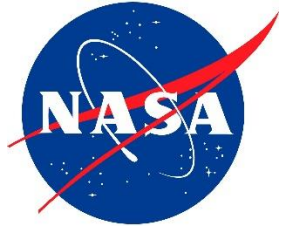# From Eyes in the Sky to Boots on the Ground
Applying NASA Earth Observations to Protect Critical Forests in Mesoamerica through the IUCN STAR Program

Nicholas Macfarlane, Ph.D.

Head of Conservation Science and Technology, IUCN

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AGENDA

1. **THE PLACE:** MESOAMERICAN CRITICAL FORESTS
2. **THE METRIC:** SPECIES THREAT ABATEMENT AND RESTORATION (STAR) METRIC
3. **THE PROBLEM:** CALIBRATING THE STAR METRIC
4. **THE SOLUTION:** BETTER FASTER CHEAPER AND MORE EFFECTIVE USING NASA EOs

Mesoamerican critical forest biomes

Protected Areas and STAR scores
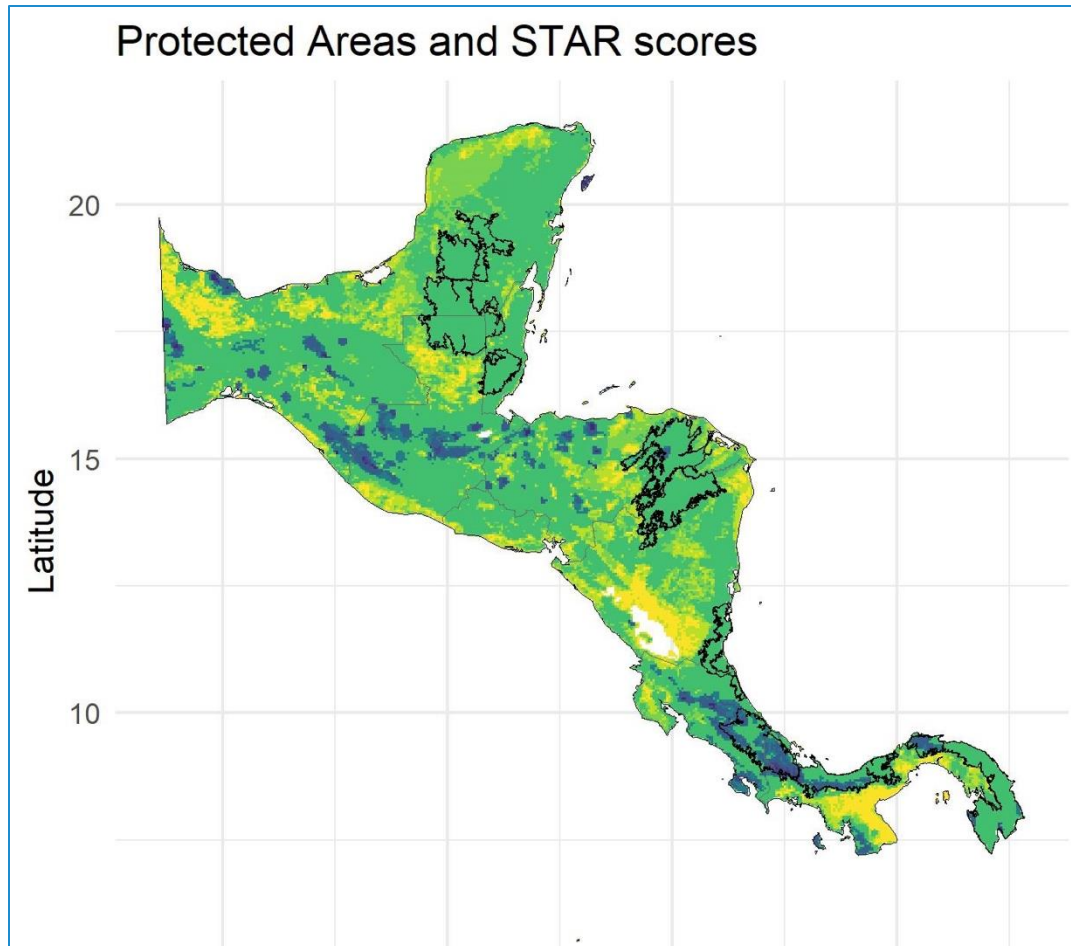
- The project will streamline and scale the management of IUCN's portfolio of protected areas in the Mesoamerican Forest using NASA Earth Observations.

- **How can we deploy Earth Observations to measure threats to species and scale calibration of STAR for better management of PAs?**
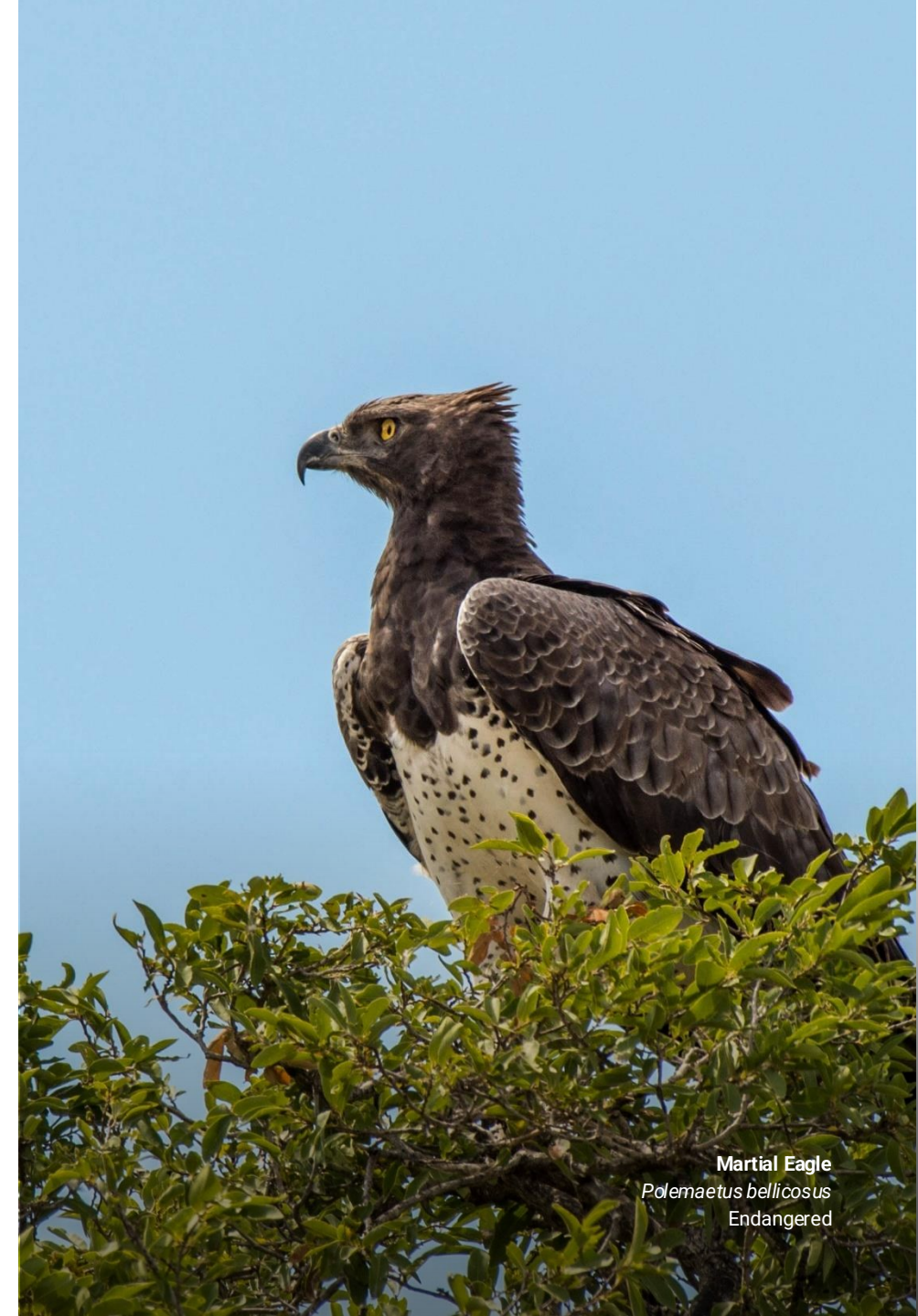
What is the STAR metric?

The Biodiversity Crisis

- About half global GDP (44 trillion USD) is dependent on healthy biodiversity

- Nature loss is an **enormous** business risk

- A key reason for the loss of biodiversity is that the economic sectors responsible for the loss of biodiversity currently have no way to measure the risk that biodiversity loss poses to them, nor to assess their contributions to stemming biodiversity loss

- In order for economic actors to contribute the Global Biodiversity Framework, they need a way to assess the impacts of their actions

- **If you can't measure it, it will disappear.**

Martial Eagle
Polemaetus bellicosus
Endangered

What is the STAR metric?

How much global conservation gain can I achieve through action X in place Y?

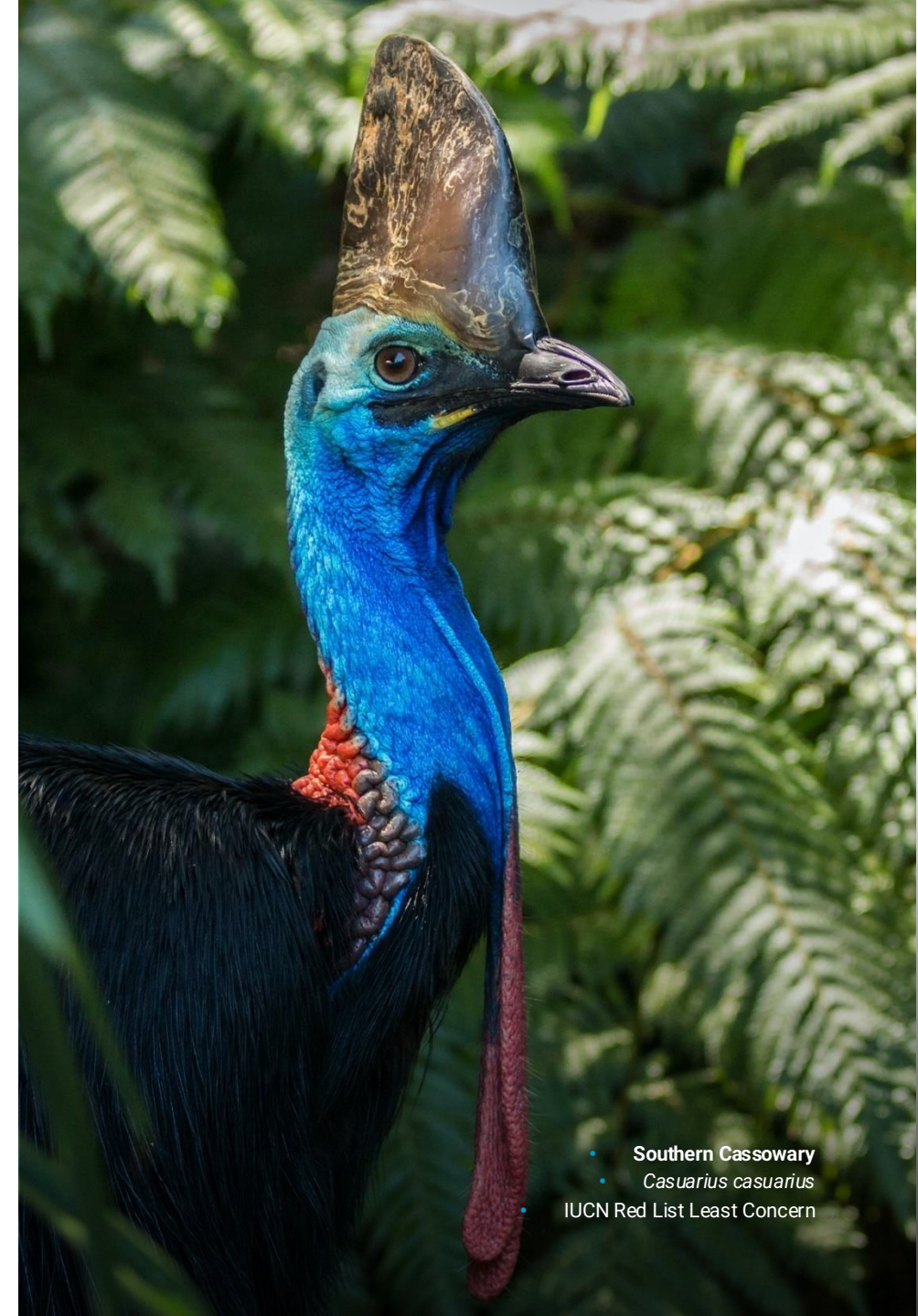STAR is based on The IUCN Red List of Threatened Species.

Two global data layers:

1. **Threat abatement (STAR$_T$)** – actions to address threats.

2. **Restoration (STAR$_R$)** – actions to restore species habitat.
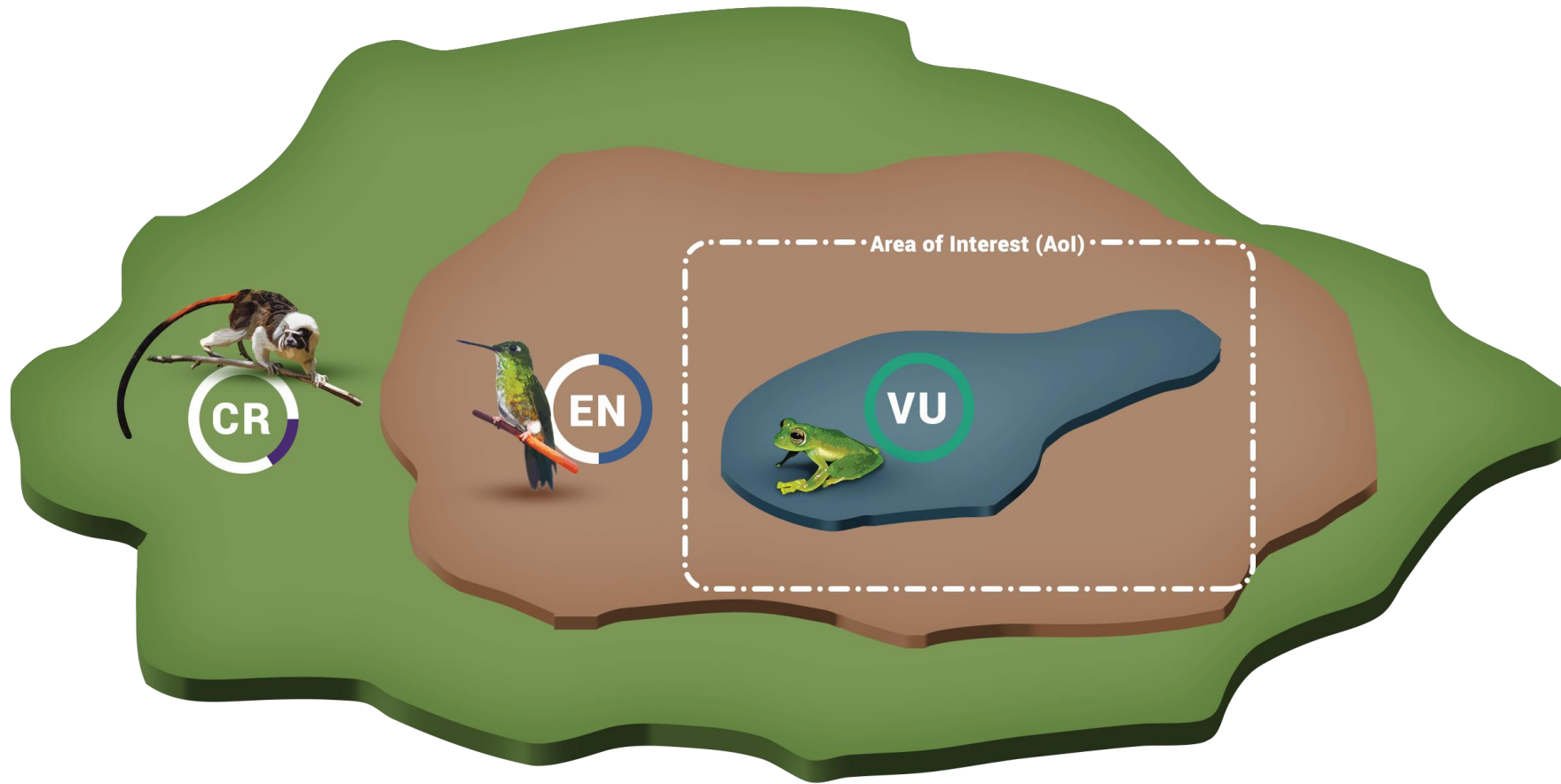
STAR is completely scalable.
It enables quantitative comparison between sites.

Mair et al., (2021) Nature Ecol. Evol

- **Southern Cassowary**
- *Casuarius casuarius*
- IUCN Red List Least Concern

STAR scores are based on the number of threatened species and proportion of their ranges within a protected area

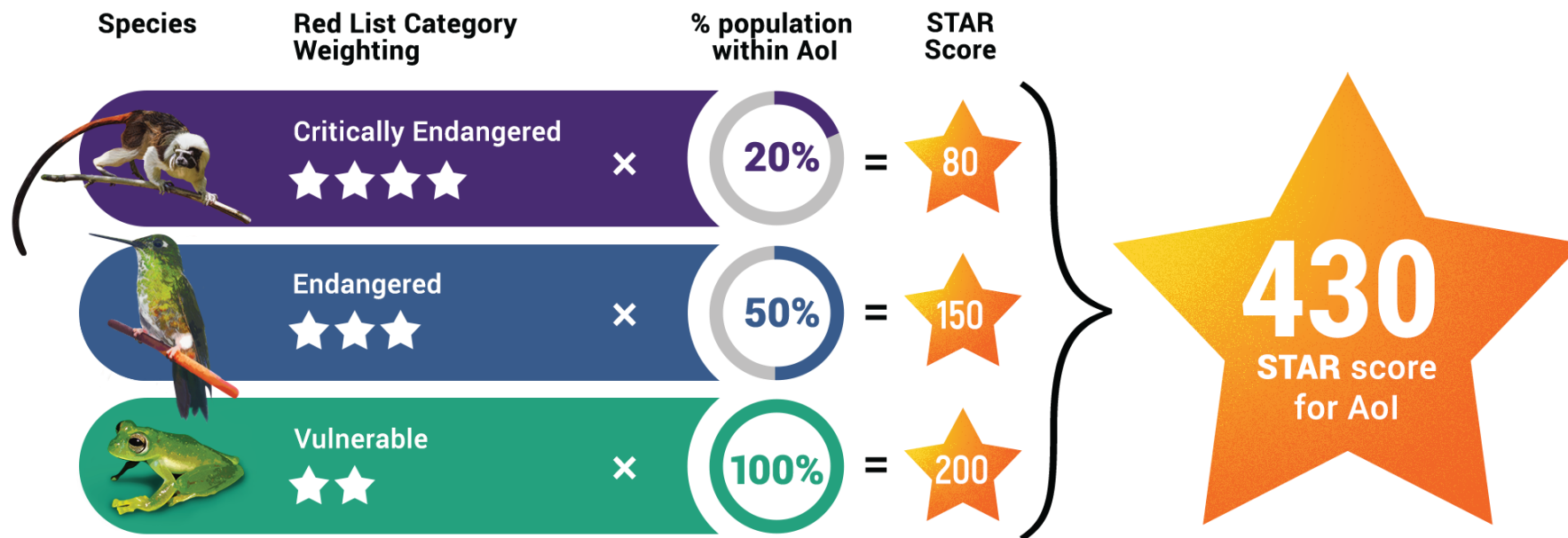**Area of Interest (AoI)**

CR

EN

VU

STAR scores are derived based on threatened species' current and restorable Area of Habitat (AoH).

The number of threatened species and the proportion of AoH for each at a site determines the score.

Scores are currently calculated for threatened species of amphibians, birds, mammals, and marine species.

Weighted species values are combined to produce STAR scores for one or more areas of interest

Species	Red List Category Weighting		% population within AoI	STAR Score
	Critically Endangered ★★★★	×	20%	80
	Endangered ★★★	×	50%	150
	Vulnerable ★★	×	100%	200

430 STAR score for AoI

- The total of START values across all included species represents the global threat abatement effort needed for all these species to become Least Concern.

- STAR scores for a given site - area of interest (AoI) show the potential contribution to reducing global species extinction risk.

STAR scores can also be further broken down by threat type

Species	IUCN Red List category	IUCN Red List category weight	Population in AoI (%)	Invasive species	Energy & mining	Biol Res Use	Agriculture	Climate change	Pollution	Potential STAR$_T$
1	EN	3 ★★★	5%	0	0	2	9	4	0	15
2	VU	2 ★★	10%	8	9	0	0	3	0	20
3	CR	4 ★★★★	2%	0	0	4	3	0	1	8
4	NT	1 ★	7%	0	0	3	4	0	0	7
		Total Potential STAR$_T$ (% of total STAR score for AoI)		8 (16%)	9 (18%)	9 (18%)	16 (32%)	7 (14%)	1 (2%)	50 STAR score for AoI

Calibrated STAR

ARE THE SPECIES AND THREATS ESTIMATED TO BE AT A SITE ACTUALLY THERE?

STAR typology	Description	Uses	Effort required
Potential STAR (estimated)	STAR score derived using the global STAR layers	Screening and initial planning	Low – desk-based exercise
Potential STAR (calibrated)	Ground-truthed, validated, version of Potential STAR (estimated)	Planning interventions	Moderate to high - May require information from the field
Realised STAR	STAR score of the actual conservation gains achieved	Tracking and reporting of progress	Moderate to high – requires assessment and tracking of threat levels

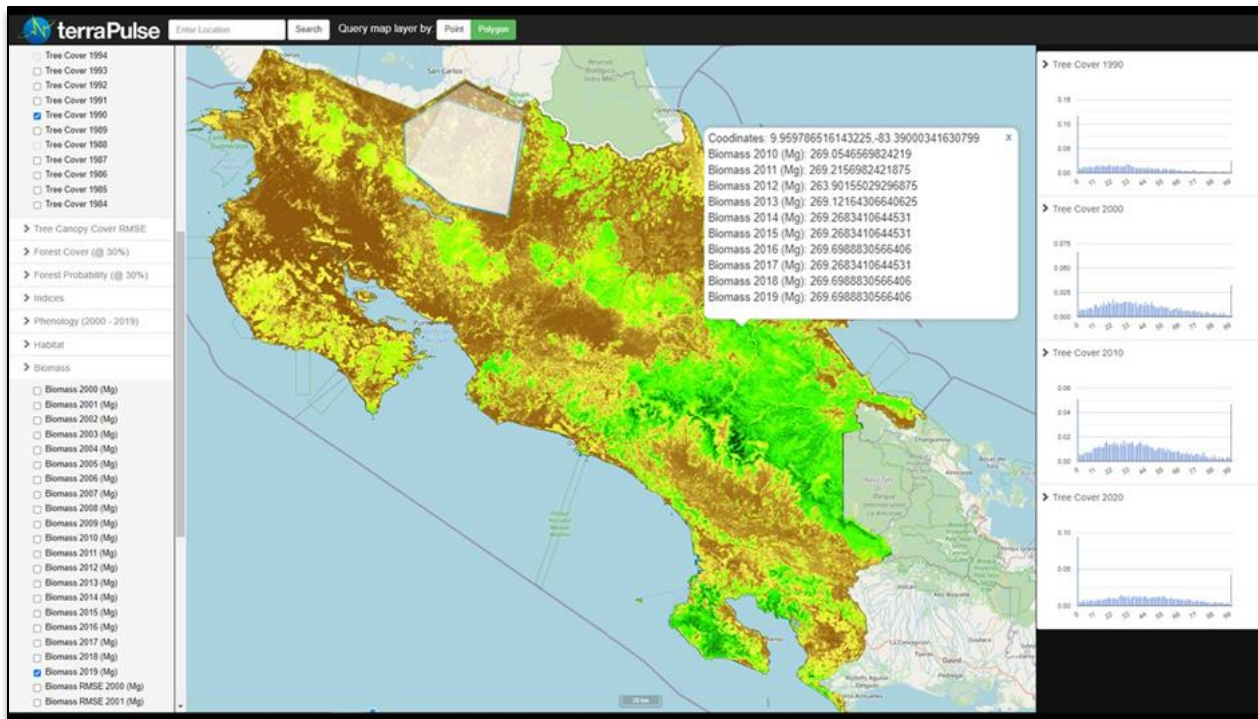**THE PROBLEM: CALIBRATION STAR IS VERY LABOR INTENSIVE**

Which of the threats to species can be assessed using Earth Observations data

I'iwi
Drepanis coccinea
Vulnerable

Remotely Sensing Conservation Threats

EO-STAR interface (ARL 5-6) mapping Aboveground Biomass (Mg) over Costa Rica.

The popup window displays annual biomass estimates from 2010-2019; side panels show histograms of tree cover in the shaded polygon in 1990, 2000, 2010, and 2020.

Prototypes were developed under support of the Biodiversity Program (NNH20ZDA001N-BIODIV) and other NASA Earth Science programs.
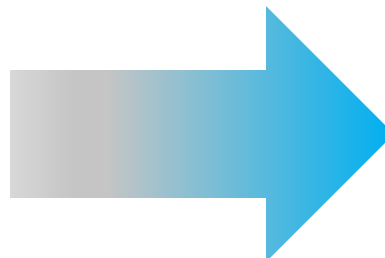
Support from the NASA Ecological Conservation Program will develop the prototype to an operational platform for IUCN worldwide.
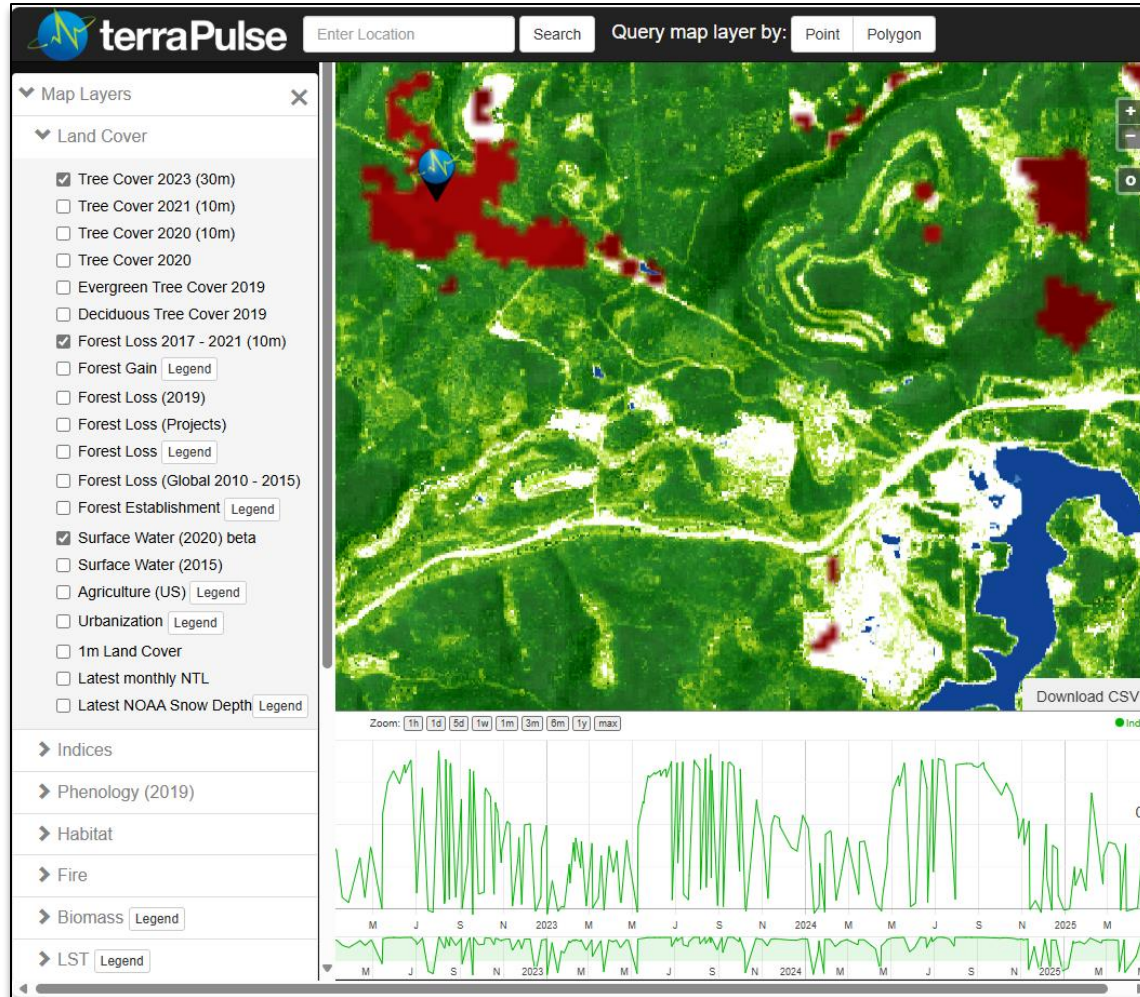
IUCN – CMP Level-1 Threat Classes v 3.2.0
(https://www.iucnredlist.org/resources/threat-classification-scheme) and Indicators.

Level 1 Threat Class	Level 2 Threat Class	Indicator	Reporting Frequency	Feasibility
1. Residential and Commercial Development	1.1. Housing & Urban Areas	**Impervious Cover (+)**	**Annual**	**4**
	1.2. Commercial & Industrial Areas	**Impervious Cover (+)**	**Annual**	**4**
	1.3. Tourism & Recreation Areas			
2. Agriculture & Aquaculture	**2.1. Annual & Perennial Non-Timber Crops**	**NDVI (+/-)**	**Monthly**	**1**
		Herbaceous land cover (+/-)	Annual	3
	2.2. Wood & Pulp Plantations	Tree Cover (+/-)	Annual	2
		Aboveground Biomass (+/-)	Annual	3
		Canopy Height (+/-)	Annual	4
	2.3. Livestock Farming & Ranching			
	2.4. Marine & Freshwater Aquaculture			
3. Energy Production & Mining	3.1. Oil & Gas Drilling			
	3.2. Mining & Quarrying	**NDVI (-)**	**Monthly**	**1**
	3.3. Renewable Energy			
4. Transportation & Service Corridors	**4.1. Roads & Railroads**	**Impervious Cover (+)**	**Annual**	**4**
	4.2. Utility & Service Lines			
	4.3. Shipping Lanes			
	4.4. Flight Paths			
5. Biological Resource Use	5.1. Hunting & Collecting Terrestrial Animals			
	5.2. Gathering Terrestrial Plants			
	5.3. Logging & Wood Harvesting	**Tree Cover (+/-)**	**Annual**	**2**
		Aboveground Biomass (+/-)	**Annual**	**3**
		Canopy Height (+/-)	**Annual**	**4**
	5.4. Fishing & Harvesting Aquatic Resources			
6. Human Intrusions & Disturbance	6.1 Recreational Activities			
	6.2. War, Civil Unrest & Military Exercises			
	6.3. Work & Other Activities			
7. Natural System Modifications	**7.1. Fire & Fire Suppression**	**Wildfire Danger (+/-)**	**Annual**	**3**
	7.2. Dams & Water Management / Use	**NDWI (+)**	**Monthly**	**1**
		Water Cover (+)	**Monthly**	**2**
		Surface Hydroperiod (+)	**Annual**	**2**
	7.3. Other Ecosystem Modifications			

Sensible Threat Indicators

EO-STAR dashboard overlaying Forest Loss (2017 – 2021) on Tree Cover (2023), and Water Cover (2020) in an area of active forest clearing. The time-series window shows Landsat-based NDVI from 1984 to present.

- Indicator levels:
  - Spectral index
    - *Fast, but abstract*
    - *e.g., NDVI, NDWI*
    - *Near-real-time monitoring*
  - Cover estimate
    - *Slow, but quantitative*
    - *e.g., tree, water cover*
    - *Annual reporting, impact assessment*

- States & changes
  - Spot value (e.g., NDVI, cover)
  - Trend (e.g., 1984 – present)
  - Change (e.g., annual)

- Delivery to end-users:
  - *terraView* monitoring dashboard
  - Analysis-Ready Data:
    - SFTP (GeoTIFF)
    - API (GeoParquet, XYZ tiles)

Core Team

Thanks

Mantled Howler Monkey
Alouatta palliata
Vulnerable