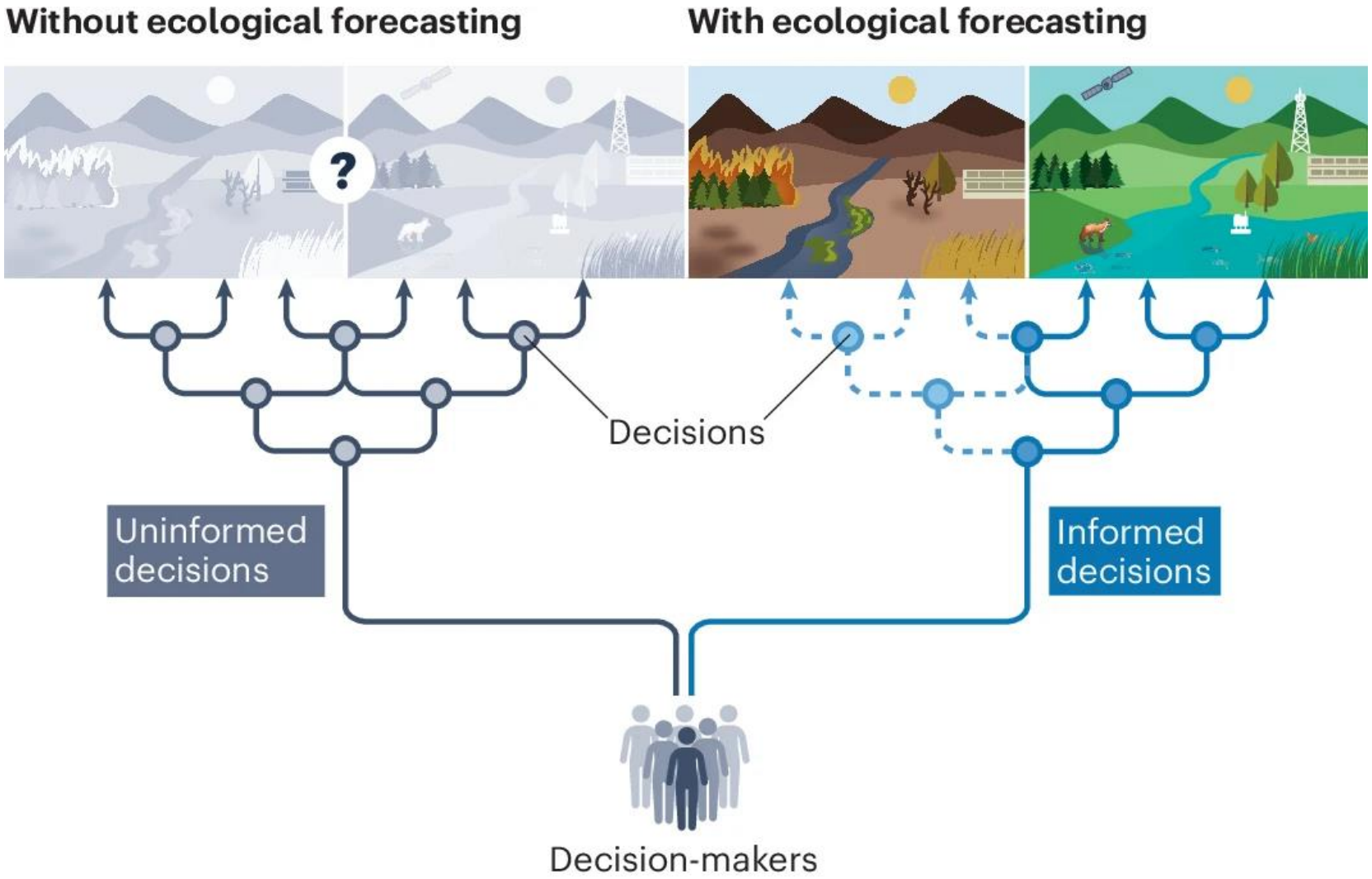
Community-developed cyberinfrastructure for efficient ecological forecasting

Jacob A Zwart, Cameron Thompson, Christopher W. Brown, Jessica L Burnett, Robert Cardeiro, Michael Dietze, Jake Kritzer, Jody Peters, Caitlin Shanahan, Emily Silva and Hassan Moustahfid

Ecological Forecasting Initiative
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The Urgent Need for Ecological Forecasting



Dietze et al. 2024 https://doi.org/10.1038/s41558-024-02182-0

U.S. Interagency Ecological Forecast Meetings 2020-2022

"Modeling is not the problem, data and observations are not the problem: ***forecast production & delivery to stakeholders*** *is the problem."*

USGS science for a changing world

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NASA

AMS

Why Are We Bad at Operationalizing Ecological Forecasts?

No dedicated agency to take on operationalization



Large number of 'medium-sized' forecasting problems

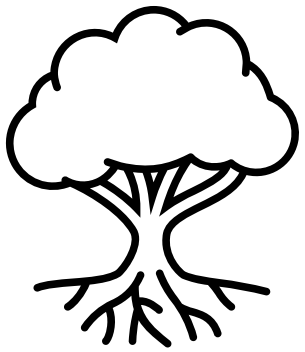






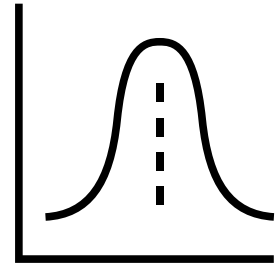


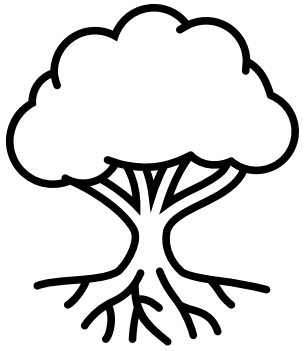

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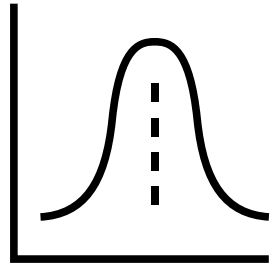
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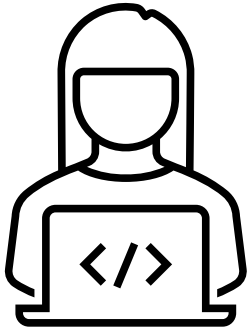


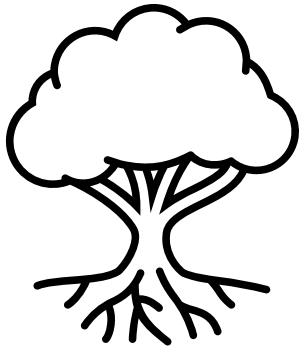




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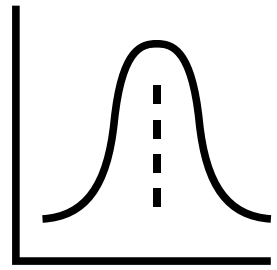


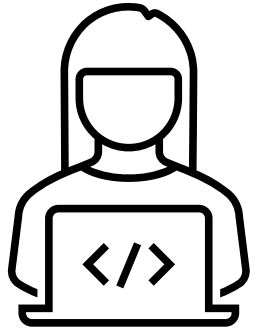


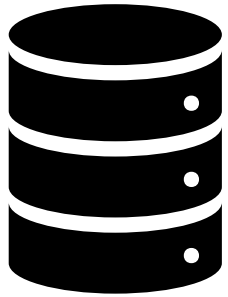


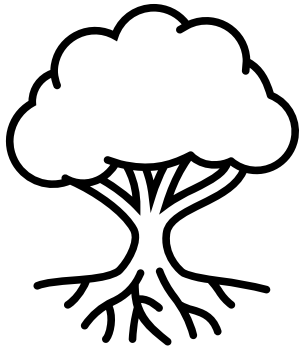


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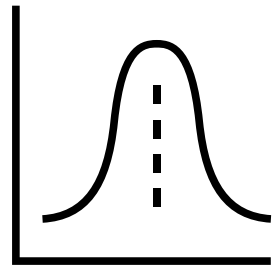


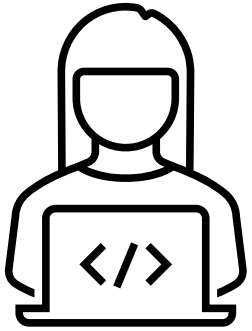


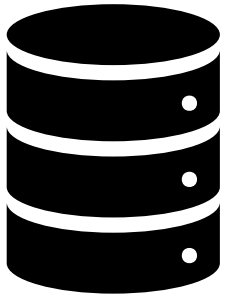


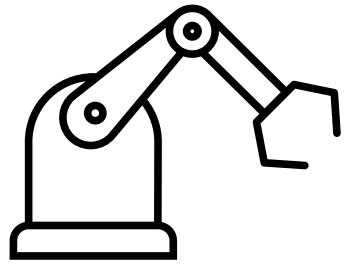


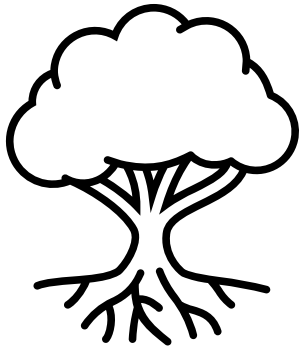
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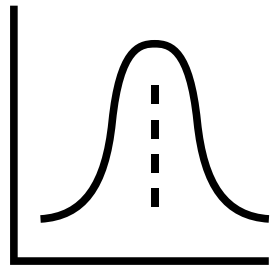


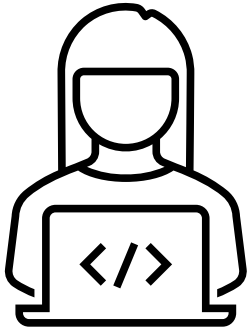


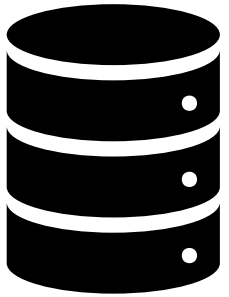


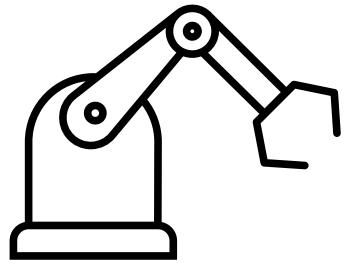


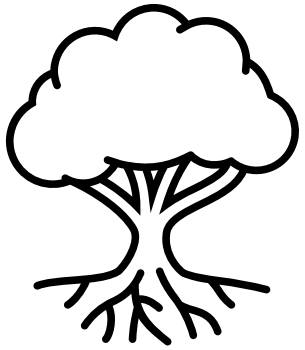
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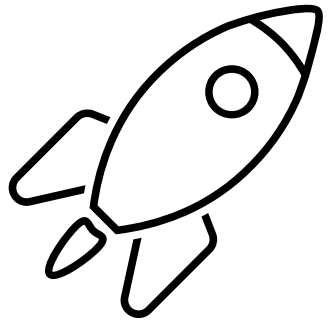










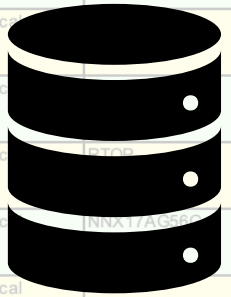


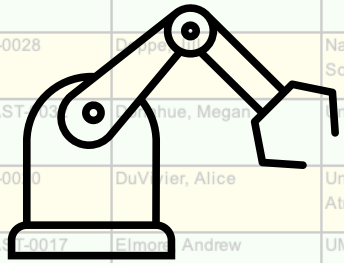
Project ID	Project	Project Title	NRA Year	NRA Name	Grant Num	Proposal Num	PI Name	PI Org
3299	Anderson (ECO4CAST 2012)	Merging Satellite and Numerical Model Data in The California Current to Create Continous Imagery and Forecasts of Harmful Algal Blooms	2012	NASA: Ecological Forecasting	NNX14AC42G	12-ECOF12-0025	Anderson, Clarissa	University of California San Diego
4445	Blair (ECO4CAST 2020)	Advancing tools to support and test an integrated biodiversity monitoring system for Colombias Protected Areas	2020	NASA: Ecological Forecasting	80NSSC21K1351	20-ECOF20-0006	Blair, Mary	American Museum of Natural History
4444	Bohrer (ECO4CAST 2020)	Ecological forecasting tools for movement-track management at the Yukon-to-Yellowstone migration corridor	2020	NASA: Ecological Forecasting	80NSSC21K1182	20-ECOF20-0003	Bohrer, Gil	Ohio State University
4454	Brandt (ECO4CAST 2020)	Integrating remote sensing and ecological forecasting into decision support for beaver rewilding	2020	NASA: Ecological Forecasting	80NSSC21K1353	20-ECOF20-0021	Brandt, Jodi	Boise State University
3634	Brauman (ECO4CAST 2016)	Earth Observations to Value Ecosystem Services: A Series of Workshops	2016	NASA: Ecological Forecasting	NNX17AG32G	16-ECO4CAST-0006	Brauman, Kate	University of Minnesot
4449	Bunn (ECO4CAST 2020)	Biodiversity, connectivity, and ecological forecasting: applying NASA earth observation data to conservation management in the Greater Kruger National Park region, South Africa	2020	NASA: Ecological Forecasting		20-ECOF20-0014	Bunn, David	Colorado State University
3303	Byrd (ECO4CAST 2012)	Forecasting Coastal Habitat Distributions through Fusion of Earth Observations, Process Models and Citizen Science: A Climate Change Adaptation Tool for the NOAA National Estuarine Research Reserve	2012	NASA: Ecological Forecasting	NNH14AX16I	12-ECOF12-0041	Byrd, Kristin	USGS
3635	Carter (ECO4CAST 2016)	Using NASA Resources to Better Inform Wildlife Conservation in the Anthropocene: Spatially Predicting Impacts of Anthropogenic Nightlight and Noise on Wildlife Habitat Integrity Across the Contiguous United	2016	NASA: Ecological Forecasting	NNX17AG36G	16-ECO4CAST-0026	Carter, Neil	University of Michigan
4455	Chirayath (ECO4CAST 2020)	Informing Coral Reef Resilience-Based Management through Prediction of Individual Coral Organismal Growth, Recruitment, And Mortality (PICOGRAM)	2020	NASA: Ecological Forecasting	RTOP	20-ECOF20-0024	Chirayath, Ved	University of Miami
3636	Daily (ECO4CAST 2016)	Using Earth Observations and Ecosystem Modeling to Improve the Sustainability of Agribusiness and Extractive Industries in Working Landscapes	2016	NASA: Ecological Forecasting	NNX17AG56G	16-ECO4CAST-0015	Daily, Gretchen	Stanford University
4456	Deppe (ECO4CAST 2020)	Full annual cycle conservation of migratory birds in the Western Hemisphere: Mapping tools for assessing and improving the conservation value of protected area networks in critical landscapes	2020	NASA: Ecological Forecasting		20-ECOF20-0028	Deppe, Jill	National Audubon Society
3637	Donahue (ECO4CAST 2016)	Forecasting Coral Disease Outbreaks Across the Tropical Pacific Ocean Using Satellite-Derived Data	2016	NASA: Ecological Forecasting	NNX17AI21G	16-ECO4CAST-0032	Donahue, Megan	University of Hawaii
4453	DuVivier (ECO4CAST 2020)	Hot spots in the ice: revealing the importance of polynyas for sustaining present and future Antarctic marine ecosystems	2020	NASA: Ecological Forecasting	80NSSC21K1132	20-ECOF20-0020	DuVivier, Alice	University Corporation Atmospheric Research
3638	Elmore (ECO4CAST 2016)	Managing Forests for Sustainable Harvest and Wildlife Habitat Using Earth Observations and Modeling of Forest Structure and Landscape Connectivity	2016	NASA: Ecological Forecasting	NNX17AG41G	16-ECO4CAST-0017	Elmore, Andrew	UMCES Appalachian Laboratory
4452	Gibbs (ECO4CAST 2020)	A decision-making activity to guide archipelago-wide rewilding of Galapagos giant tortoises	2020	NASA: Ecological Forecasting	80NSSC21K1473	20-ECOF20-0019	Gibbs, James	State University of New York
3639	Goes (ECO4CAST 2016)	Decision and Information System for the Coastal Waters of Oman (DISCO)-An Integrative Tool for Managing Coastal Resources Under Changing Climate	2016	NASA: Ecological Forecasting	NNX17AG66G	16-ECO4CAST-0022	Goés, Joaquim	Lamont-Doherty Earth Observatory
3642	Hall (ECO4CAST 2016)	Integrating Earth Observations with Improved Topoclimate and Connectivity Tools to Inform Climate-Smart Conservation	2016	NASA: Ecological Forecasting	NNX17AF58G	16-ECO4CAST-0018	Hall, Kimberly (Kim)	The Nature Conservanc
3640	Hansen (ECO4CAST 2016)	Informing UN-Assisted National Biodiversity Strategy Action Plans with Earth Observations: Application to Forest Integrity and Connectivity	2016	NASA: Ecological Forecasting	NNX17AG51G	16-ECO4CAST-0002	Hansen, Andrew (Andy)	Montana State Univers
4447	He (ECO4CAST 2020)	Predicting the Long-Distance Dispersal of Ichthyoplankton in the Intra-Americas Sea: A Data-Assimilative Decision Support Tool for Effective Living Marine Resource Management	2020	NASA: Ecological Forecasting	80NSSC21K1471	20-ECOF20-0009	He, Ruoying	North Carolina State University & Fathom Science
3297	Hille Ris Lambers (ECO4CAST 2012)	Snow, Montane Wildflowers, and Citizen Scientists	2012	NASA: Ecological Forecasting	NNX14AC34G	12-ECOF12-0010	Hille Ris Lambers, Janneke	Univ. of Washington
3641	Hu (ECO4CAST 2016)	Forecasts of Pelagic Sargassum Blooms and Transports in the Intra-	2016	NASA: Ecological	NNX17AF57G	16-ECO4CAST-0014	Hu, Chuanmin	University of South

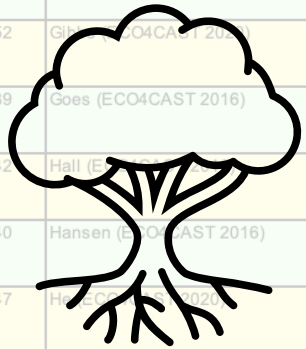
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4453	DuVivier (ECO4CAST 2020)	Polynya Significance: revealing the importance of polynyas for sustaining present and future Antarctic marine ecosystems	2020	NASA: Ecological Forecasting	80NSSC21K1132	20-ECOF20-0010	DuVivier, Alice	University Corporation for Atmospheric Research
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Boutique Solutions

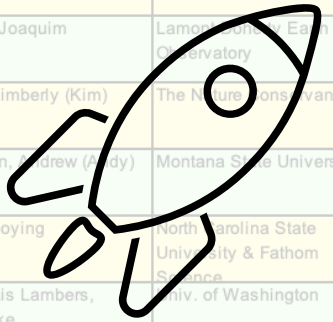




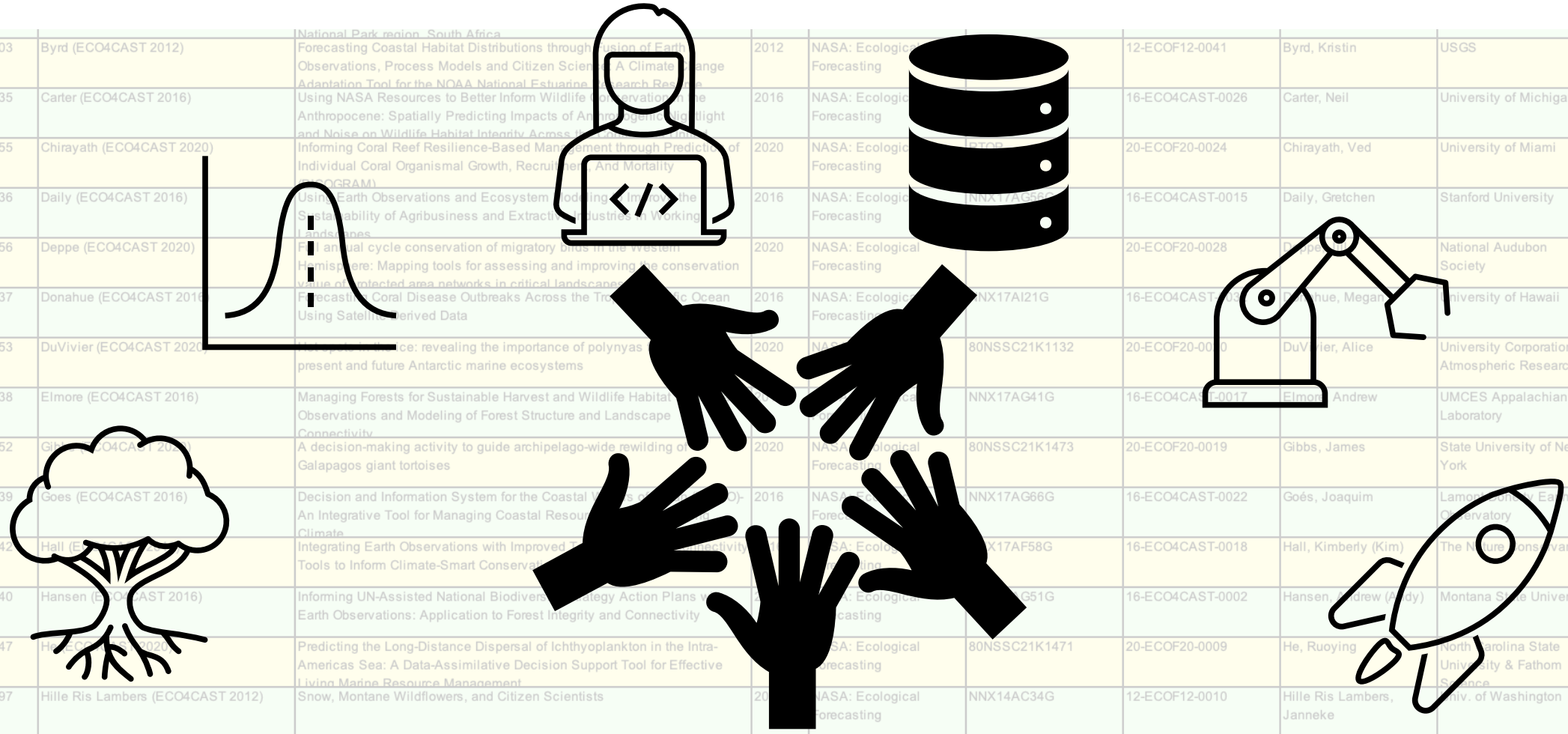








Shared Solution



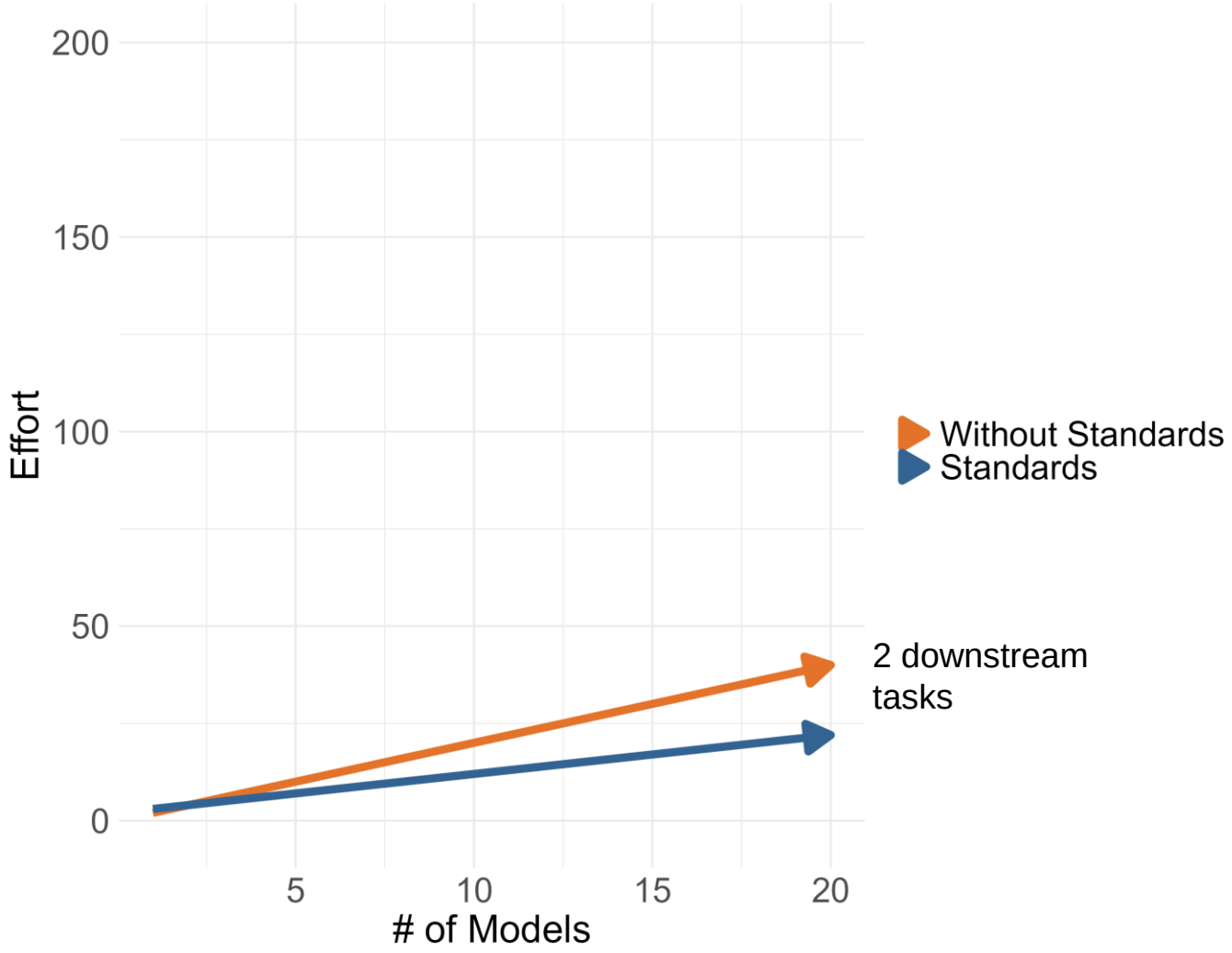
Benefits of Shared Cyberinfrastructure

- Shared costs and expertise
  - NASA - ~$5M/product for operationalization



Benefits of Shared Cyberinfrastructure

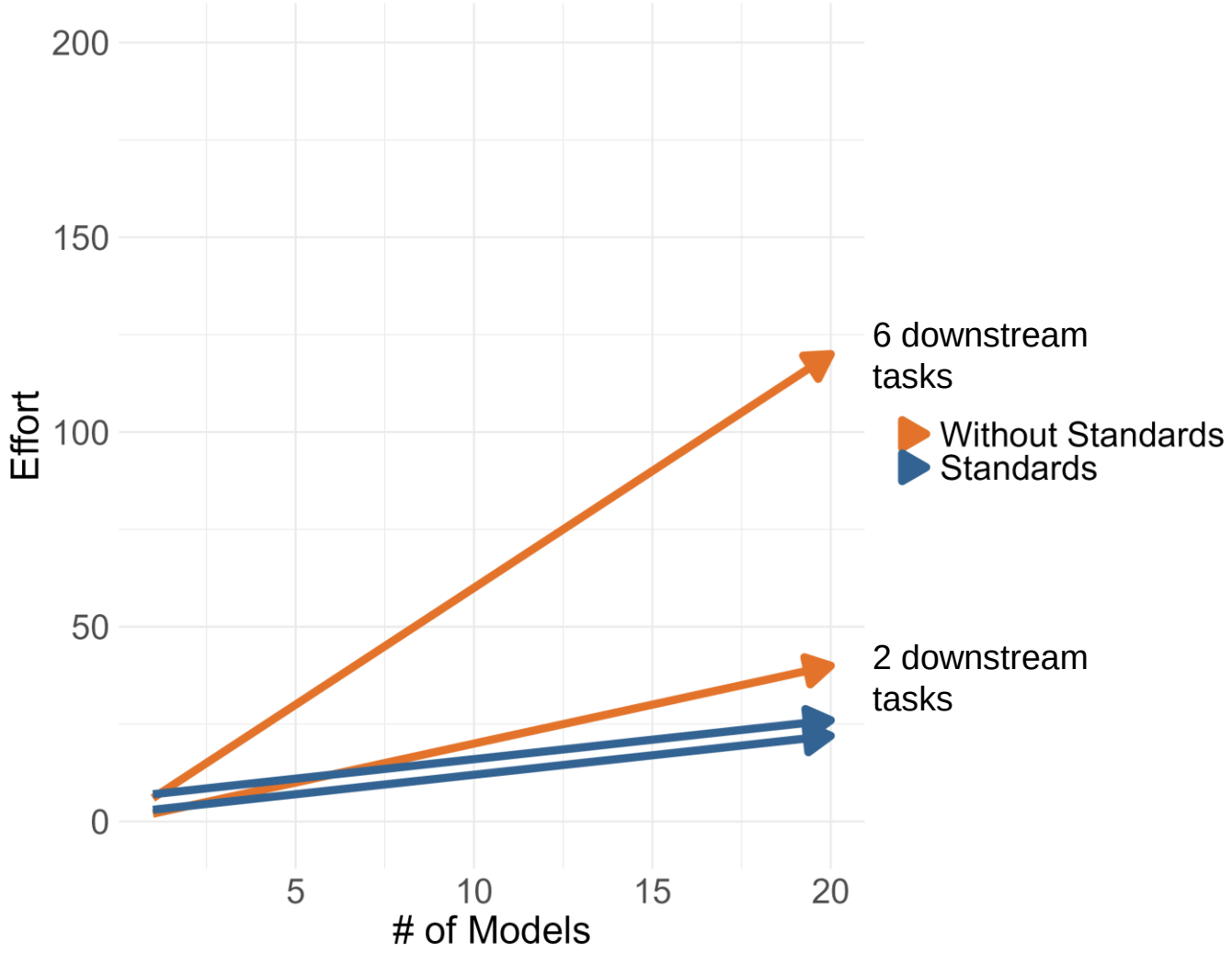
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Fer, I., et al. *Global Change Biology* 27, no. 1 (2021): 13-26.

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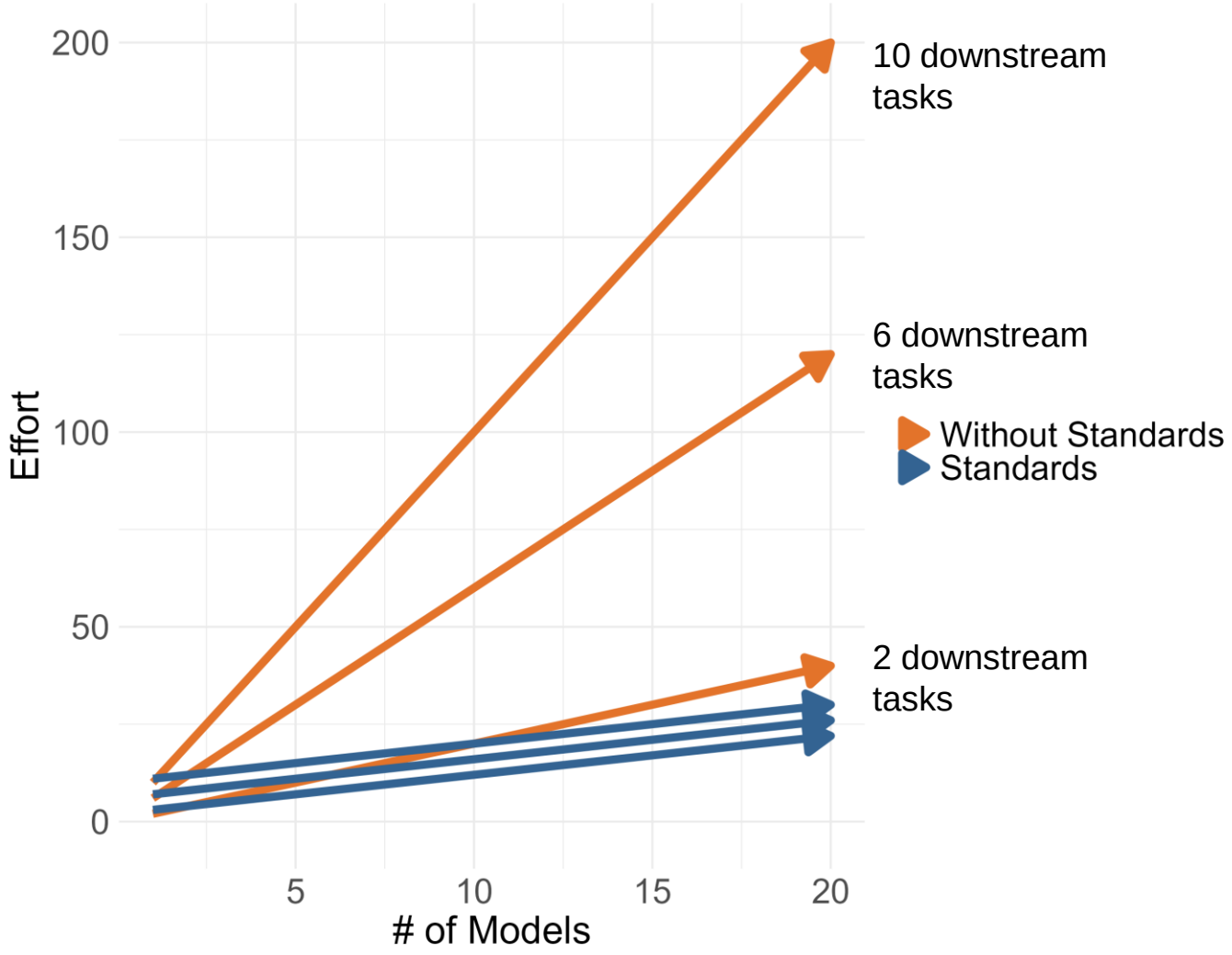
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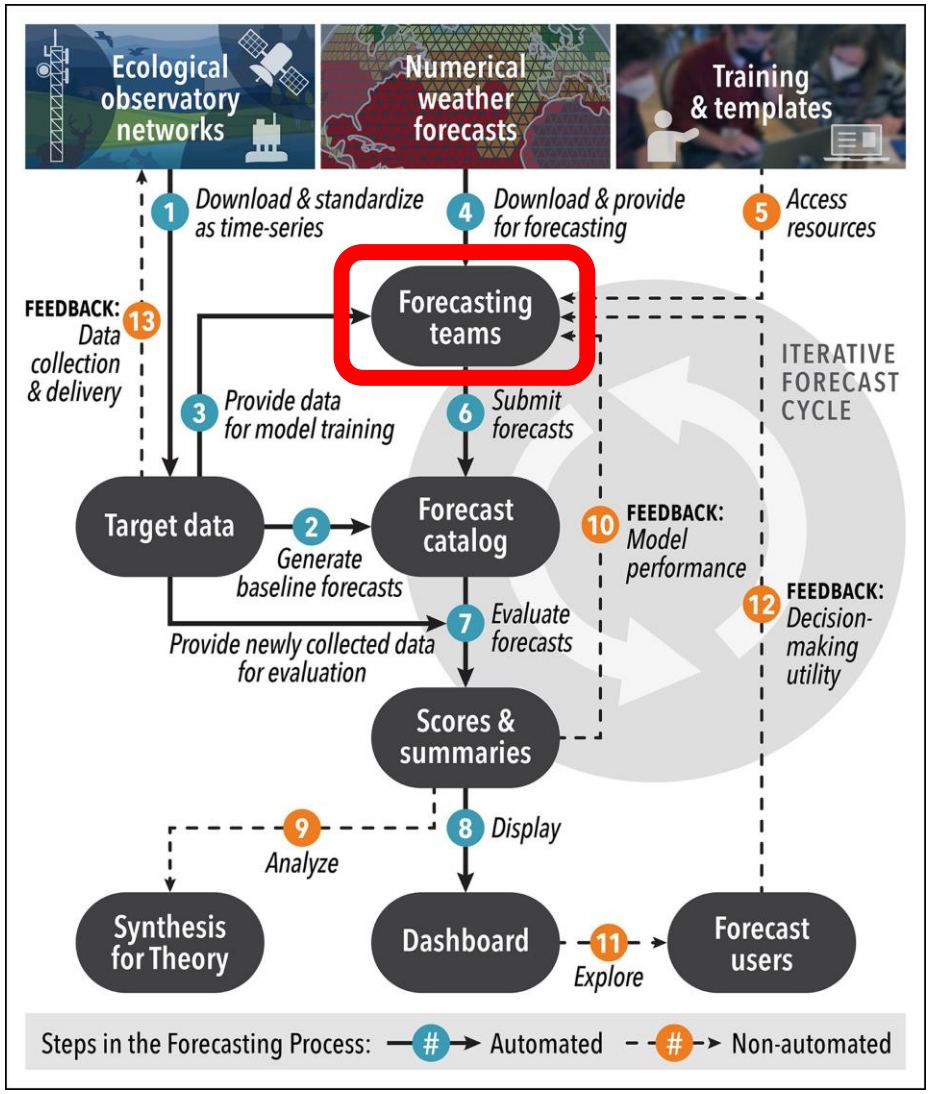
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Benefits of Shared Cyberinfrastructure

- Shared costs and expertise
  - NASA - ~$5M/product for operationalization
- Reduced effort for model analyses
- Reduce errors
- Focus effort on science questions



Thomas et al. 2023. Front Ecol Environ 2023; 21(3): 112–113, doi:10.1002/fee.2616

Forecast Cyberinfrastructure Workshop 2024





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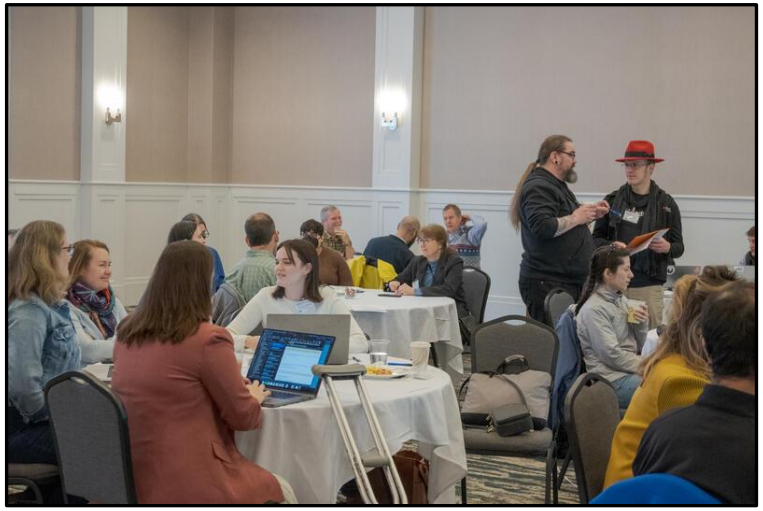
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U.S. DEPARTMENT OF COMMERCE

NASA

Goals of the Workshop

- *Advance community-developed cyberinfrastructure (CI) for ecological forecasts, with the goal of minimizing redundancy of efforts and lowering the barrier to producing more accessible, standardized forecasts*

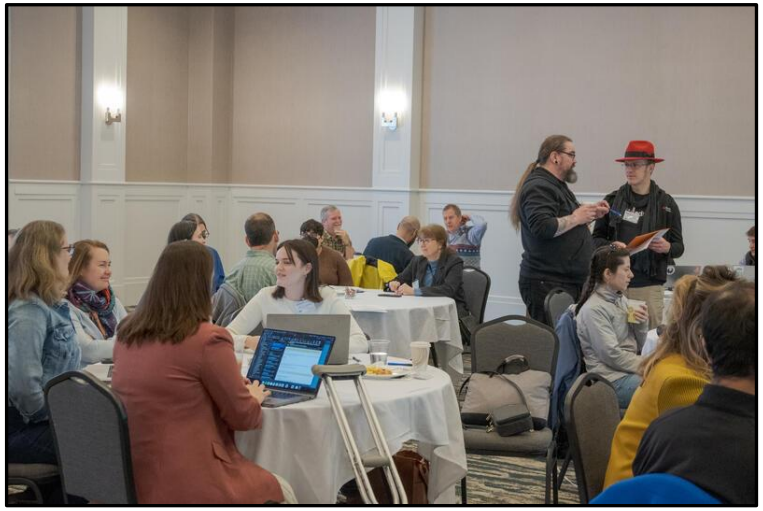


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Workshop Topics

1. Apply Design Justice Principles to forecast CI
2. Identify best practices for CI
3. Synthesize barriers, gaps, and other challenges for CI
4. Implement common CI design principles across organizations



Design Justice Principles Applied to Forecast CI

Design Justice Principles

“Design justice rethinks design processes, centers people who are normally marginalized by design, and uses collaborative, creative practices to address the deepest challenges our communities face.”
- Design Justice Network

Workshop Challenge:
design cyberinfrastructure that supports workflows for communities with limited Internet access.



Identify Best Practices for Forecast CI

1. Stakeholder-Driven Co-Development
2. Use Standards
3. Leverage Cloud and Modular Architectures
4. Use Open-Source Technologies



Synthesize Barriers, Gaps, and Other Challenges for Forecast CI

1. Diverse Applications of Ecological Forecasts
2. Overcoming the Learning Curve and Barriers to Entry
3. Unsustainable Funding and Resourcing Models
4. Organizational Inertia and Misaligned Incentives
5. Challenge of Meaningful Stakeholder Engagement



Implement Common CI Design Principles Across Organizations

1. Build communities of practice around Ecological Forecast CI
2. Develop compelling communication materials on Ecological Forecast CI
3. Find and empower champions at various levels within agencies and equip them with communication tools
4. Expand the workforce and bridge expertise
5. Align with agency missions and priorities
6. Advocate for ecological forecasting CI



Workshop Outcomes

Open-access, version-controlled online document in GitHub.

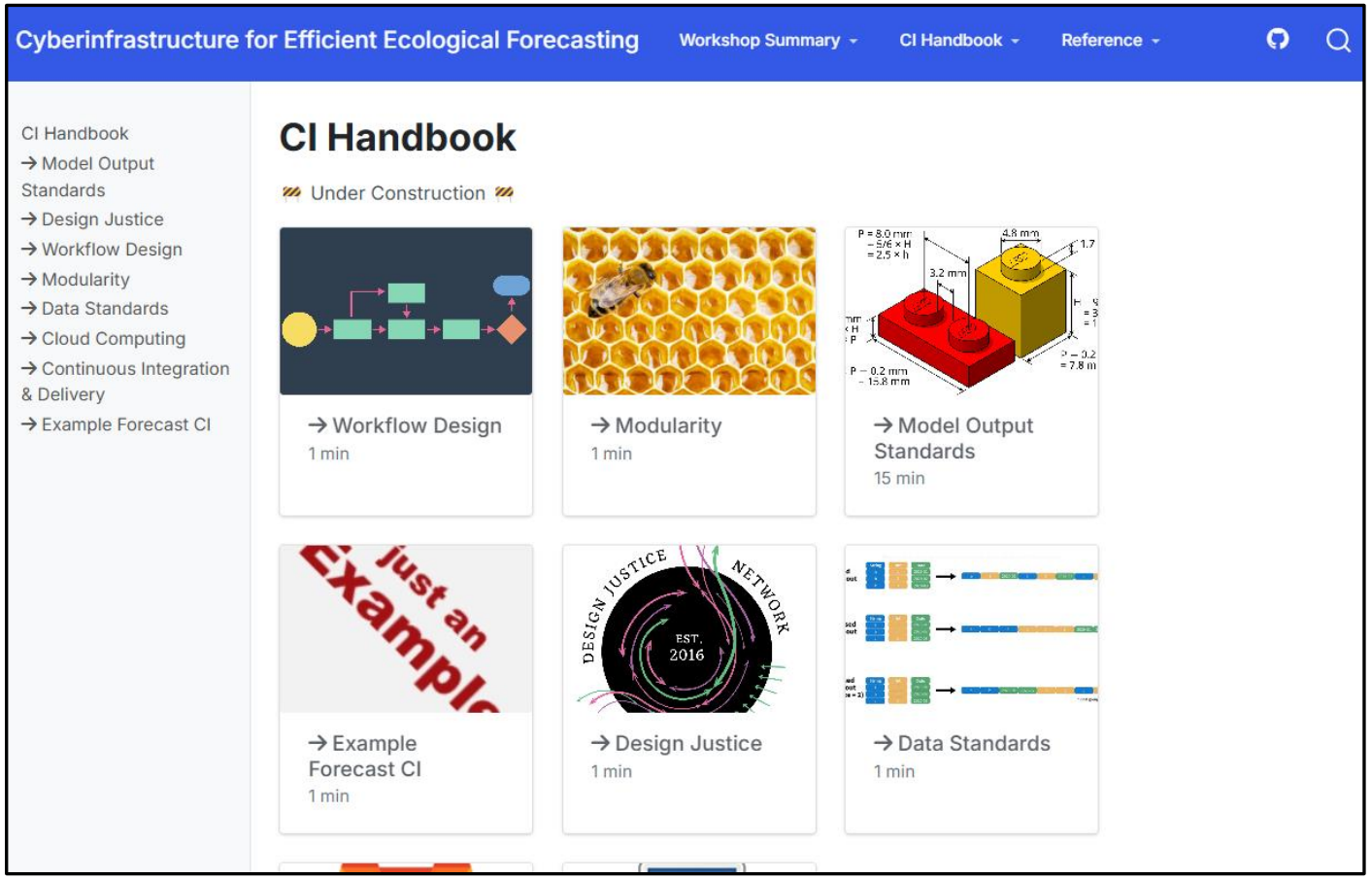


Contribute!

https://github.com/eco4cast/efi-ci-workshop-2024

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Next Steps

- Potential follow up workshop to advance ecological forecasting CI technical aspects.
- Interested in learning more please contact:
  - Jacob Zwart - jzwart@usgs.gov

Ecological Forecasting Initiative
Cyberinfrastructure (CI) Workshop 2024

