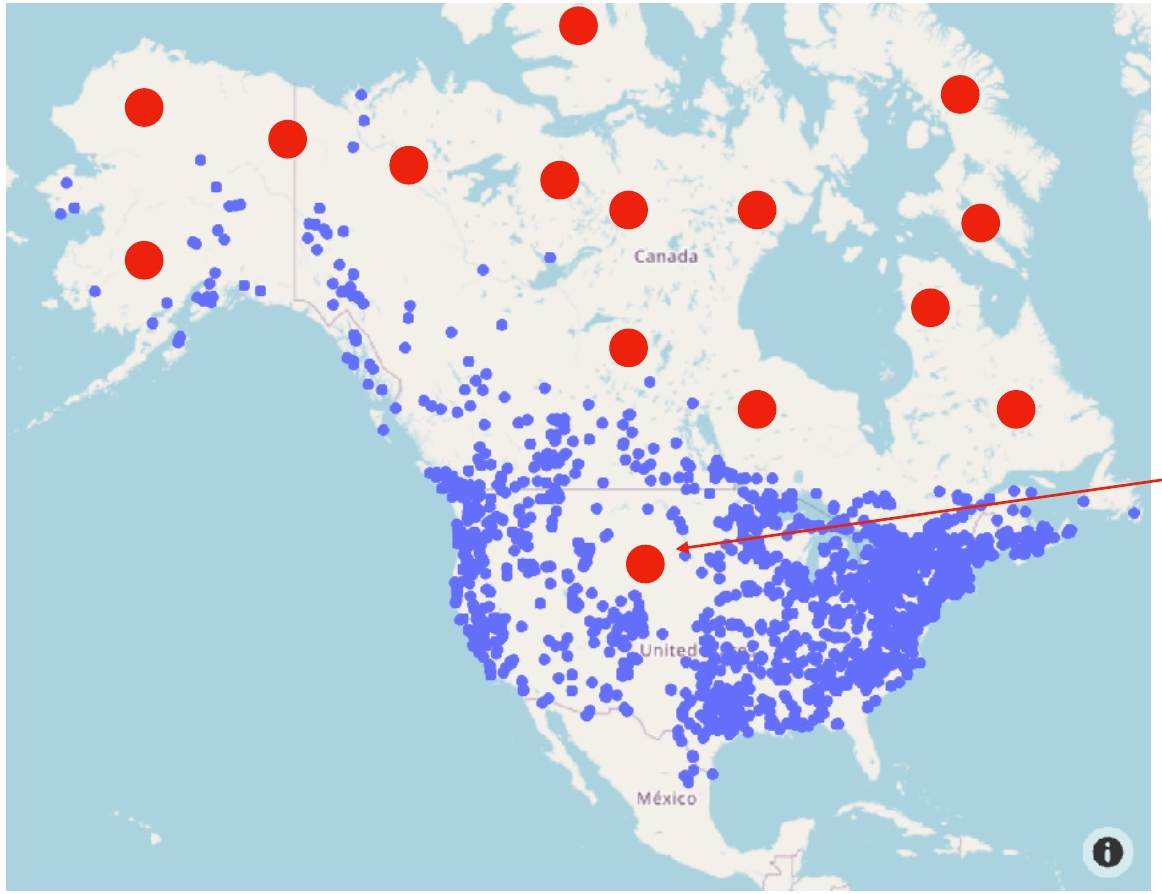
che cosa fa il modello in un caso simile?

Sfide degli SDM

A. Osservazioni di specie

Castoro americano (Castor canadensis)





iNaturalist

Casuale uniforme, fuori dal «dominio della specie»

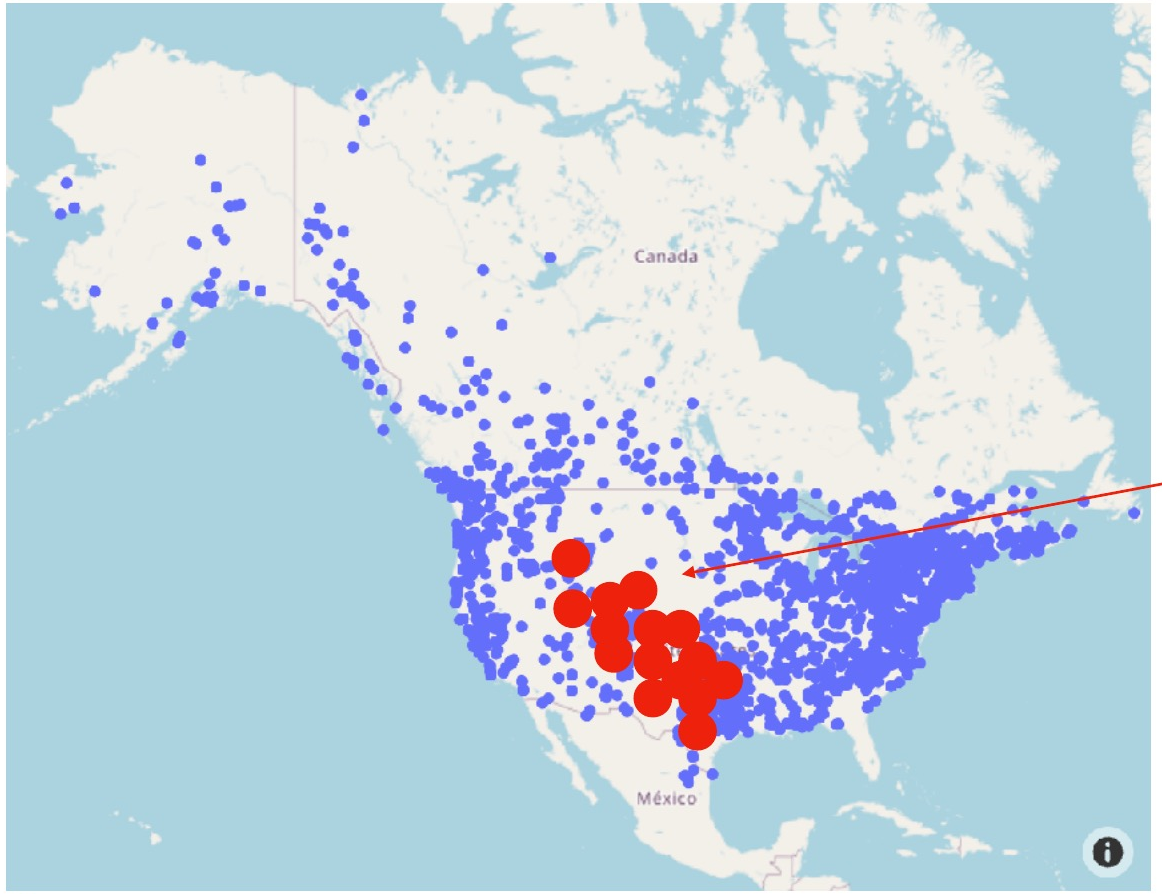
quanto lontano è «abbastanza lontano»?

Sfide degli SDM

A. Osservazioni di specie

Castoro americano (Castor canadensis)





iNaturalist

Sfondo del gruppo target

→ assenze = presenze di altre specie

Corregge il bias di campionamento! Ma se gli areali delle specie non si sovrappongono?

Sfide degli SDM

B. Descrittori ambientali



Enhanced Vegetation Index (EVI) annuale

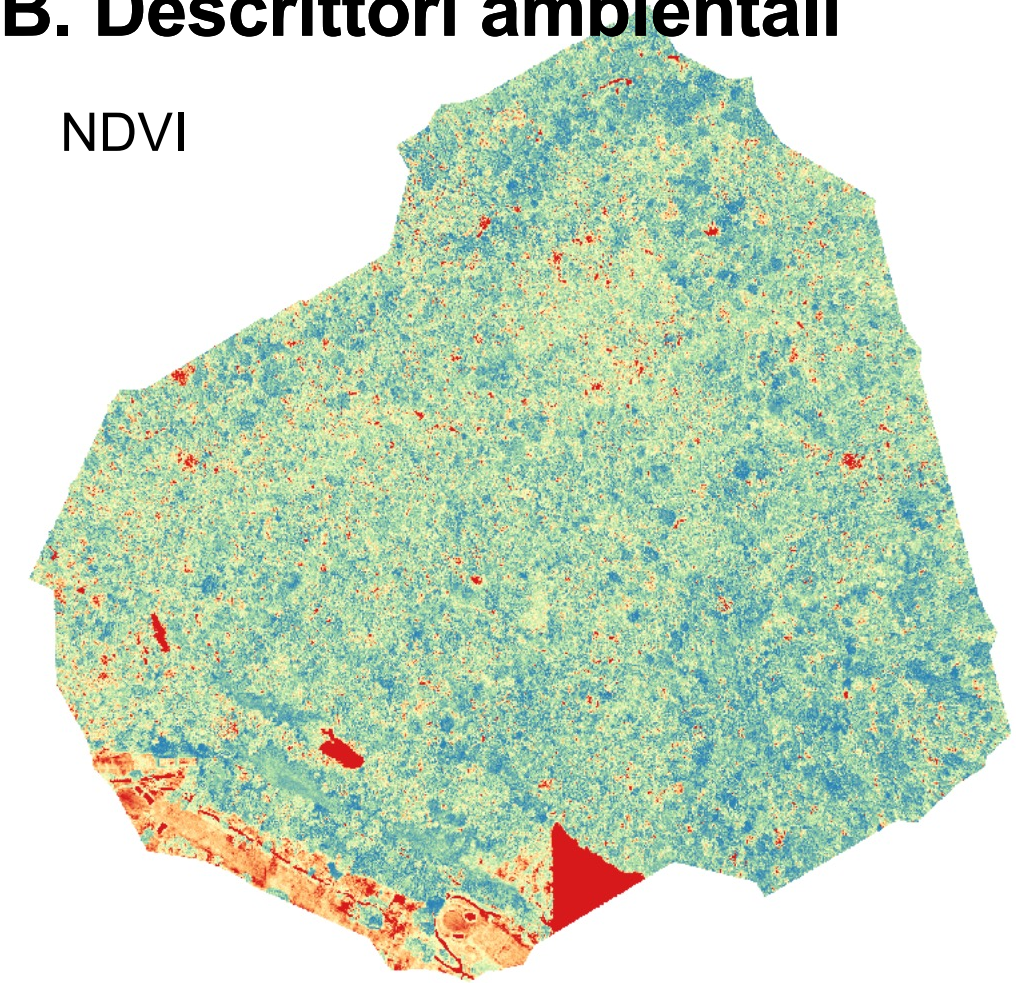
indice di umidità topografica

«precipitazioni medie mensili del trimestre più piovoso, 1984-2016»

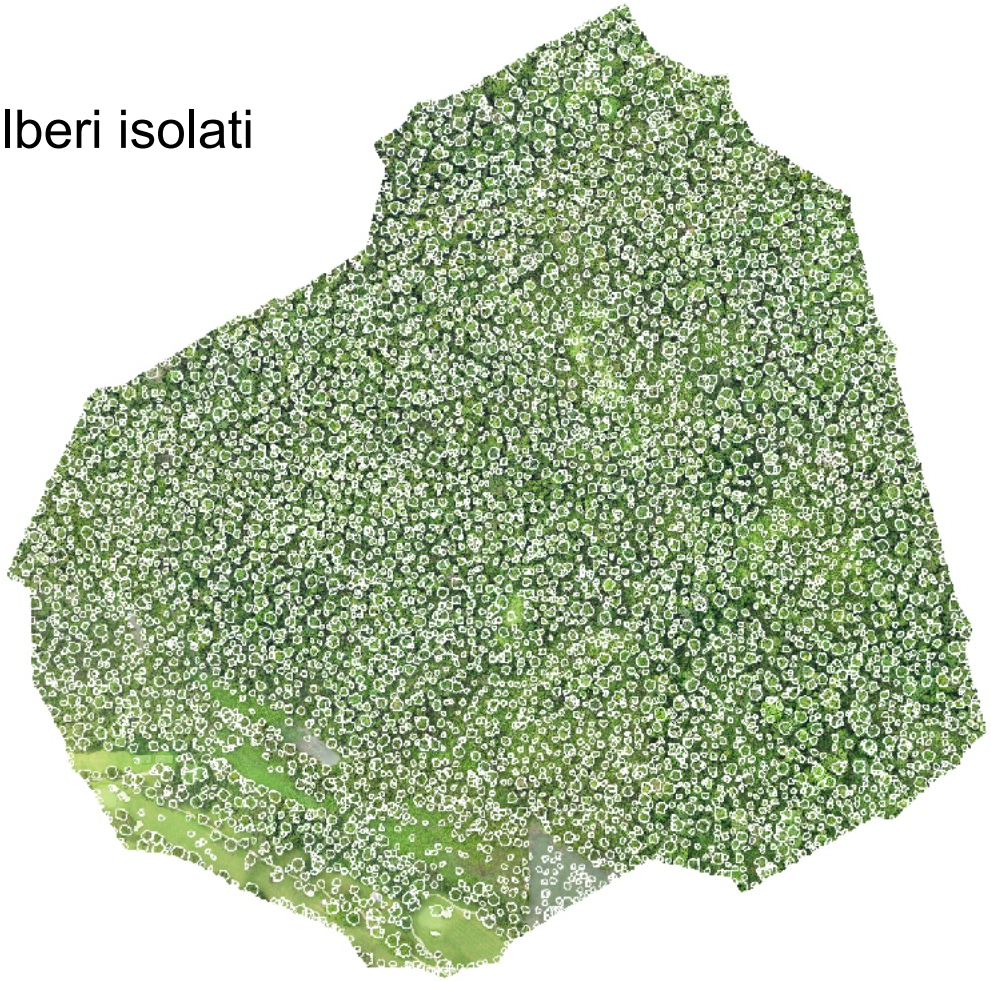
Sfide degli SDM

B. Descrittori ambientali

NDVI



alberi isolati



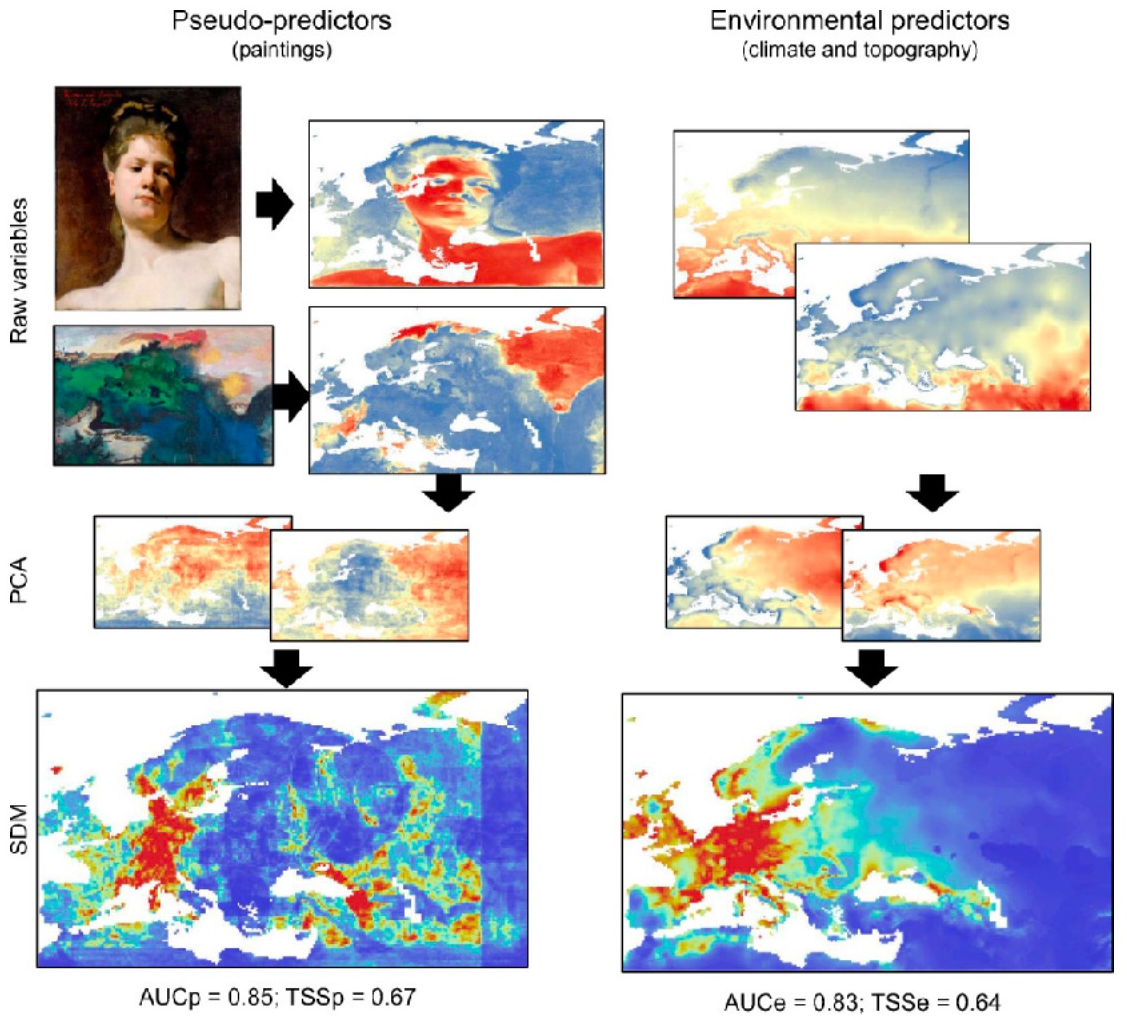
Stiamo mappando l'habitat o la specie stessa?

cfr. Bradley et al., 2012

Sfide degli SDM

B. Descrittori ambientali

Attenzione alle correlazioni spurie!

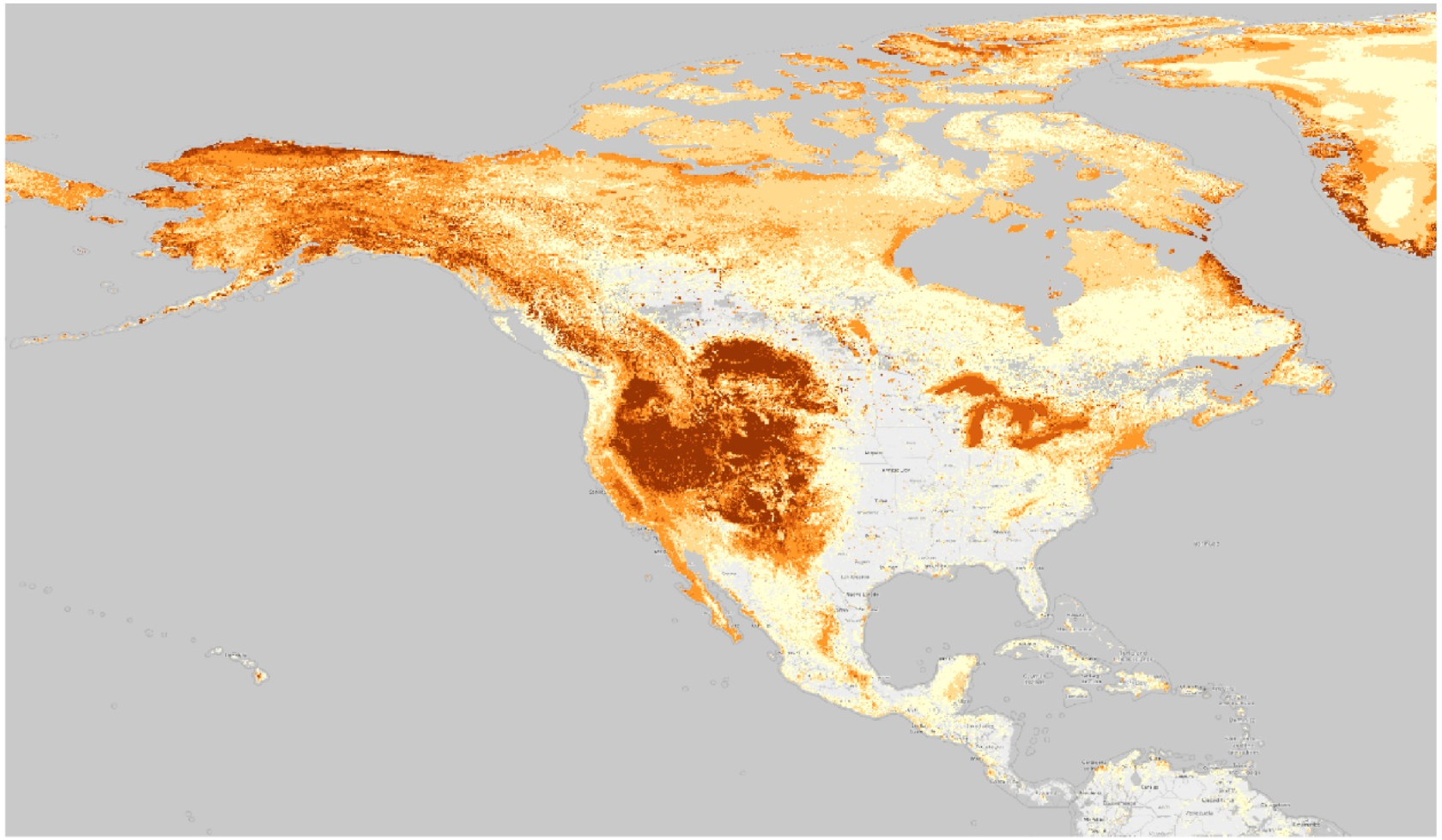


Fourcade et al., 2018

Sfide degli SDM

C. Output del modello

È una buona mappa di previsione?

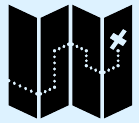


Gli SDM e oltre

Multimodalità

ambiente abiotico


dati satellitari


prodotti cartografici


posizione


clima

ambiente biotico


conoscenze testuali


tratti delle specie


interazioni tra specie


salute delle popolazioni

osservazioni di specie


rilievi

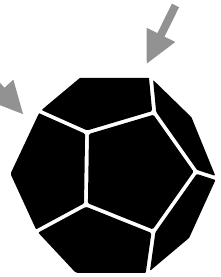

fototrappole


registratori sonori


censimenti aerei


eDNA


citizen science

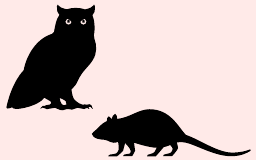

DeepSDM

output


distribuzione delle specie


salute delle popolazioni


dinamiche (ad es. invasioni)


comunità/ assemblaggi


salute degli ecosistemi

intermezzo:
IA multimodale



IA multimodale

Esempi

TaxaBind (Sastry et al., 2025)



Fototrappole, smartphone, citizen science

Telerileva mento

Conoscenze testuali

Registratori acustici

Telerileva mento

IA multimodale

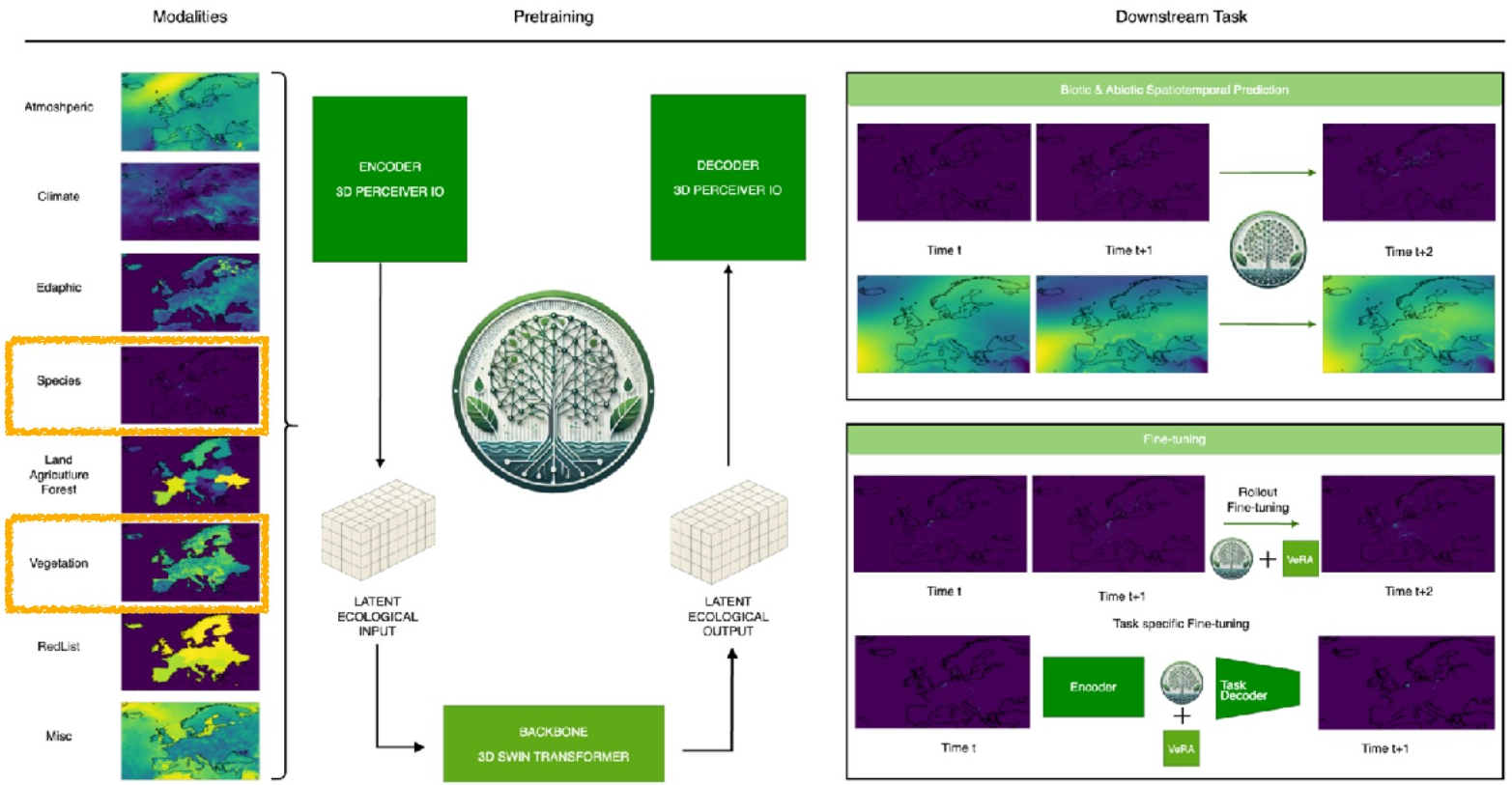
Esempi

BioAnalyst (Trantas et al., 2025)

In generale:

Da usare con cautela!

Vale anche, tra l'altro, per Google AlphaEarth…

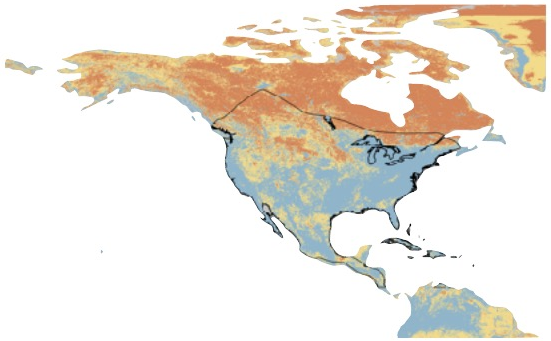


IA e biodiversità

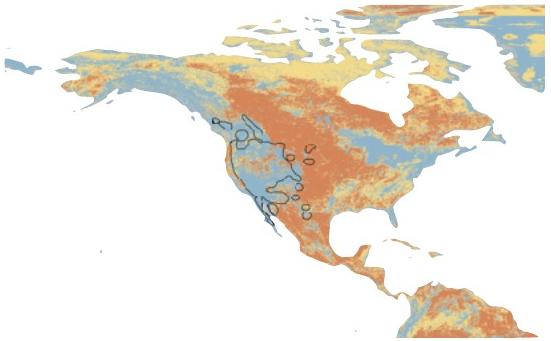
III. Dalle comunità agli ecosistemi

IA e biodiversità

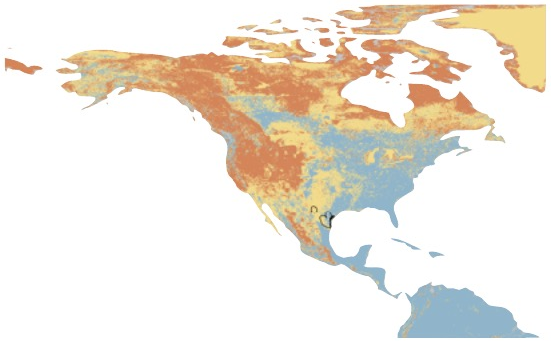
III. Dalle comunità agli ecosistemi



specie A



specie B



specie C

- Sappiamo rilevare le specie e mapparne la distribuzione
- Ma:
  - Quanto sono in salute, loro e il loro ambiente?
  - Dove si troveranno in futuro?

IA e biodiversità

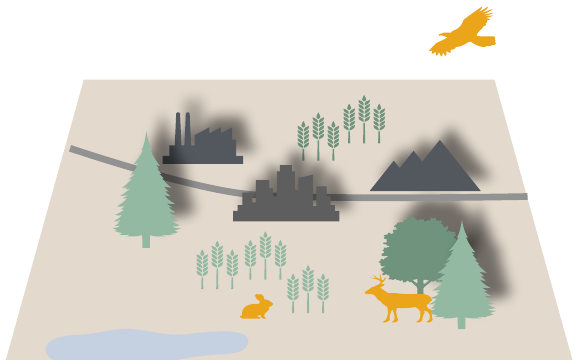
Dinamiche degli ecosistemi

individui: sensori + IA
distribuzione: SDM ambiente: telerilevamento

cambiamenti climatici: 1.
spostamento dell'areale: simulazioni

(ad es. SDM + ERA5)

specie invasive: modelli grafici





oggi



[2]

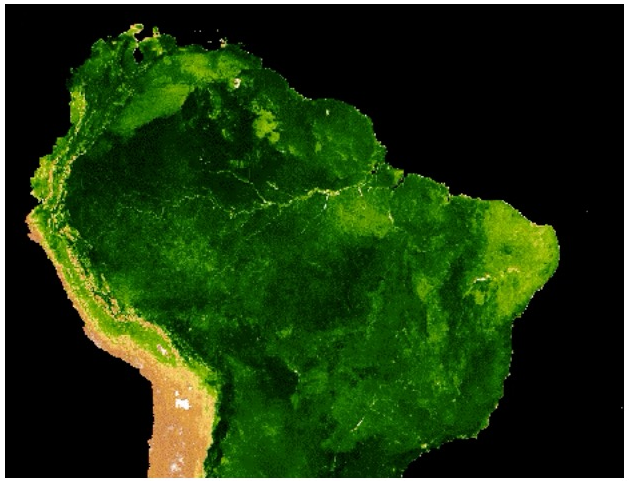
IA e biodiversità

Ambiente

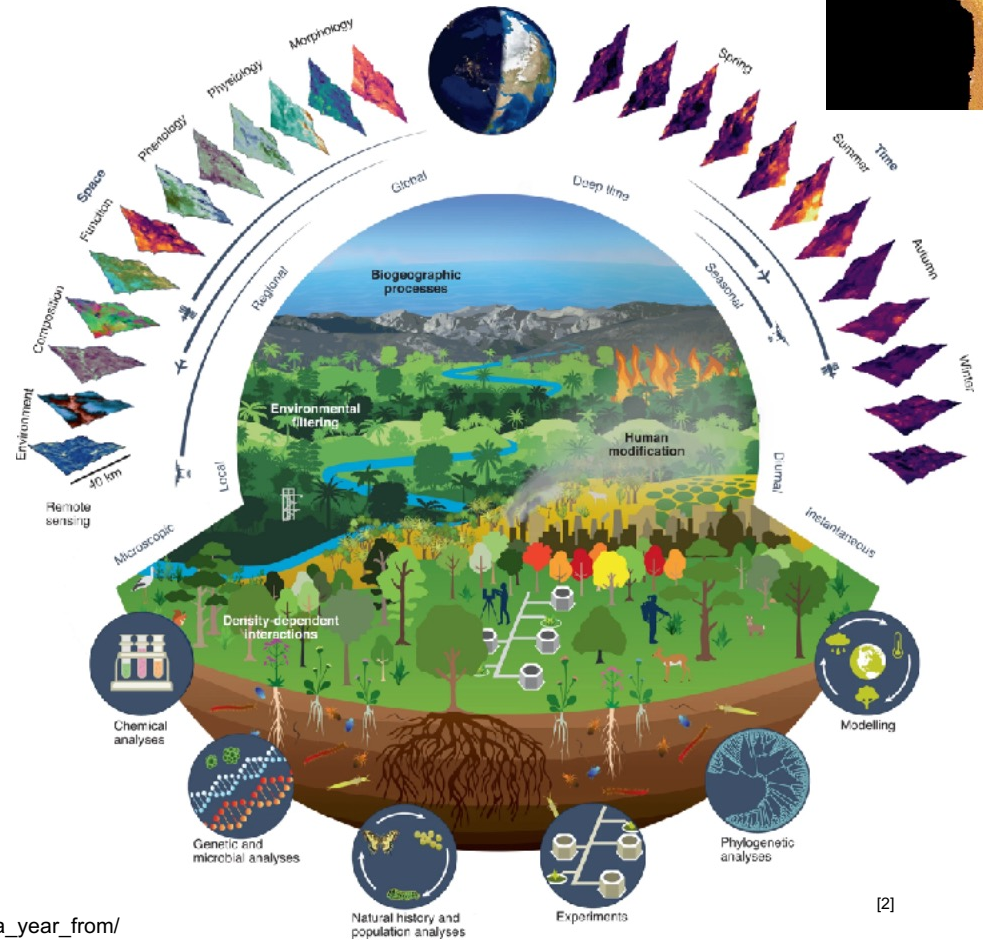
Esempi di prodotti da telerilevamento:

- Tratti funzionali delle piante
- Salute delle piante
- Cicli fenologici

NDVI 2021–2022



[1]

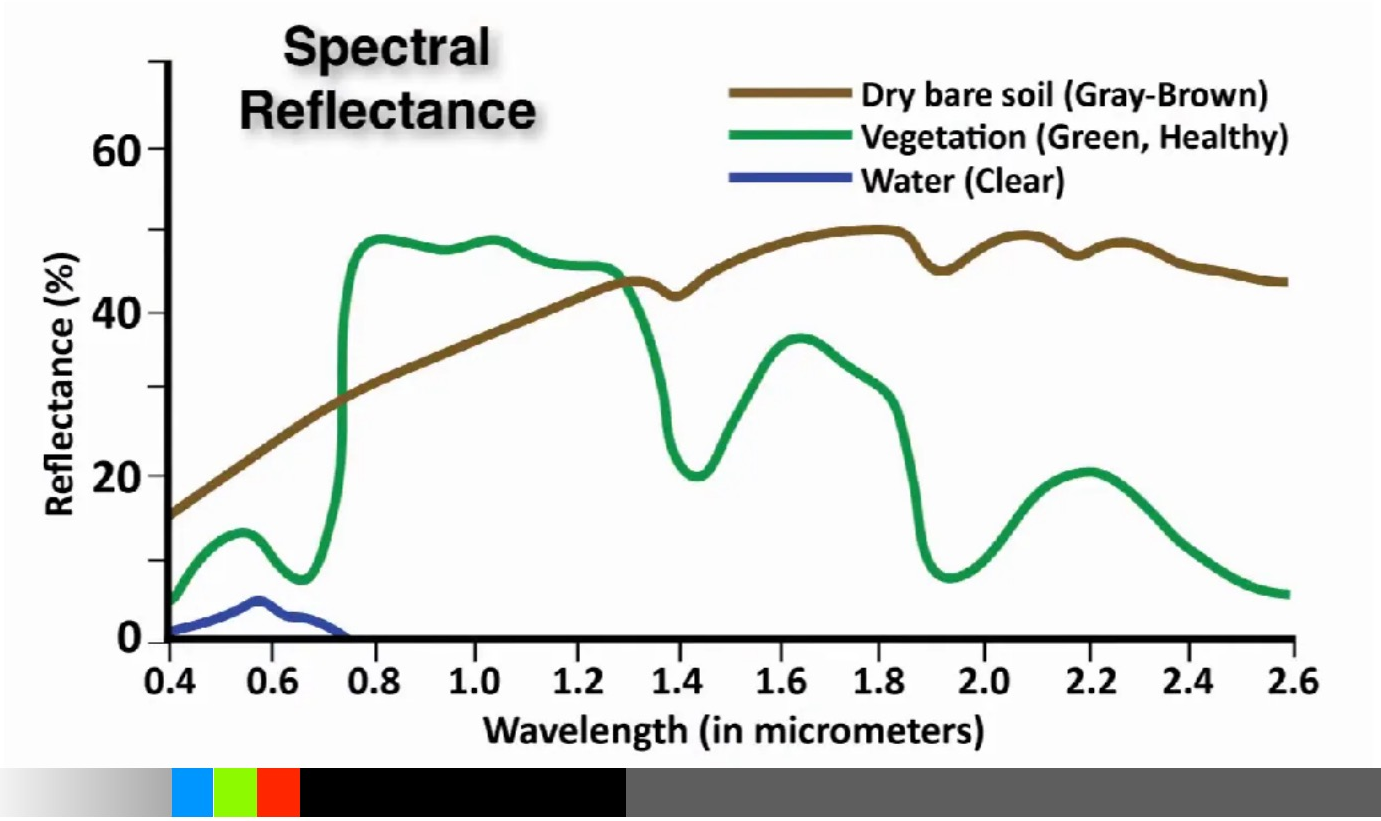


[2]

[1] https://www.reddit.com/r/dataisbeautiful/comments/s5ca95/amazon_vegetation_index_ndvi_over_a_year_from/
[2] Cavender-Bares et al., 2022

IA e biodiversità

Ambiente



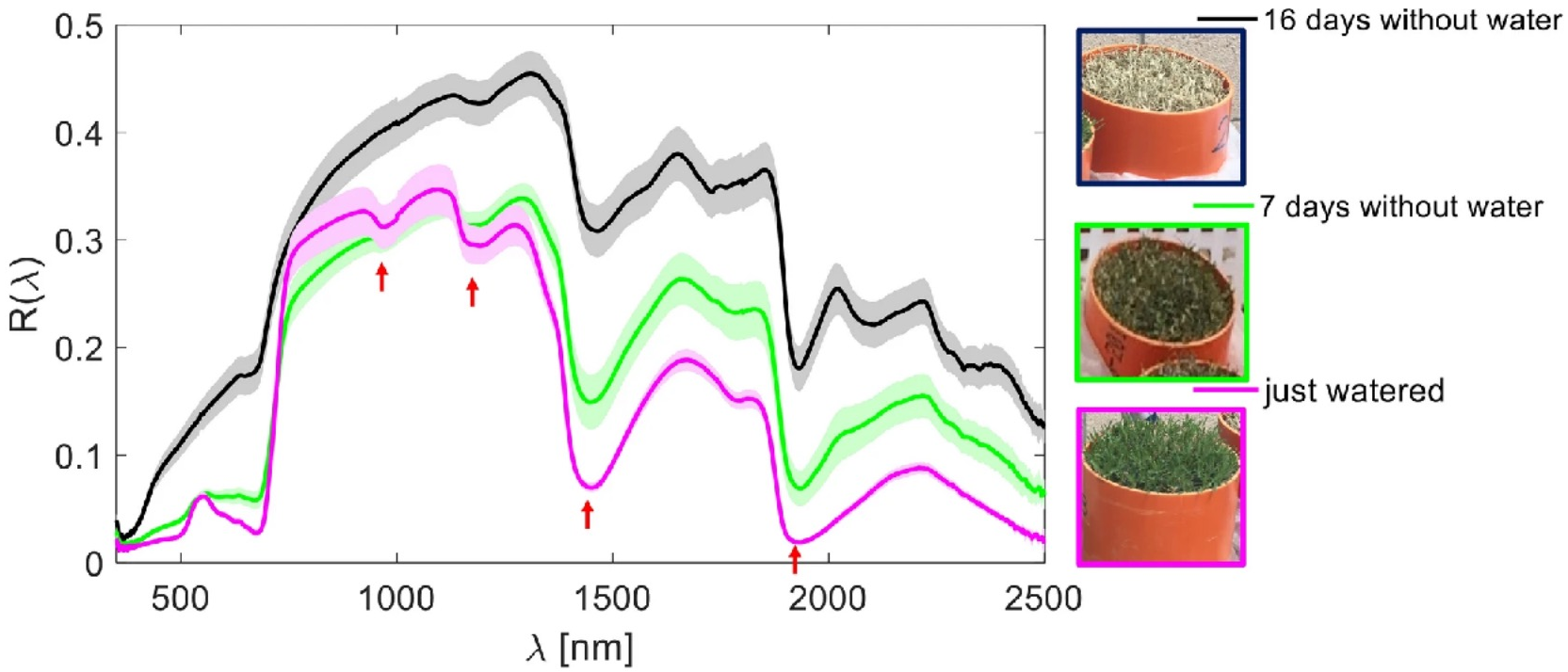
UV visibile vicino onde corte termico

infrarosso

Illustrazione: https://mapscaping.com/understanding-spectral-reflectance-in-remote-sensing/

IA e biodiversità

Ambiente





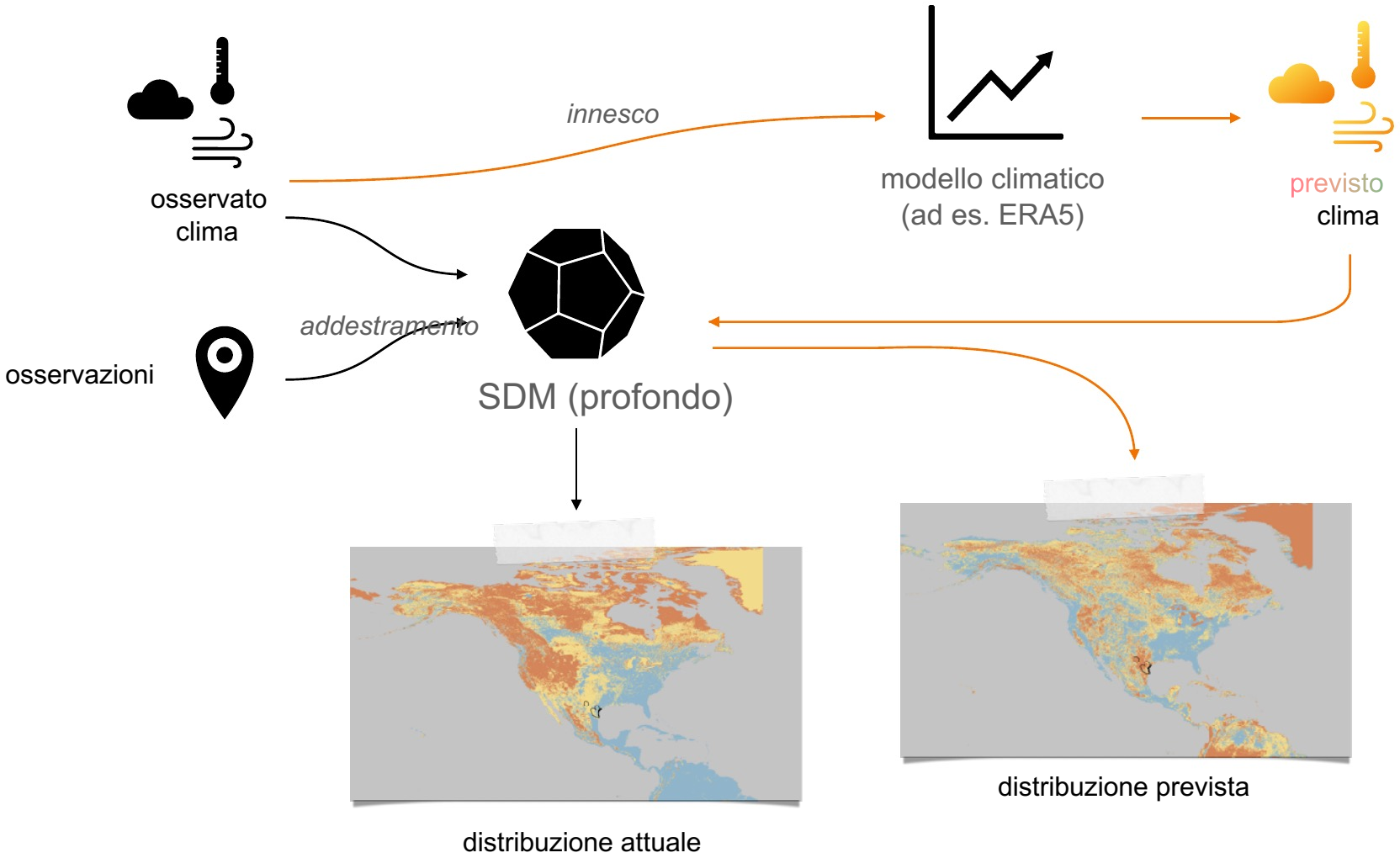
UV visibile vicino onde corte termico

infrarosso

Illustrazione: https://www.nature.com/articles/s41598-020-72006-6/figures/1

IA e biodiversità

Cambiamenti climatici



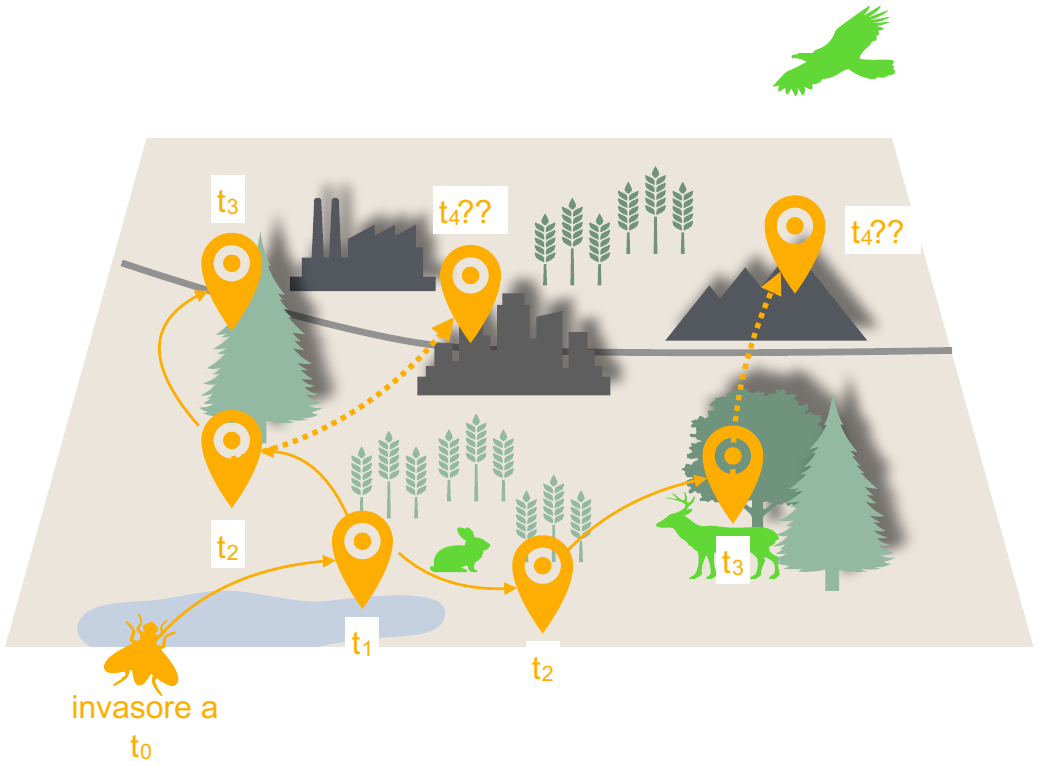
D: problemi

- qualità del modello climatico
- qualità dell'SDM
- fattori ignorati:
  - altri fattori abiotici
  - barriere alla dispersione
  - interazioni biotiche
  - reti di retroazione
  - influenza umana
- etc.

Sono tutte questioni irrisolte!

IA e biodiversità

Invasioni biologiche



Sfida chiave: le invasioni sono un processo dinamico

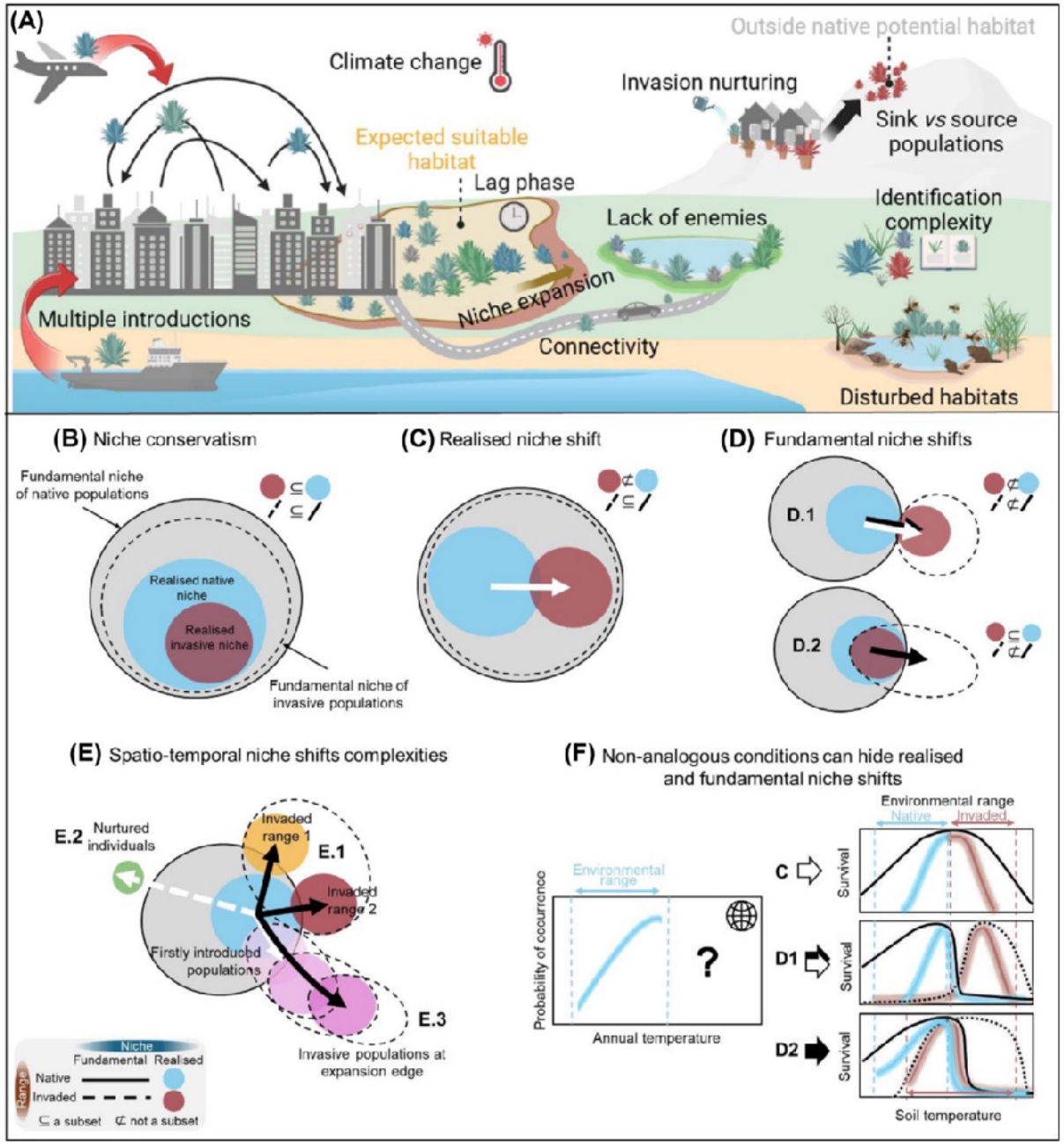
dynamic

1. L'invasore arriva in un luogo preciso (ad es. un porto) 2. La specie inizia a diffondersi
    2.1. Senza controllo 2.2. Con limiti: ad es. barriere alla dispersione
3. L'ecosistema locale ne risente 4. Le specie locali iniziano a reagire

Come modellarlo?

IA e biodiversità

Invasioni biologiche



Fenollosa et al., 2026

IA e biodiversità

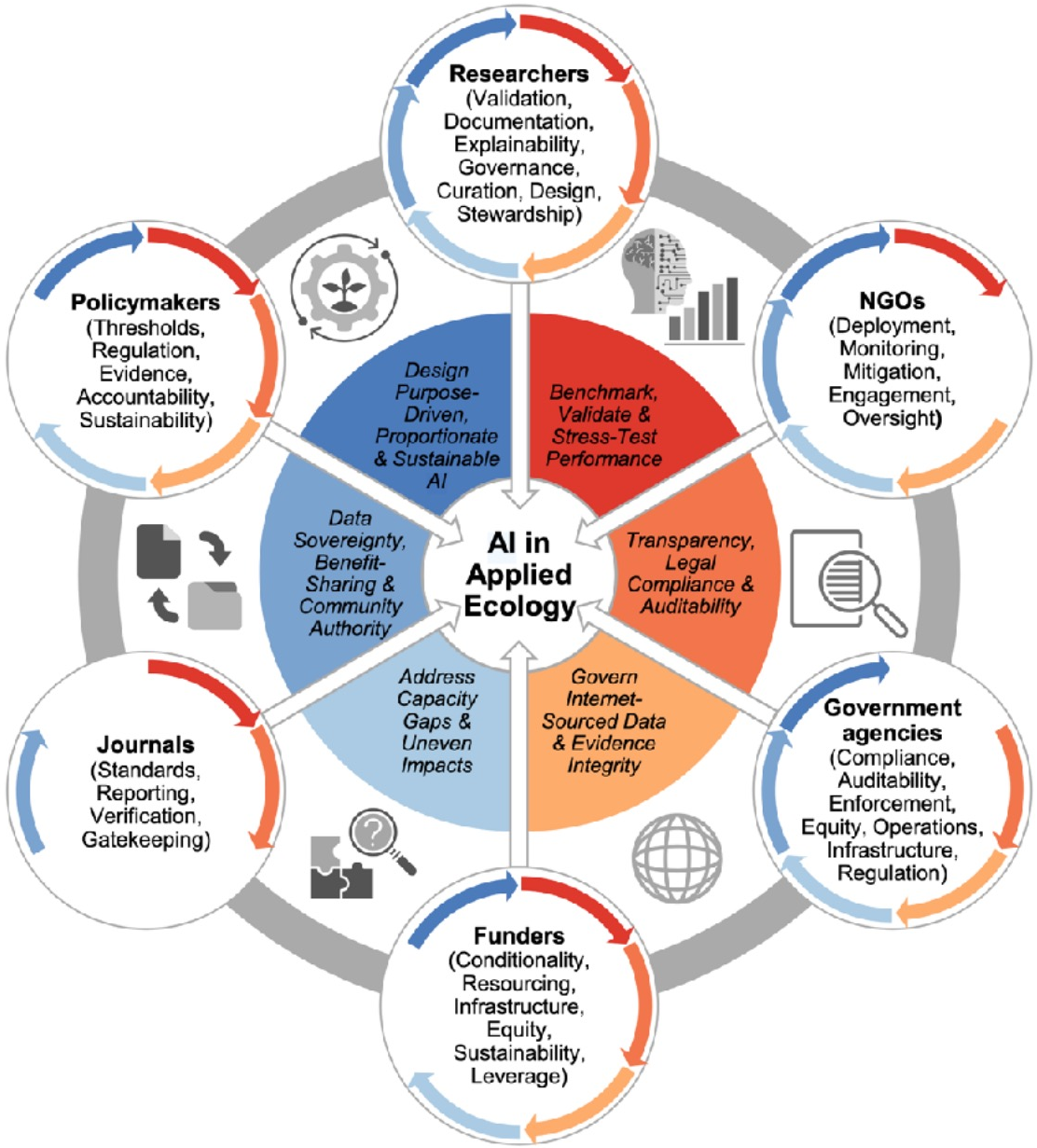
IV. L’IA per le politiche ambientali

IA e politiche

Fase 1: ricerca in uso

Preoccupazioni chiave, nuove o accentuate:

- Effetti dei bias
- Stabilità (pipeline, ecc.); TRL:
  livello di maturità tecnologica
- FAIR: reperibili, accessibili, interoperabili, riutilizzabili
- CARE: beneficio collettivo, autorità di controllo, responsabilità, etica
- Standard (acquisizione, valutazione, ecc.)
- Riproducibilità
- Privacy; proprietà/custodia
- Conflitti tra portatori di interesse
- Legalità
- Facilità d'uso
- etc.



Ammar et al., 2026

Sfide per la biodiversità

Fase 2: quali aspetti delle politiche possiamo modellare?



Habitat:
- Copertura (e uso) del suolo
- Salute

Specie:
- Distribuzione delle specie
- Comunità (+ interazioni)

Migrazioni:
- Cambiamenti climatici
- Invasioni

Altro:
- Antropici (bracconaggio, etc.)

IA per il supporto decisionale:
- Indicatori e indici:
  - Species Habitat Index
  - Living Planet Index
  - etc.
- Proattiva:
  - Prioritizzazione della conservazione
  - Sistemi di raccomandazione

IA e politiche

Indicatori e indici

Idea: condensare lo stato della biodiversità in un unico numero

Parte essenziale delle politiche di conservazione. Esempio: COP-15:

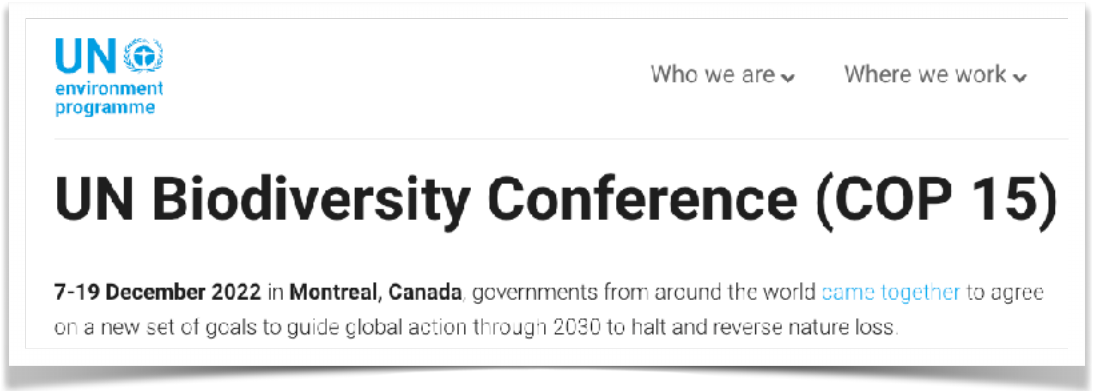


Table 2.

Proposed indicators for the Kunming-Montreal global biodiversity framework

Draft Goal/ Target	Headline indicator	Component indicator	Complementary indicator
A	A.1 Red List of Ecosystems A.2 Extent of natural ecosystems A.3 Red List Index A.5 The proportion of populations within species with an effective population size > 500	Ecosystem Intactness Index Ecosystem Integrity Index Species habitat Index Biodiversity Habitat Index Protected Connected (Protconn) index Parc connectedness EDGE Living Planet Index Change in the extent of water-related ecosystems over time	Forest area as a proportion of total land area Forest distribution Tree cover loss Grassland and savannah extent Mountain Green Cover Index Peatland extent and condition Permafrost thickness, depth and extent Continuous Global Mangrove Forest Cover Trends in mangrove forest fragmentation Trends in mangrove extent Live coral cover
B[b]	B.1 Services provided by ecosystems*	Red List Index (for utilized species) Living Planet Index (for used species)	Levels of poverty in biodiversity depended communities Ecological Footprint
3	3.1 Coverage of protected areas and OECMs	Protected area coverage of key biodiversity areas Protected Area Management Effectiveness (PAME) ProtConn	Protected area downgrading, downsizing and degazettement (PD) Status of key biodiversity areas IUCN Green List of Protected and Conserved Areas
Draft Goal/ Target	Hea		
		Protected Area Connectedness Index (PARC-Connectedness) Red List of Ecosystems Connectivity Indicator (in development) The number of protected areas that have completed a site-level assessment of governance and equity (SAGE) Species Protection Index	Number of hectares of UNESCO designated sites (natural and mixed World Heritage sites and Biosphere Reserves) Protected area and OECM management effectiveness (MEPCA) indicator Protected Area Isolation Index (PAI) Protected Areas Network metric (ProNet) Extent to which protected areas and other effective area-based conservation measures (OECMs) cover Key Biodiversity Areas that are important for migratory species Coverage of Protected areas and OECMS and traditional territories (by governance type)

https://www.cbd.int/doc/c/179e/aecb/592f67904bf07dca7d0971da/cop-15-l-26-en.pdf

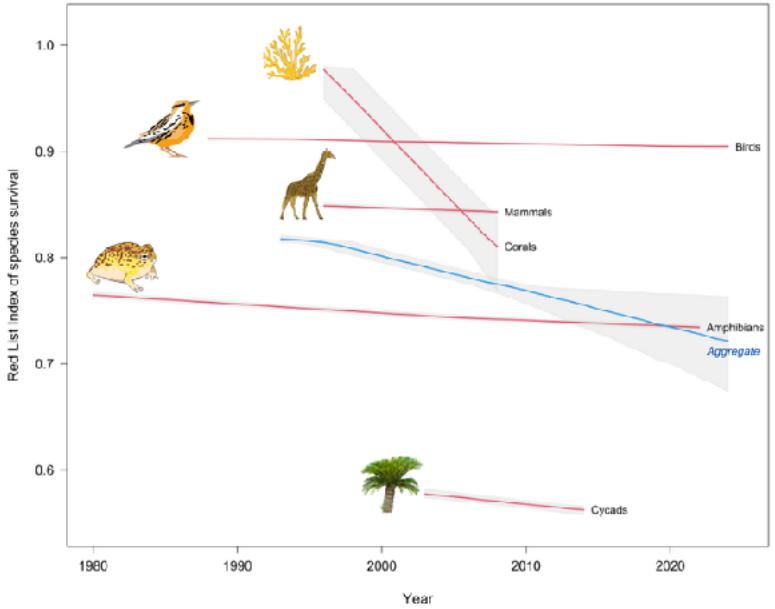
IA e politiche

Indicatori e indici

Esempi:

- Indice della Lista Rossa IUCN
- Species Habitat Index
- Species Protection Index
- Indice del Pianeta Vivente

➡️Compromesso tra espressività e semplicità…



https://www.iucnredlist.org/assessment/red-list-index

Species level	2+ years of data
Known location	Standardised method

Data we can use

Vertebrate species:

- Full population counts
- Estimates (e.g. population size estimated from measured parameters)
- Densities (including converted camera trap data)
- Indices
- Proxies (e.g. breeding pairs, nests, tracks)
- Measures per unit effort (e.g. fish caught per net per hour)
- Biomass (e.g. spawning stock biomass)
- Samples (e.g. where a proportion of the population is regularly monitored)

Data we may use in future

- Occupancy data

Data we can't use

- Data from experimental observations
- Survival rates
- Recruitment data e.g. number of eggs or young
- Catch or hunting data with no measure of effort
- Data where method has changed (unless corrected for)
- Opportunistic sighting data

We can keep data confidential!

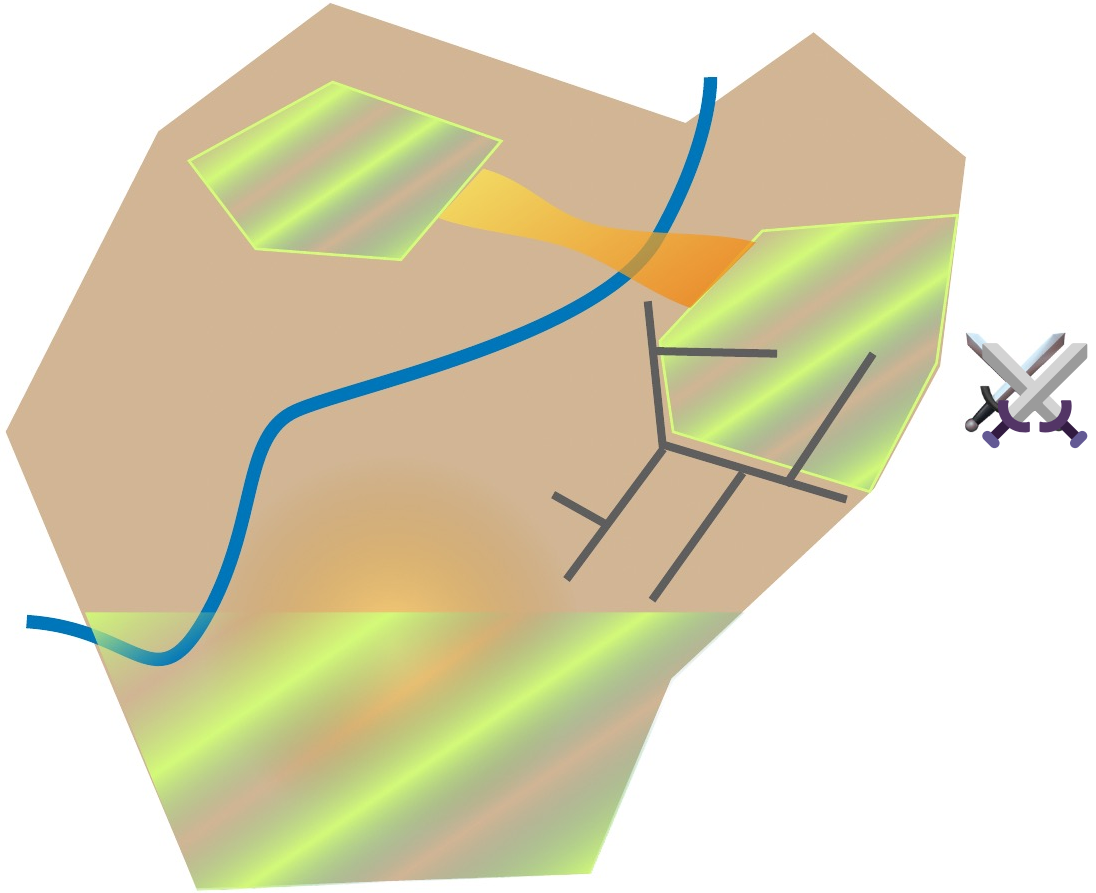
Sensitive/unpublished data are not publicly available, but used to estimate trends

https://www.livingplanetindex.org/about_index

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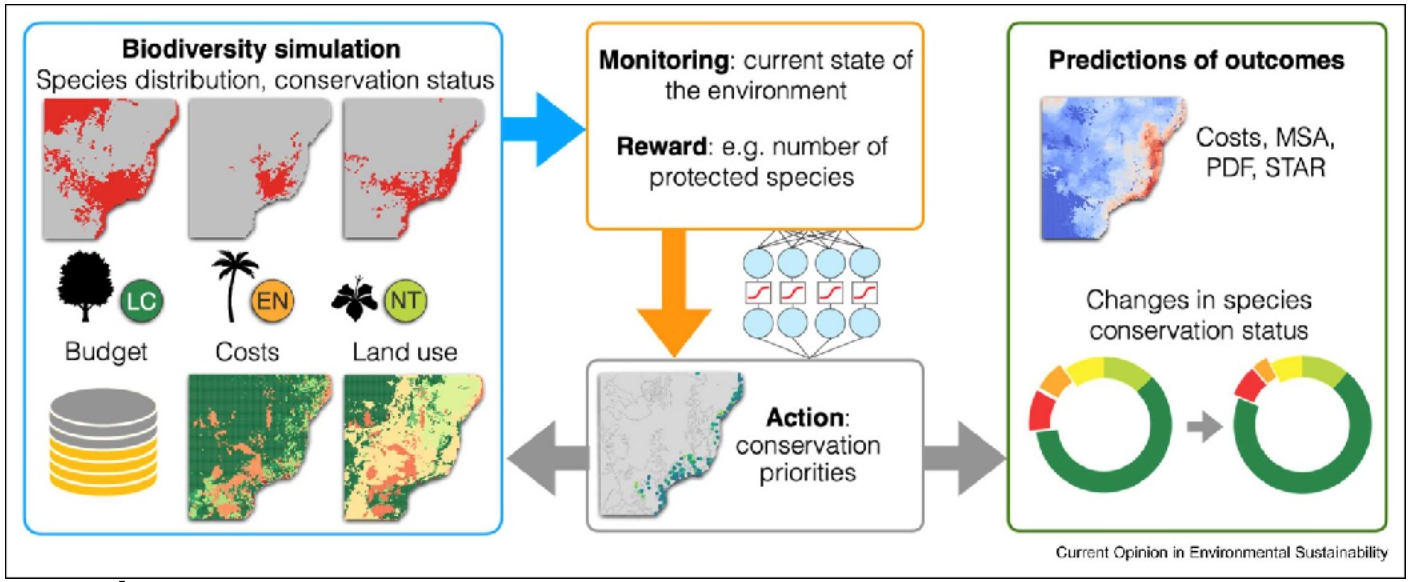
Prioritizzazione delle aree

1. Superficie da tutelare: ad es. 30%
    a. 30% di che cosa?
    b. Perché 30%?
2. Quali aree?
    a. Parchi nazionali
        ➡️È ecologicamente sostenibile?
    b. Hotspot di biodiversità
        ➡️Misurati come? Con indici (vedi slide precedenti)?
        ➡️E i corridoi ecologici, per esempio?
        ➡️Influenza umana (abitazioni, recinzioni, ecc.)?
        ➡️Geopolitica?
        ➡️Comunità locali e indigene?



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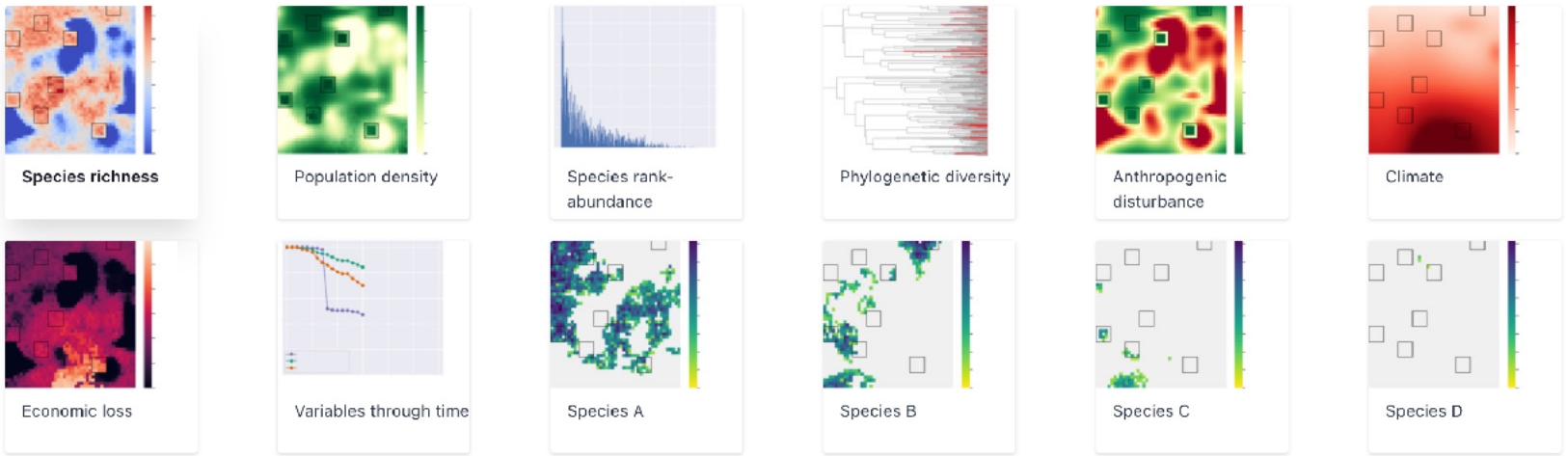
Prioritizzazione delle aree



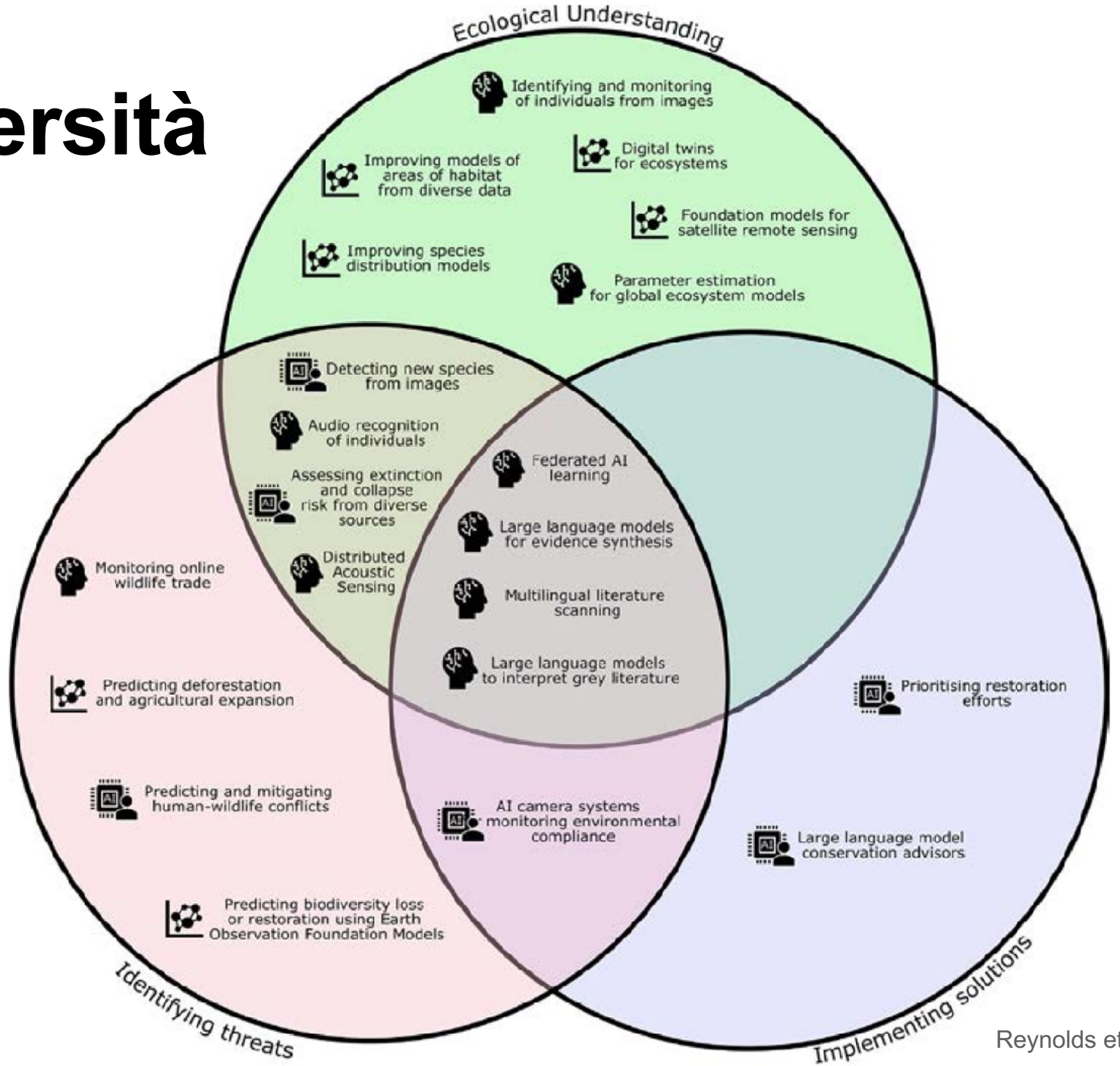
CAPTAIN:

Conservation Area Prioritization Through Artificial INtelligence

https://www.captain-project.net/



IA e biodiversità



Reynolds et al., 2025

Domande?



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V. Risorse utili per voi!

IA e biodiversità

V. Risorse utili: comunità

Canale Slack AI for Conservation

aiforconservation@gmail.com

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V. Risorse utili: comunità

Esempi di workshop nelle conferenze di machine learning e computer vision:

Tema	Conferenza	Workshop
Biodiversità ed ecologia	ECCV / ICCV	Computer Vision for Ecology (CV4E) https://cv4e-workshop.github.io/
	ICPR	Computer Vision for Biodiversity Monitoring and Conservation https://cvbmc.github.io/2026/
	ECCV / ICCV	Marine Vision https://vap.aau.dk/marinevision/
Clima	ECCV / ICCV	AI for Climate and Conservation https://sites.google.com/g.harvard.edu/aicc2eccv26/
	NeurIPS	Tackling Climate Change with Machine Learning https://www.climatechange.ai/events/neurips2026
Osservazione della Terra / telerilevamento	CVPR	EarthVision https://www.grss-ieee.org/events/earthvision-2026/
	ECML-PKDD	MACLEAN https://sites.google.com/view/maclean26
	BMVC	MVEO https://mveo.github.io/

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V. Risorse utili: formazione

Volete saperne di più?

- Scuola estiva CV4Ecology (2 sett.)
  https://cv4ecology.csail.mit.edu
- Corso IA ed ecologia di Imageomics
  https://imageomics.osu.edu/news/2024/06/imageomics-institute-launches-new-ai-ecology-course

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V. Risorse utili: fototrappole

- Dataset pubblici:
  - https://lila.science/ (globale)
  - https://agouti.eu/ (Europa)
- Modelli:
  - Rilevamento:
    - Megadetector: https://github.com/agentmorris/MegaDetector lo standard (e il più potente) rilevatore di animali
- Classificazione delle specie (consiglio: usare insieme a MegaDetector):
  - SpeciesNet: https://github.com/google/cameratrapai
  - BioCLIP (v2): https://imageomics.github.io/bioclip/ Modello fondazionale visione-linguaggio (utilizzabile per classificare le specie)
- Stima della posa:
  - DeepLabCut: https://github.com/DeepLabCut/DeepLabCut

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V. Risorse utili: registrazioni acustiche

- Dataset acustici pubblici:
  - Xeno-Canto: https://xeno-canto.org/
  - Macaulay: https://www.macaulaylibrary.org/
  - Raccolta qui: https://bioacoustic-ai.github.io/bioacoustics-datasets/

- Modelli:
  - BirdNET: https://birdnet.cornell.edu/analyzer/
  - Perch: https://github.com/google-research/perch
  - BatDetect: https://github.com/macaodha/batdetect2

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V. Risorse utili: modelli di deep learning

Tipo o compito	Repository
Transformers	https://github.com/huggingface/transformers
Modelli generali di computer vision	https://github.com/huggingface/pytorch-image-models
Rilevamento di oggetti generale	Ultralytics/YOLO, Grounding DINO*
Segmentazione delle istanze generale	Segment Anything* (v2*, v3*)
Rilevamento di animali (fototrappole)	https://github.com/microsoft/CameraTraps
Classificazione delle specie (fototrappole)	https://github.com/google/cameratrapai
Rilevamento aereo di oggetti	OWL*, HerdNet, POLO, BirdDetector (fauna); DeepForest (alberi)
Modelli fondazionali di telerilevamento	vari modelli qui*____
PyTorch per dati geospaziali	https://github.com/microsoft/torchgeo
Modelli fondazionali per l'ecologia	BioCLIP*, BioCLIP-2*, TaxaBind*
Modelli di ecologia acustica	BirdNET, Perch (v2), BatDetect2

** (basato su) modello fondazionale*

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V. Risorse utili: dataset

Tipo o compito	**Repository**
Immagini (aeree, fototrappole, ecc.) annotate	https://lila.science/
Immagini di fauna da drone	https://github.com/agentmorris/drone-wildlife-datasets
Re-identificazione individuale	https://github.com/WildlifeDatasets/wildlife-datasets
Repository di telerilevamento satellitare	USGS EarthExplorer (http://earthexplorer.usgs.gov/): Landsat, etc. Copernicus (https://browser.dataspace.copernicus.eu/): Sentinel etc.
Immagini satellitari per il deep learning	https://github.com/satellite-image-deep-learning/datasets
(dataset ambientali vari)	https://github.com/rockita/Environmental_Intelligence

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V. Risorse utili: dataset

Tipo o compito	Repository
Osservazioni di specie	**GBIF (https://gbif.org/): the ecological resource** **iNaturalist (https://inaturalist.org/): largest citizen science species obs. DB** **eBird (http://ebird.org/): the ecological resource for birds** **Pl@ntNet (https://plantnet.org/): huge plant database & ID initiative from France** **etc.**
Tratti delle specie	TRY (https://www.try-db.org/): for plants OpenTraits (https://opentraits.org/datasets.html): collection
Interazioni tra specie	GloBI (https://www.globalbioticinteractions.org/)
Movimento animale	MoveBank (https://www.movebank.org/)

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L’IA per la biodiversità e gli ecosistemi

Scuola estiva Climate Change AI
Settimana 5 · Settoriale IV

Benjamin Kellenberger | 2026-08-17

