



Initial progress toward ecosystem accounts in the United States

Ken Bagstad, Carter Ingram, and Carl Shapiro



Acknowledgements

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NCA in the U.S.: USGS-SESYNC working group

- **Goal:** By 2019, we will have demonstrated that NCA in the US is feasible and we will illustrate how to achieve that
- **Objectives:**
 - Develop a methodological and institutional strategy for NCA in the US
 - Develop the “proof of concept” for NCA in the US
 - Raise awareness of NCA among key private and public stakeholders



The screenshot shows the USGS website header with the logo and tagline "science for a changing world". The main navigation bar includes "Home", "About", "Projects", "Publications and Other Products", and "Proposal Process". Below this, there are links for "Participant Information", "Contact", and "NSF Internships". The main content area is titled "Powell Center Working Group Project Information" and "Accounting for U.S. ecosystem services at national and subnational scales". It lists the Principal Investigator(s) as Kenneth J Bagstad, Jane Carter Ingram, and Carl D Shapiro. The Award Date is 2017. There is an image of a city skyline with a park in the center. To the right of the image is a text block explaining ecosystem services and their benefits. At the bottom, there is a caption about a memo issued by the White House Council on Environmental Quality in October 2015.

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Powell Center Working Group Project Information
Accounting for U.S. ecosystem services at national and subnational scales

Principal Investigator(s):
Kenneth J Bagstad (*Geosciences and Environmental Change Science Center*)
Jane Carter Ingram (*Ernst and Young*)
Carl D Shapiro (*Science and Decisions Center*)

Award Date: 2017



Ecosystem services - the benefits that nature provides to society and the economy - are gaining increasing traction worldwide as governments and the private sector use them to monitor integrated environmental and economic trends. When they are well understood and managed, ecosystems can provide these long-term benefits to people - such as clean air and water, flood control, crop pollination, and recreational, cultural, and aesthetic benefits. Within the U.S. government, a memo issued by the White House Council on Environmental

Quality in October 2015 charged agencies with incorporating these values in planning, investment, and regulatory processes.

tinyurl.com/us-nca

Multi-year workplan

- **2016-2017:**

- Introductory journal article on NCA in the U.S.

- First iteration U.S. & subnational land account

- First iteration U.S. & subnational water account

- Solicit critical feedback on land & water accounts

- **2017-2019:**

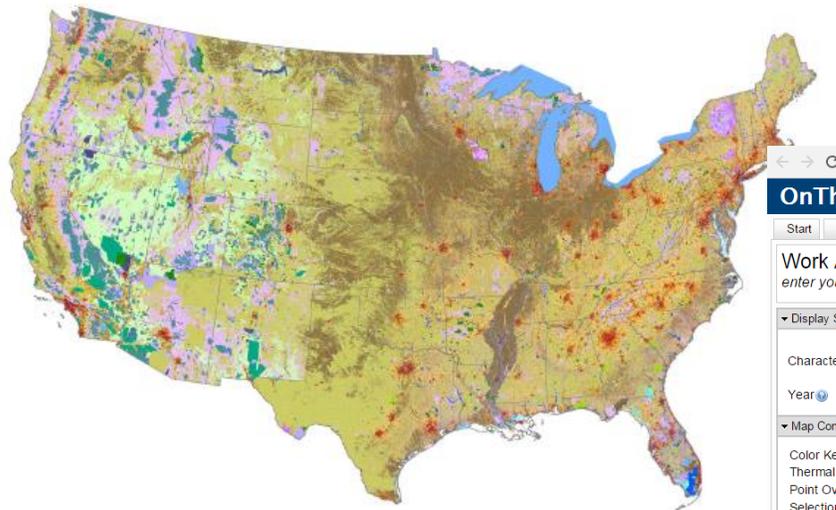
- Second iteration U.S. & subnational land & water accounts

- Pilot test national-scale ecosystem accounts for selected
ecosystem services

- Conduct public & private-sector outreach

Land use: putting beneficiaries on the map for land & ecosystem accounts

Census OnTheMap: Locates jobs by NAICS code



OnTheMap

Work Area Profile Analysis
enter your own subtitle

Display Settings

Characteristic Filter: NAICS Industry Sector: Manufacturing
Year: 2012

Map Controls

Color Key

Thermal Overlay

Point Overlay

Selection Outline

Identify Zoom to Selection

Clear Overlays Animate Overlays

Report/Map Outputs

Detailed Report

Export Geography

Print Chart/Map

Legends

- 5 - 194 Jobs/Sq.Mile
- 195 - 761 Jobs/Sq.Mile
- 762 - 1,706 Jobs/Sq.Mile
- 1,707 - 3,030 Jobs/Sq.Mile
- 3,031 - 4,732 Jobs/Sq.Mile
- 1 - 3 Jobs
- 4 - 47 Jobs
- 48 - 235 Jobs
- 236 - 741 Jobs
- 742 - 1,809 Jobs

Analysis Selection

Change Settings

Job Counts by NAICS Industry Sector in 2012

View as: Bar Chart

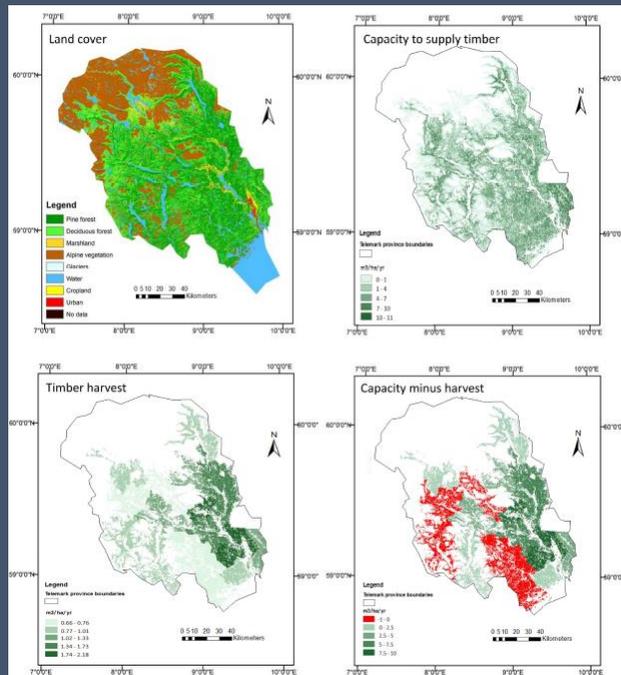
Job Counts by NAICS Industry Sector 2012

NAICS Industry Sector	Count	Share
Total All Jobs	95,252	100.0%
Agriculture, Forestry, Fishing and Hunting	1,149	1.2%
Mining, Quarrying, and Oil and Gas Extraction	25	0.0%
Utilities	581	0.6%
Construction	3,818	4.0%
Manufacturing	16,998	17.8%
Wholesale Trade	3,646	3.8%
Retail Trade	12,504	13.1%
Transportation and Warehousing	1,974	2.1%
Information	830	0.9%
Finance and Insurance	1,983	2.1%
Real Estate and Rental and Leasing	800	0.8%
Professional, Scientific, and Technical Services	2,491	2.6%
Management of Companies and Enterprises	1,466	1.5%
Administration & Support, Waste Management and Remediation Services	5,191	5.4%

Theobald 2014

Mapping beneficiaries & ES flows in accounting

- Key concepts defined by Hein et al. (2016)
- Approaches tested for the Pacific Northwest USA (Bagstad et al. 2014); Norway (Schroter et al. 2014)



RESEARCH ARTICLE

Defining Ecosystem Assets for Natural Capital Accounting

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Abstract

In natural capital accounting, ecosystems are assets that provide ecosystem services to people. Assets can be measured using both physical and monetary units. In the international System of Environmental-Economic Accounting, ecosystem assets are generally val-

OPEN ACCESS

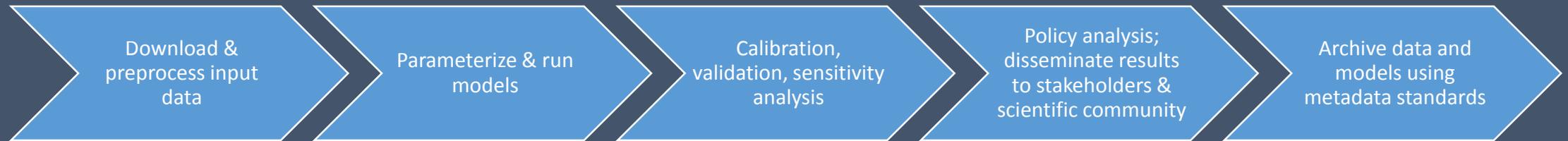
Citation: Hein L, Bagstad K, Edens B, Obst C, de Jong R, Lesschen JP (2016) Defining Ecosystem

Next working group meetings (May & late 2017)

- Which ecosystem services & geographies will we analyze?
 - Start smaller (state or large watershed), work up to national scale
 - 2001-2006-2011, with 2016 added late next year
- Which datasets and models can most credibly quantify ecosystem services in a large, heterogeneous country?
- How can we speed the process in ways that will make the job easier for us and others in the future (i.e., cloud/supercomputing, context-aware modeling, GIS tools)?
 - *3 C's: Collaborative, cloud-based, context-aware*

Speeding the process: Standard data & modeling flow

- First time running an environmental modelers:



- Second, third, fourth time:

Same thing!

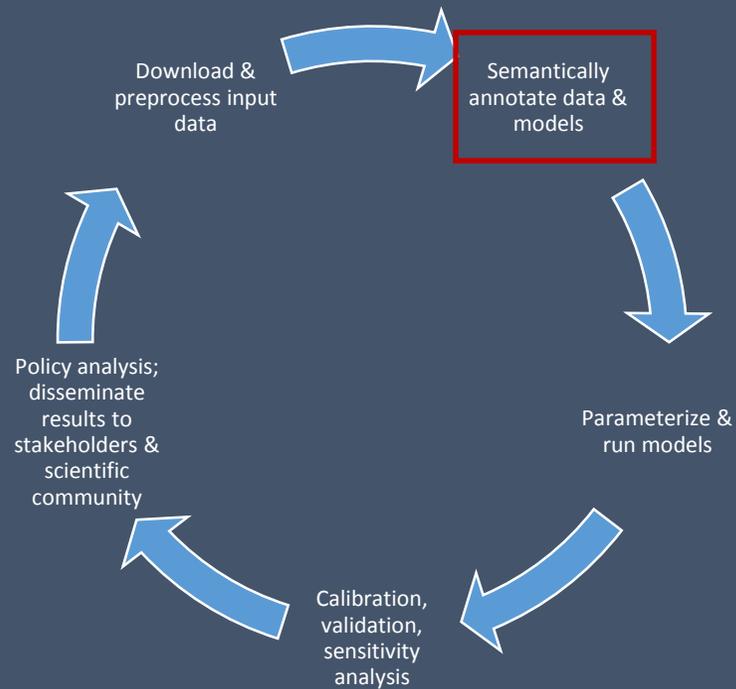


At the end of the project, budgets are tight, and people want to get the paper/report out without worrying about proper archiving

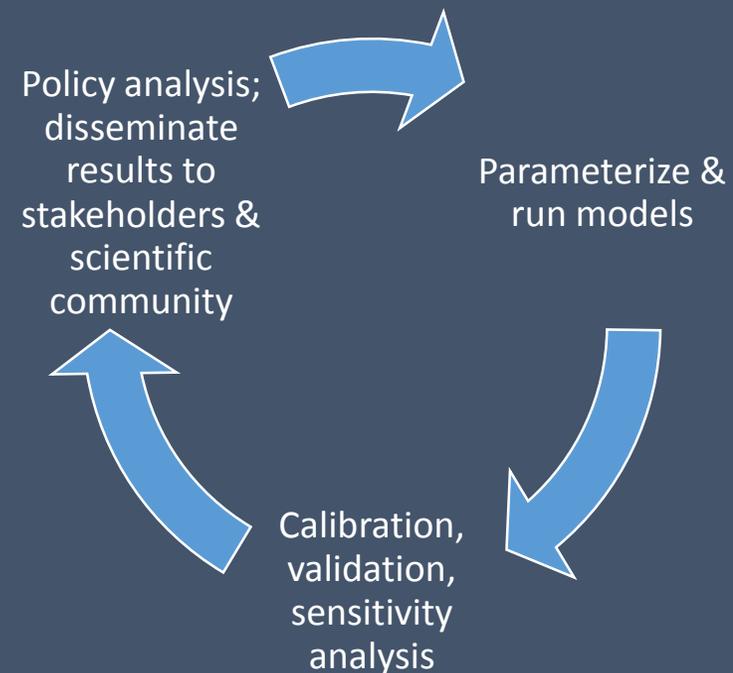


Speeding the process: Semantic data & modeling flow in ARIES

- First time modelers:



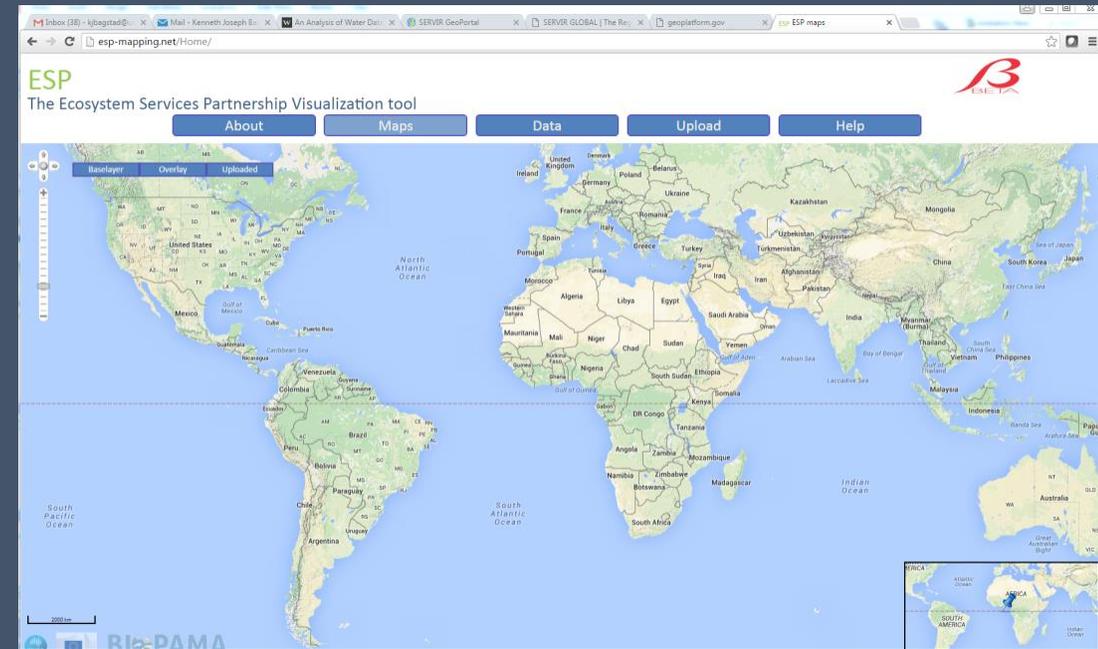
- Second, third, fourth time modelers:



- Archival work is up front, after that it's usable by anyone

Collaboration: how well do we currently share data?

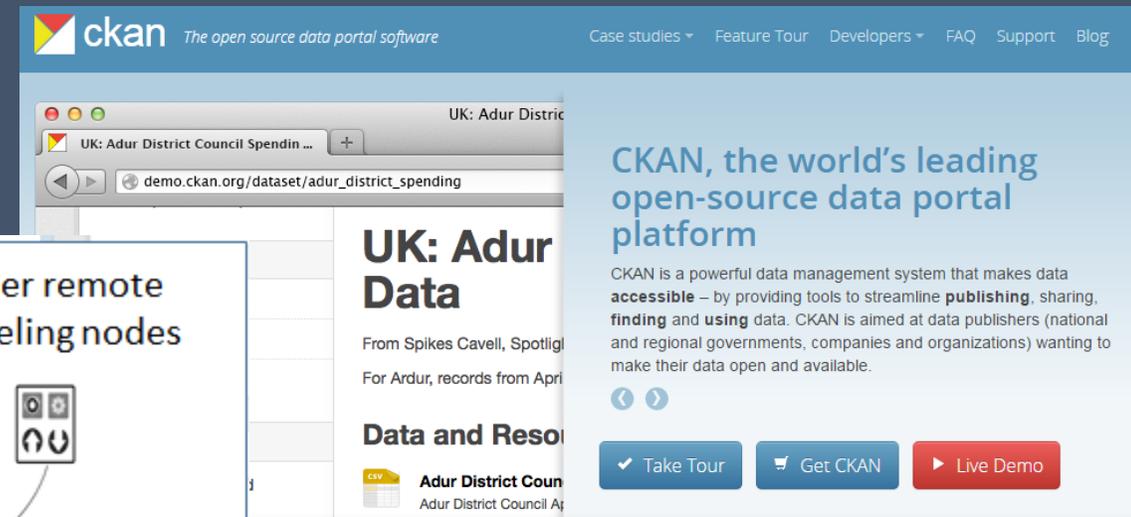
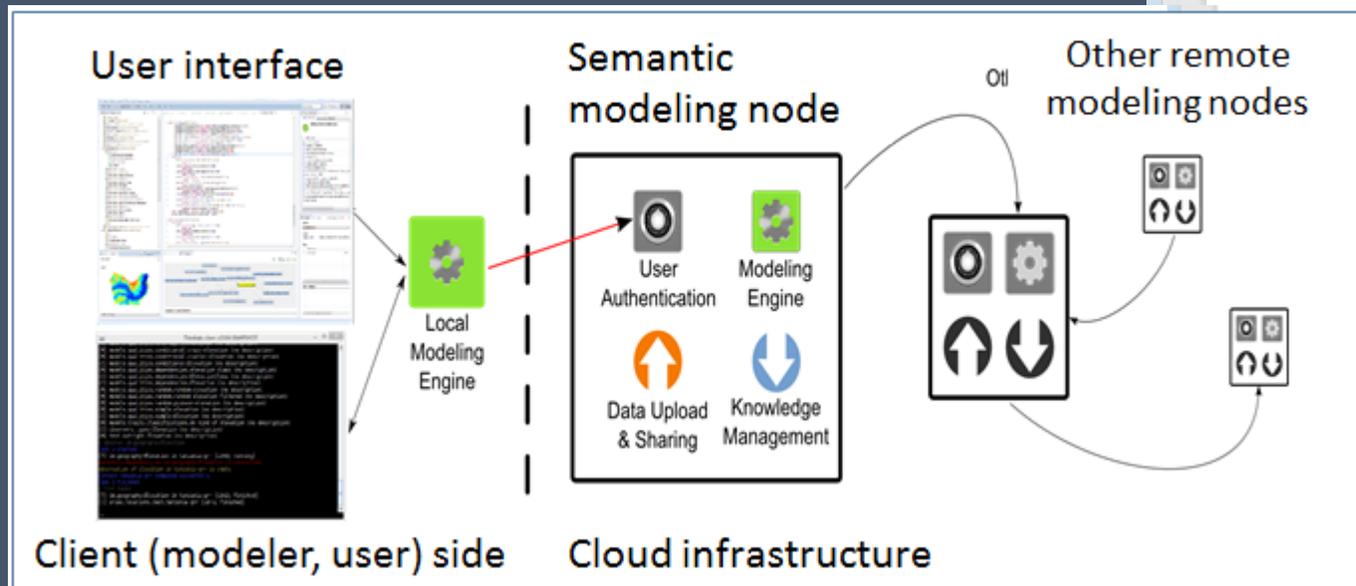
- ESP Visualization Tool (Drakou et al. 2015) has been online since January 2015, and currently hosts 29 ecosystem service maps derived from 9 studies
 - What are our data sharing & documentation incentives (new open data initiatives?)
 - Why not use Open Geospatial Consortium (OGC) standards & make it machine readable?



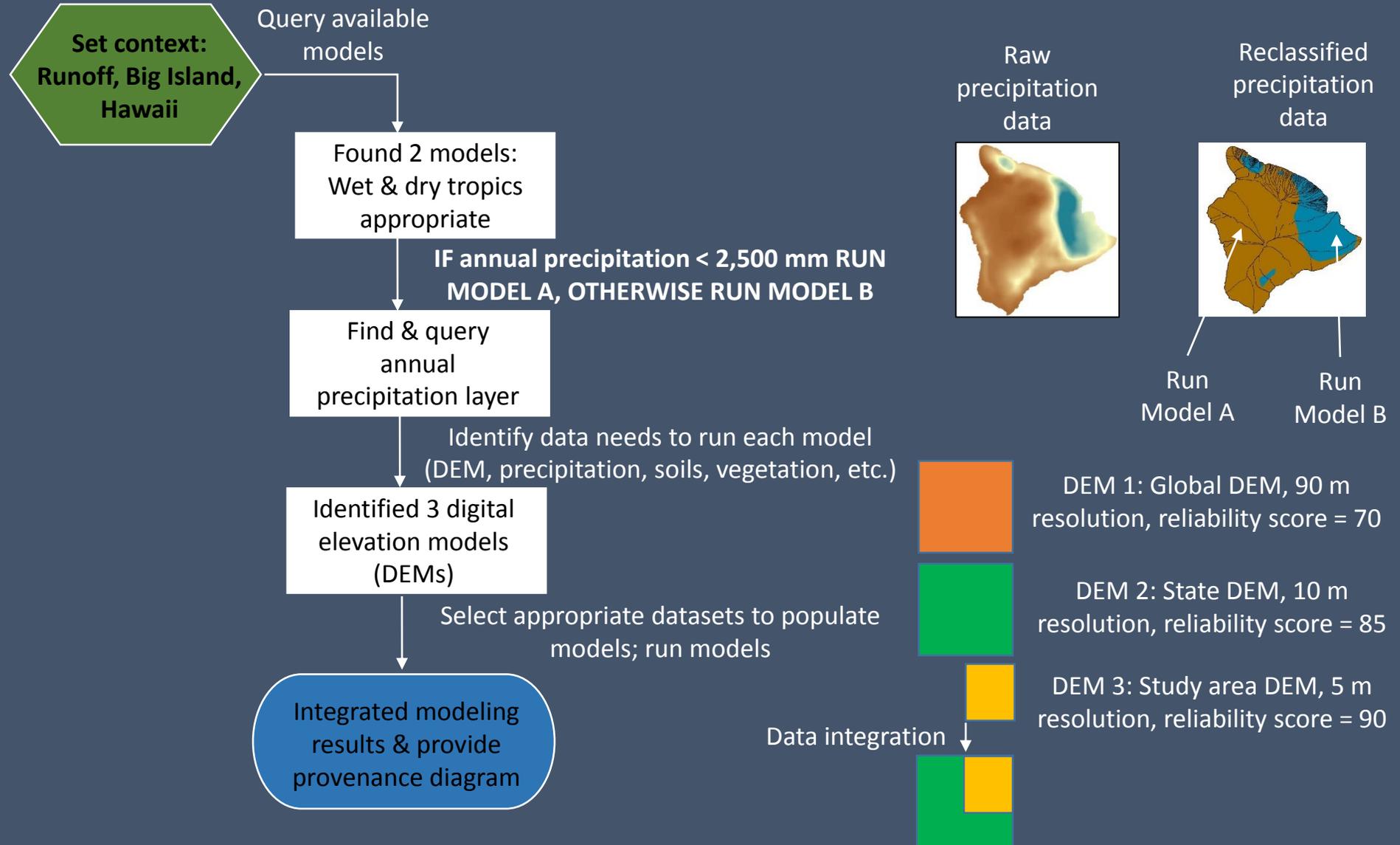
www.esp-mapping.net

Collaboration facilitated with *cloud-based* data and models

- Machine-readable datasets, served by using OGC standards (e.g., Web Coverage Service (WCS)/Web Feature Service (WFS), JSON)
- Data export protocols (e.g., CKAN)



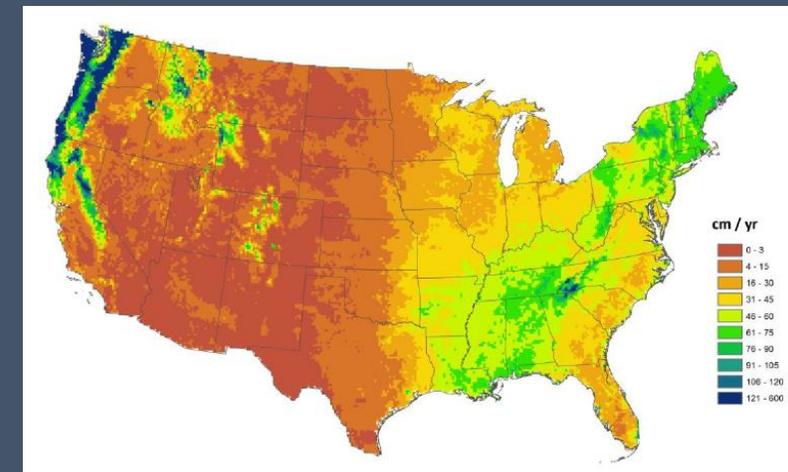
Heterogeneous environments necessitate *context awareness*: automates data & model assembly using best available knowledge



Existing environmental & ecosystem service models

- LandCarbon
- SPARROW (nutrient models)
- Various water models (e.g., Brown et al. 2016)
- National pollination assessment (Koh et al. 2016)
- National coastal flood models (e.g., Narayan et al. 2016)
- Past InVEST, ARIES, or other ES model applications (need to be context-aware)
- Models already in or being ported into ARIES: distributed water model, LPJ-GUESS, InVEST models, some ESTIMAP models

Brown et al. 2016



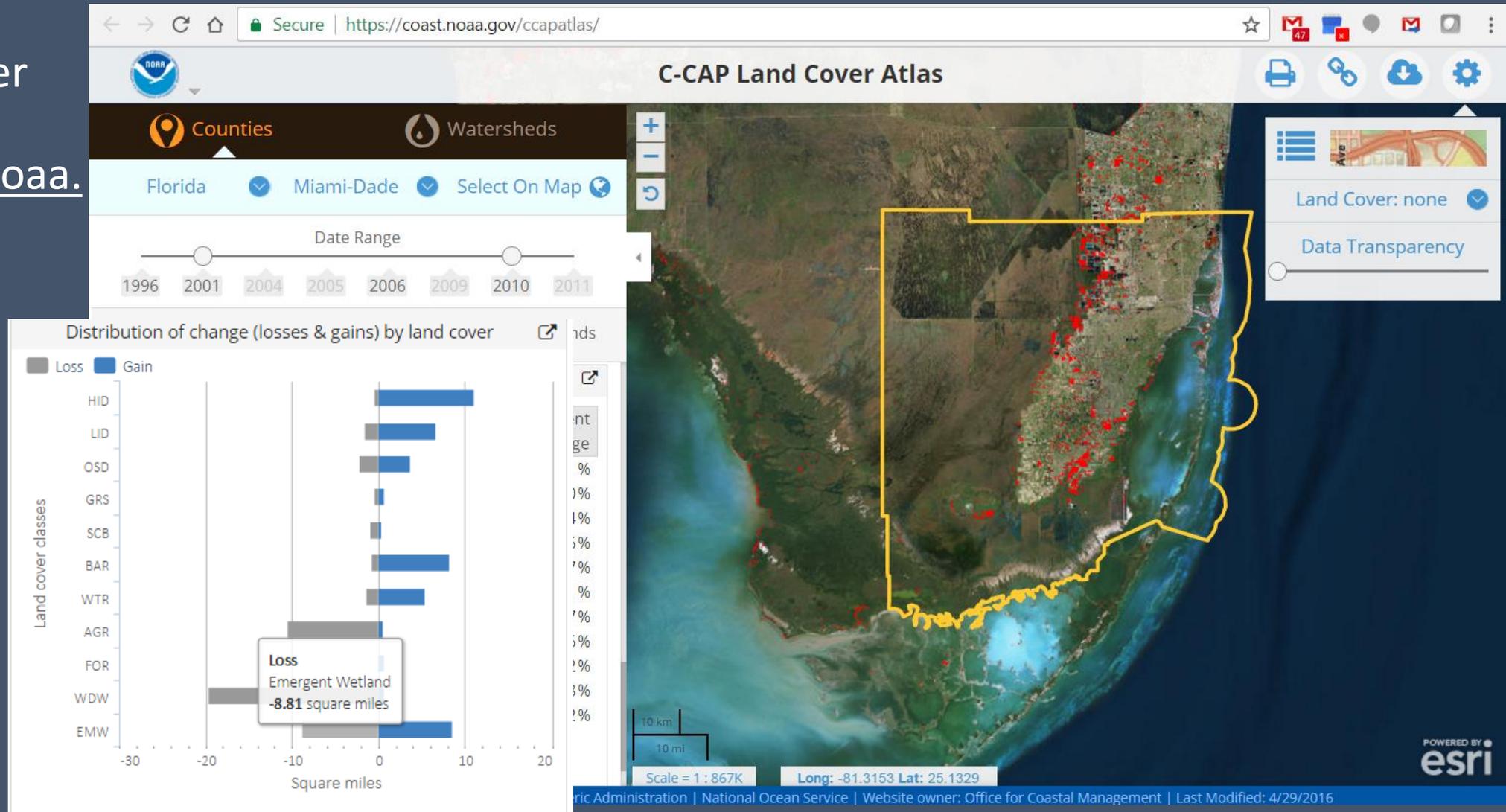
Key EO datasets

National Land Cover Dataset	Potential ecosystems (USGS)
National Land Use Dataset	Census TIGER & Homeland Security (infrastructure)
National Hydrography Dataset	Cropland Data Layer (USDA)
LANDFIRE (forests & forestry)	Census LEHD (employment by industry)
PRISM (climate)	Census (demographics)
GAP (ecosystems, biodiversity)	National Flood Hazard Dataset
National Elevation Dataset	GeoMAC (wildfire)

Most at 30 m spatial resolution, updated periodically (annually to decadal)
Hosted on GeoServer (OGC-compliant) for machine readability

Tools to speed ecosystem accounting

- CCAP Land Cover Atlas (<https://coast.noaa.gov/ccapatlas/>)



Tools to speed ecosystem accounting

The screenshot shows the ArcMap interface with the following components:

- Table Of Contents:** Lists layers including 'District_boundary' and 'Carbon storage, 2000 (T)'. A legend below shows five color-coded carbon storage ranges in T (Tera-tonnes):
 - 90.19999695
 - 90.19999696 - 134.5599955
 - 134.5599956 - 199.7952875
 - 199.7952876 - 361.5788118
 - 361.5788119 - 752.9905639
- ArcToolbox:** The 'Ecosystem Accounting Tools' folder is expanded, showing the 'Additions & Reductions Ecosystem Accounting Tool' selected.
- Additions & Reductions Ecosystem Accounting Tool Dialog:** A dialog box with the following fields:
 - Input Raster (Opening Stock):** Carbon storage, 2000 (T)
 - Input Raster (Closing Stock):** Carbon storage, 2010 (T)
 - Output Raster (Net Change):** D:\Rwanda_Natural_Capital\Tool_For_Add_Reductions\Subtract_Output\CON_00_90.tif
 - Output Raster (Additions):** D:\Rwanda_Natural_Capital\Tool_For_Add_Reductions\Conditional_Output\POS_00_90.tif
 - Output Raster (Reductions):** D:\Rwanda_Natural_Capital\Tool_For_Add_Reductions\Conditional_Output\NEG_00_90.tif
- Input Raster (Closing Stock) Description:** A text box explaining the closing stock input: "Input Closing Stock raster dataset (The most recent year of the two input datasets)".

Summary

- We need new tools and approaches to:
 - 1) Simulate ecosystem services accurately across large, heterogeneous contexts
 - 2) Leverage supercomputing/cloud computing power to work at high spatiotemporal resolution *and* large extent
 - 3) Build on each others' work, rather than start at square one (i.e., enable collaborative modeling and reuse of growing data archives, incl. EO, crowdsourced data) – semantics, machine readability
 - 4) Allow relatively quick and easy updating of ecosystem accounts in new years
- 3 C's: Coding data & models within a collaborative, cloud-based, context-aware approach like ARIES is a promising technique to meet these challenges