Biggest Bang for Your Buck: Using NASA Earth Observations to maximize island-ocean ecosystem benefits following invasive species removals

Rock islands southern lagoon Palau
Credit: Island Conservation

David Will
Island Conservation

Island Conservation
Nature. Oceans. People.

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Islands are the epicenter of the extinction, failing ocean health, and climate crises

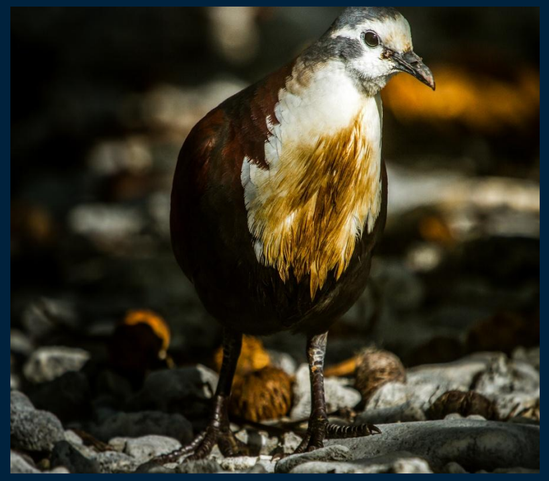
41%
Islands are home to our world's most vulnerable plants and animals

86%
Invasive species are the leading cause of extinction

Blue-foot Booby egg devoured by an invasive rat
Credit: Island Conservation / Rory Stansbury

Eradicating invasive mammals is a proven intervention that prevents extinction and restores island-ocean ecosystems

>6% of all globally threatened species benefited



Jones et al. 2016

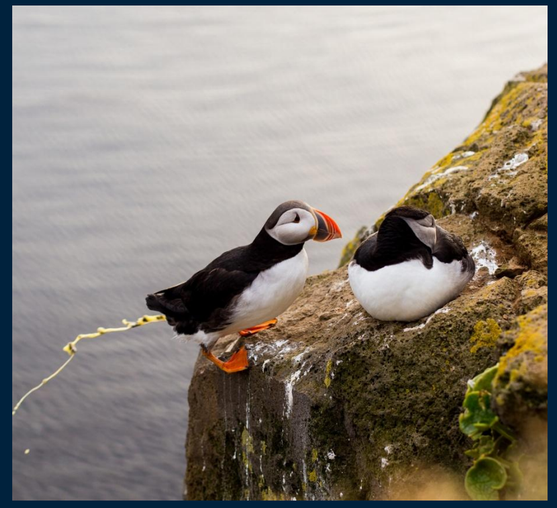
Critically endangered Polynesian Ground Dove
Credit: Island Conservation / Marie-Helene Burle

>940,000 ha of unique forest benefited

Honzák et al. 2024

Recovering Pisonia forest following rat removal.
Credit: Island Conservation

Seabird poop benefits land and sea



Sandin et al. 2022

An Atlantic Puffin doing its part.
Credit: Shutterstock / Ale Koziura

Aligned with >25 SDG targets

de Wit et al. 2020

Invasive rat damage on local crops. Credit: Andy Wright

To maximize outcomes and attract new investments, island restoration needs to consider multiple benefits

2012 - 2023

ISLAND CONSERVATION

Preventing Extinctions

Biodiversity

2024 – 2028+

Island Conservation

Nature. Oceans. People.

Biodiversity

Ocean health

Ecosystem stability

Community well-being

How do we restore islands to maximize benefits?

Strategy Decisions: Where?

Where do we allocate resources to restore priority islands?

Restoration Action Decisions: How?

How do we improve restoration efforts?

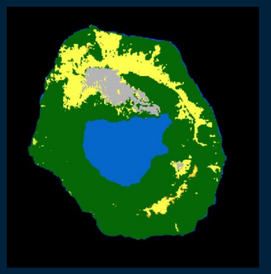
Islands are important, but (often) forgotten

Challenges

- Limited coverage in global data products
- Outdated field surveys
- Subjective, biodiversity focused prioritization
- Limited access and experience with EO

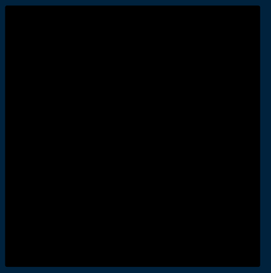
NASA image of the day Oct 2024

Tofua, Tonga



Landcover

ESA WorldCover 2021

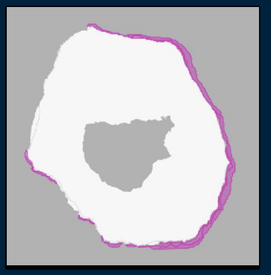


Tree cover, Canopy height

Hansen et al. 2013,

Patapov et al. 2021,

Sexton et al. 2013



Coral reef

UNEP-WCMC 2021

Project goal

A decision support system to guide Island Conservation and global partners on where and how to restore and rewild island ecosystems to maximize benefit for nature and people.




Strategy Decisions: Where?

- Where should we invest to restore islands to maximize potential impact?
- Where should we invest in monitoring to demonstrate impact?

Botanist documenting tree species on Late, Tonga
Credit: Island Conservation/ Baudouin des Monstiers

Clear objectives systematically assess high potential for multiple benefits

11 Earth observation products

- UNEP-WCMC 2015 (global island database)
- MODIS (chlorophyll-a)
- Burnett 2024 (coral atoll vegetation)
- Beyer 2018 (coral reef persistence)
- ESA Worldcover 2021 (landcover)
- NASA SRTM DEM (elevation)
- WorldClim (precipitation)
- UNEP-WCMC 2021 (warm-water coral reef)
- UNEP-WCMC 2020 (seagrasses)
- Giri 2011 (mangroves)
- Jayathilake 2020 (kelp)

5 Expert and local knowledge products

- Threatened Island Biodiversity Database 2018 (IUCN threated species)
- Birdlife International 2018 (important bird areas)
- Sea Turtle Nesting Sites of the World
- Rewilding and restoration targets
- Human use and cultural practices

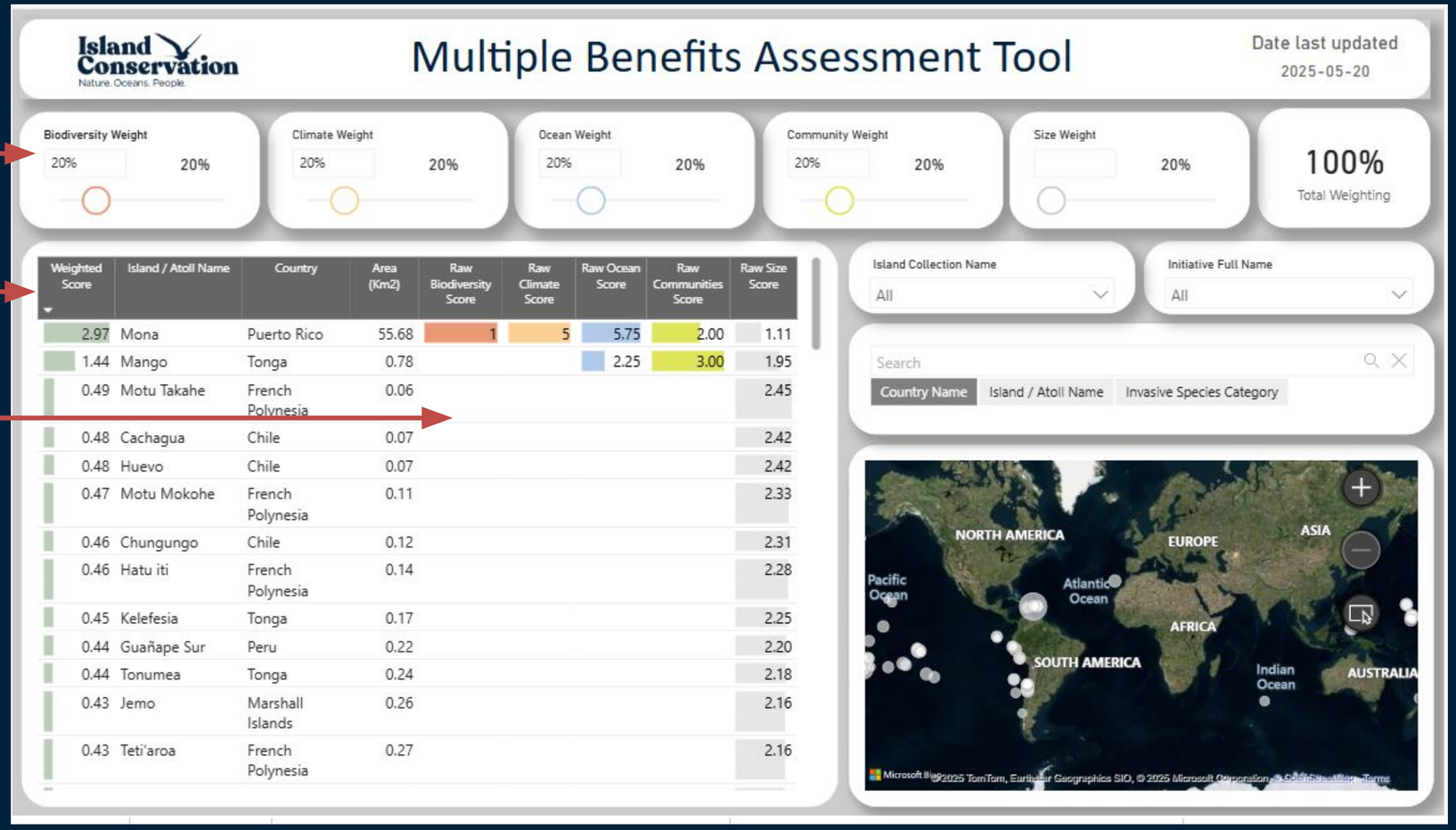
- **Biodiversity Score**
  - ***Current conservation risk:*** Species Extinction Risk * Irreplaceability * Severity of negative impact
  - ***Species rewilding potential:*** Conservation target species list (local knowledge)
- **Ecosystem Stability Score**
  - ***Vegetation condition risk:*** 4 Landcover classes * 7 Ecoregion classes * Severity of negative impact
  - ***Climate stability potential*:** 6 climate stability categories
  - ***Soil stability risk:*** Negative impact threshold, Elevation threshold, 7 precipitation classes
  - ***Ecosystem restoration potential:*** 5 Conservation target categories (local knowledge)
- Ocean Score
  - ***Seabird nutrient dependence:*** 7 oceanographic productivity classes
  - ***Nearshore habitat beneficiary potential:*** 4 coastal ecosystem classes
  - ***Important marine connector breeding site protection potential:*** 5 marine IBA and sea turtle nesting criteria
  - ***Marine connector rewilding potential:*** Conservation target species list (local knowledge)
- **Communities Score**
  - ***Food security risk:*** Country risk threshold, 6 impacted food system categories (local knowledge)
  - ***Zoonotic disease exposure:*** Country risk threshold, Vector presence threshold, 5 human habitation classes (local knowledge)
  - ***Livelihoods and cultural practice impact risk:*** 4 impacted livelihood categories (local knowledge)
- **Size-efficiency Score**
  - ***Island Size:*** 10 island size classes

The Multiple Benefits decision support tool helps maximize the multiple benefits of island restoration

User-defined importance of objectives and size efficiency

Ranked, weighted list

Evaluate trade-offs and drill down to see details



Case Study: Where is there the highest potential for maximizing ecosystem stability?

Interventions

Repatriations

ma'oma'o (EN)

Evidence of invasive pig damage documented during baseline monitoring in March 2025 on Nu'utele, Samoa. Eradication efforts are currently underway.
Credit: Island Conservation / Amy Levine

PRISMSS
RESTORING ISLAND RESILIENCE

Impact targets on Nu'utele Samoa

- Seabird abundance
- Landcrab abundance
- Seedling density
- Tree cover, vegetation productivity, and canopy moisture

SPREP
Secretariat of the Pacific Regional Environment Programme

FA'AVAE I LE ATUA SAMOA

SAMOA CONSERVATION SOCIETY

BirdLife INTERNATIONAL

Restoration Action Decisions: How?

- Where should we monitor before eradication to assess impacts and guide planning?
- Where is ecosystem recovery after intervention on track, and where is it not?
- Where are the most suitable microhabitats to maximize the likelihood of successful species rewilding and translocations?
- Which areas need active restoration, and where is passive recovery enough?

Conservation scientist using drones to map vegetation on Pinzón, Galapagos. Credit: Island Conservation

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We developed an island restoration monitoring framework

- Uses Landsat data to estimate trends and changes in vegetation structure and condition over time
- Uses Bayesian time-series analysis to estimate spatially-explicit effects of interventions
- Enables decision makers to evaluate the impact of interventions and identify priority areas for further restoration action
- Outputs can be combined with field data to tell the story of island restoration and to direct conservation actions

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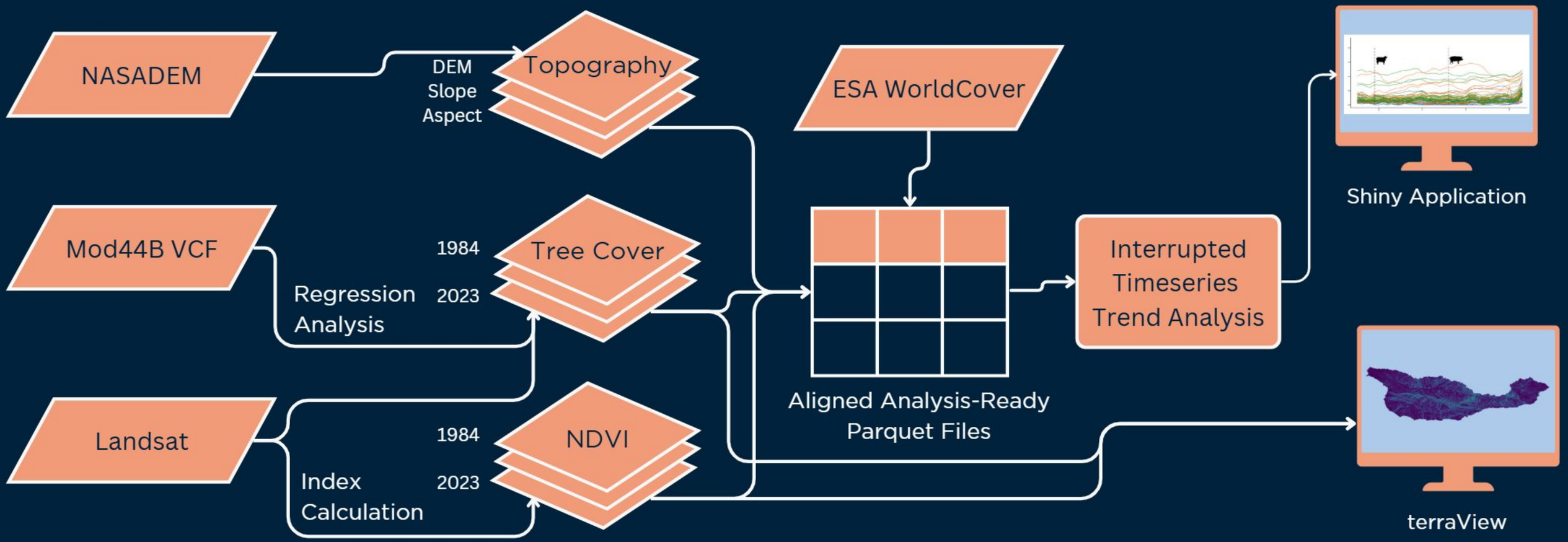
The island monitoring framework is globally consistent and spatially explicit



Honzák et al. 2024

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We use interrupted time series analysis to quantify the response of vegetation to interventions on islands

Approach: Bayesian interrupted time series model for each pixel

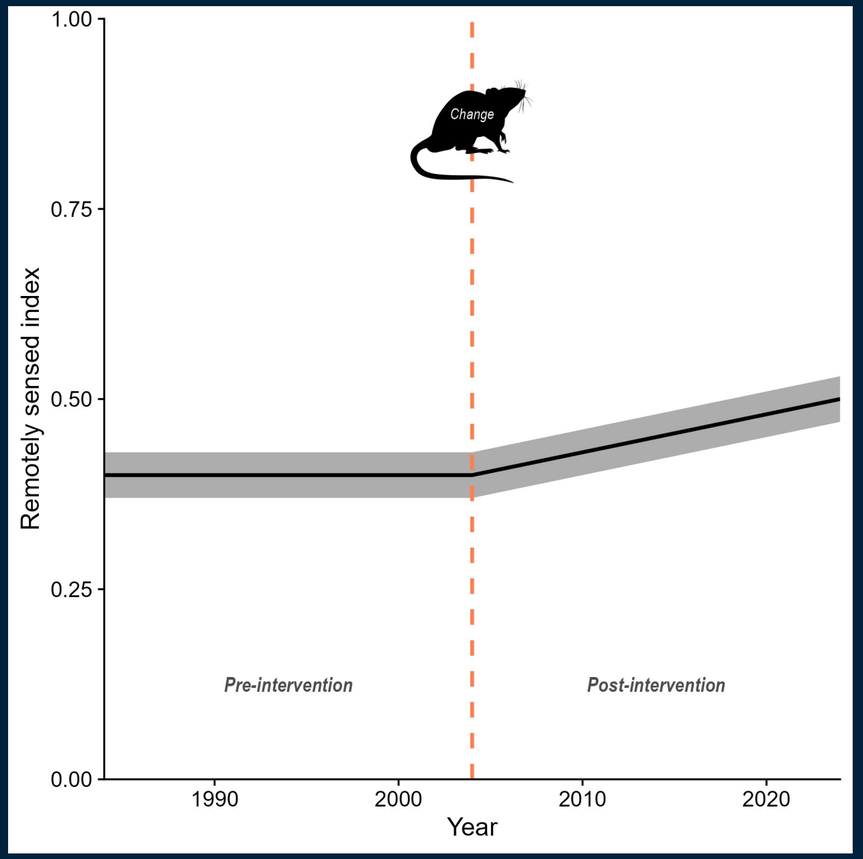
$$Y_t = \alpha + \beta_1 \text{time} + \beta_2 \text{intervention} + \beta_3 \text{time since} + \varepsilon_t$$

Why this approach

- Reveals temporal trends before and after intervention
- Captures within island variation
- Quantifies uncertainty across space and time

What we report

- Total change in index before and after intervention
- Annualized rate of change
- Uncertainty for all estimates



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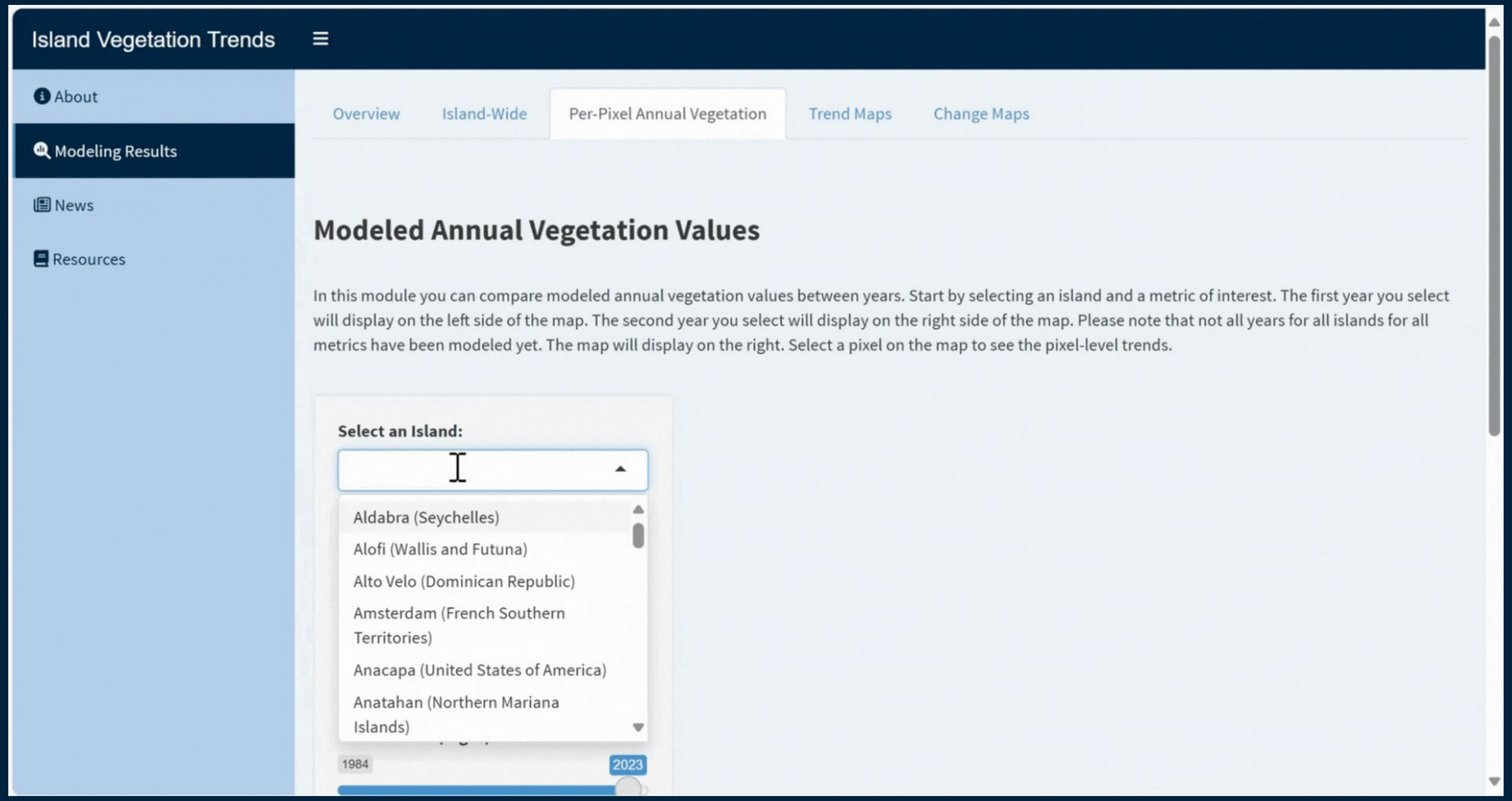
Outputs are integrated into an interactive tool (in development)

- View and summarize predictions
- Filter results based on user-defined thresholds
- Export summaries and maps to operationalize decisions



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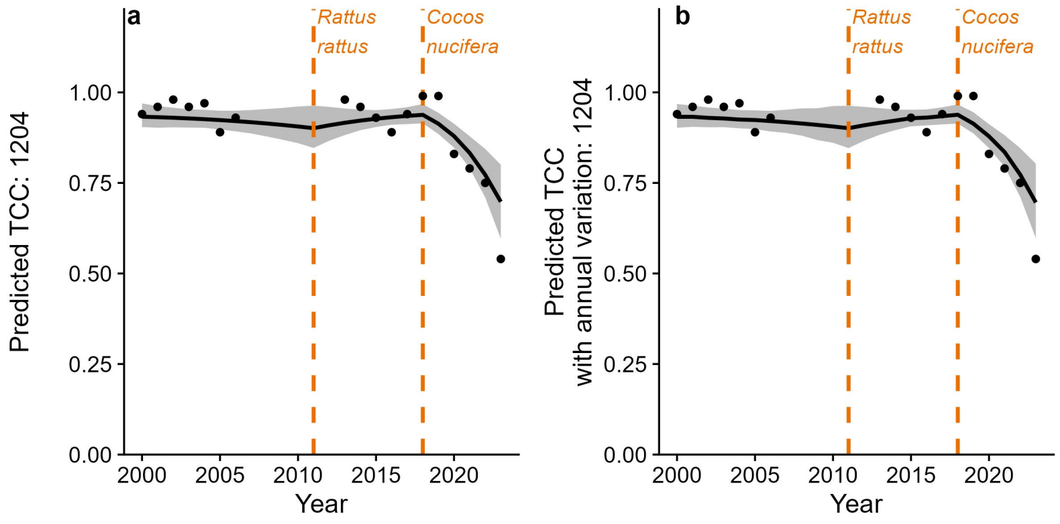
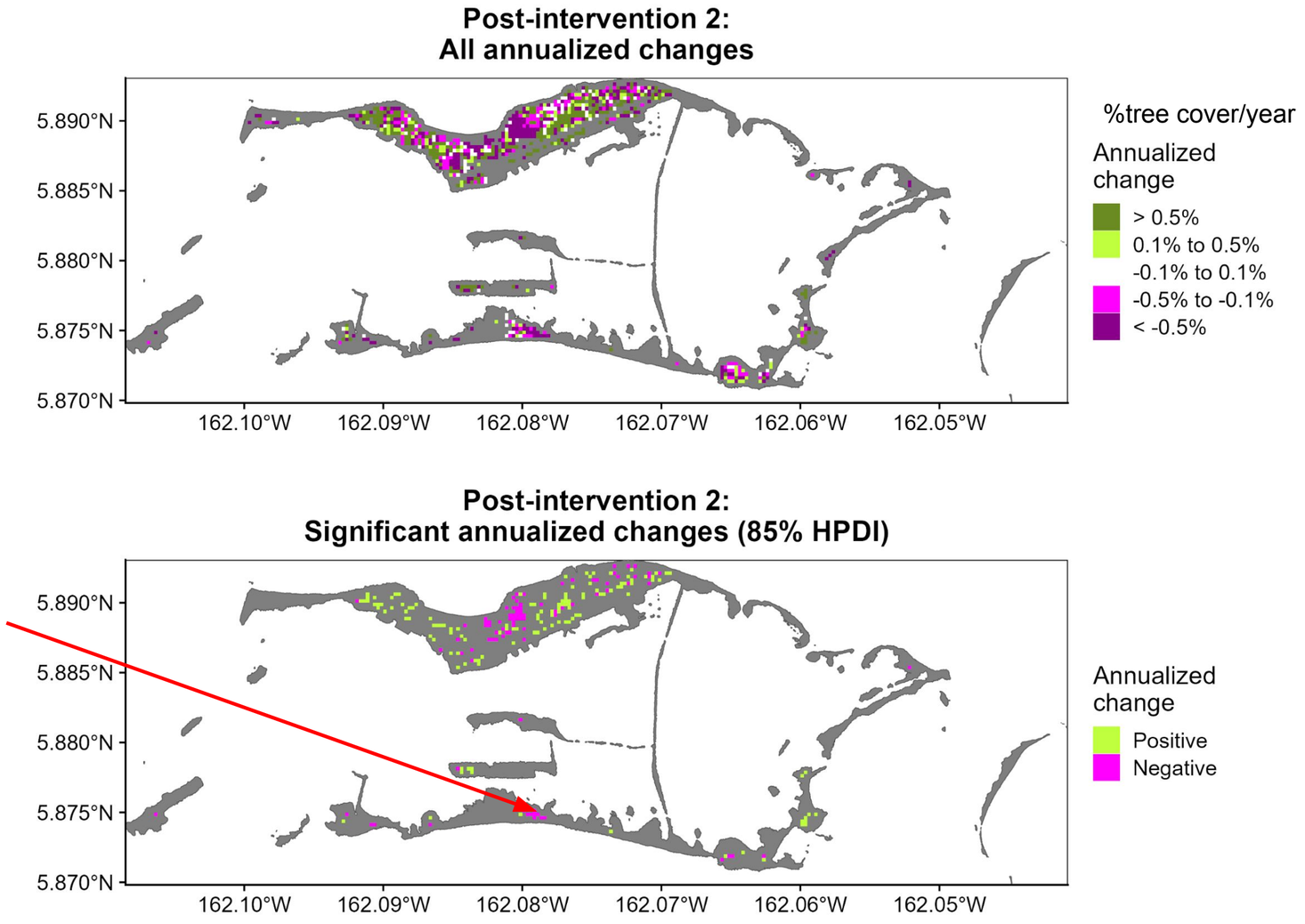
Palmyra Atoll NWR: Is rainforest realignment on track?

Palmyra: 2000 – 2006, 2013 – 2023

LiDAR calibrated Tree Cover





Pinzón: Where to reintroduce locally extinct Woodpecker Finches?

Island monitoring framework supports rewilding efforts

Used Landsat derived tree canopy cover combined with accessibility, wind protection, and risk of predation to select optimal collection and release sites

Group 1 collection site (Santa Cruz)

★ Release site (Pinzón)

"I felt more confident going into the field knowing I had selected highly suitable and accessible sites"
~ Paula Castaño, Island Conservation

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Island restoration decisions are underway

Multiple Benefits Tool

- Scoping new project opportunities for the Island-Ocean Connection Challenge
- Identifying portfolio of “high potential sites” to achieve 5-year strategic goals

Island Monitoring Framework

- Where to conduct active restoration to maximize forest integrity on Santa Cruz, USA?
- How is ecosystem recovery progressing on Palmyra Atoll, USA following invasive coconut removal and native planting?
- Where is the most suitable habitat to rewild black-capped petrels on Alto Velo, Dominican Republic?
- Where is the most suitable habitat to rewild Tongan megapodes on Late and Tofua, Tonga?

Researchers searching for suitable habitat to inform future Tongan megapode reintroduction efforts on the summit of Late, Tonga based on NASA Landsat derived estimates of tree canopy cover and thermal brightness temperature. Credit: Island Conservation / Cozette Romero

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Project team and end users

Project Team	Multiple Benefits End Users	Island Monitoring End User
Christy Wails	Amy Levine	Paula Castaño
Brad Cosentino	Coral Wolf	Coral Wolf
Joe Sexton	Carleigh McDonald	Nick Holmes
Panshi Wang	Wes Jolley	Cameron Williams
Miro Honzák	Jose Luis Cabello	Alex Wegmann
Elke Windschitl	Patty Baiao	Katie Franklin
Amy Levine	Richard Griffiths	Cielo Figuerola
Coral Wolf		Jose Luis Herrera
Doug Gillings		
Sierra Moore		

Monitoring team on Nu'utele, Samoa.
Credit: Island Conservation / Cozette Romero

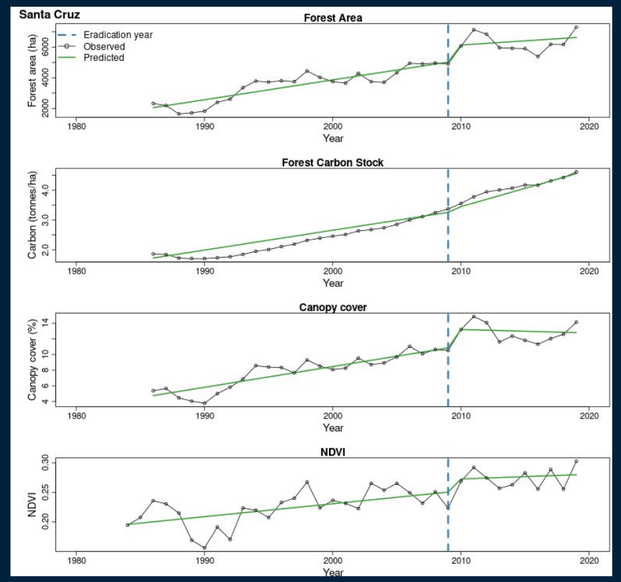
Data for island restoration are publicly accessible

Scan to access article

Shiny.io application

Time serial estimates for 1,000 islands

islandconservation.shinyapps.io/islandTimeSeries



terraView application

Annual remote sensing data products for 1,000 islands

https://apps.terrapulse.com/terraView/nasaislands/

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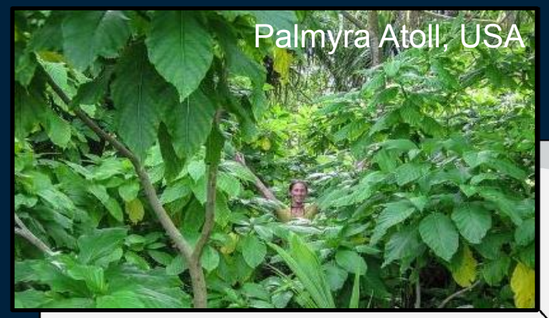
We are using this framework to advance restoration action decisions for 100 globally important islands



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Case Study: Assessing rainforest realignment on Palmyra Atoll NWR, United States

Interventions

Repatriations and habitat restoration

Guam Sihek (EW)

Decision: Where to create native rainforest to maximize breeding of tree-nesting seabirds?

Transport of native plants to be planted as part of the Palmyra Atoll Rainforest and Reef Resilience Project. Credit: USFWS

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The Nature Conservancy

Case Study: Directing rewilding efforts on Pinzón, Galápagos

Interventions

Repatriations

Pinzón Island giant tortoise (EW→VU)

Woodpecker Finch (NT)

Decision: Where to release the locally extinct Woodpecker Finch to maximize the likelihood of rewilding success?

Woodpecker finch being released on Pinzón in 2024 at a site selected based on Landsat-derived Insights of habitat suitability.
Credit: Island Conservation / Carolina Torres

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