# Science, Technology, and Policy Rising to the Challenge of Food Security

Brian Wee, Ph.D.
Chief of Strategic Alliances
National Ecological Observatory Network (NEON), Inc.

2014-08-18
Cyberinfrastrucure and Water Resources in the Lower Mekong Region











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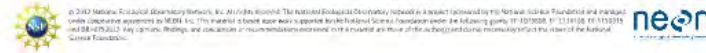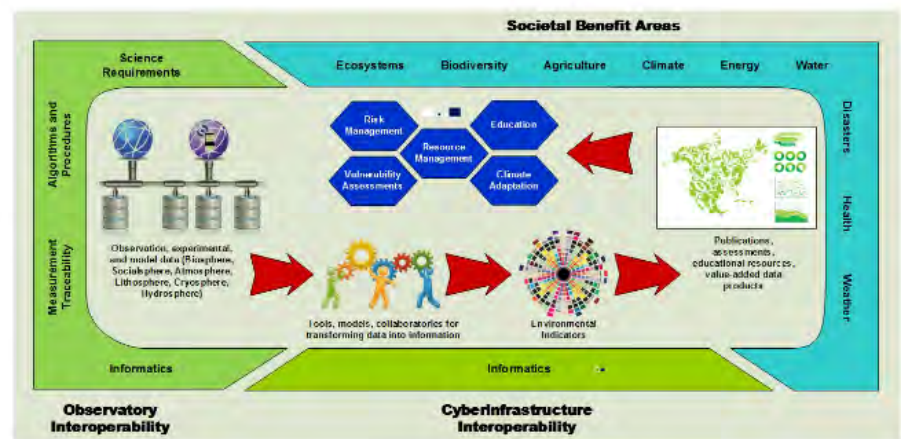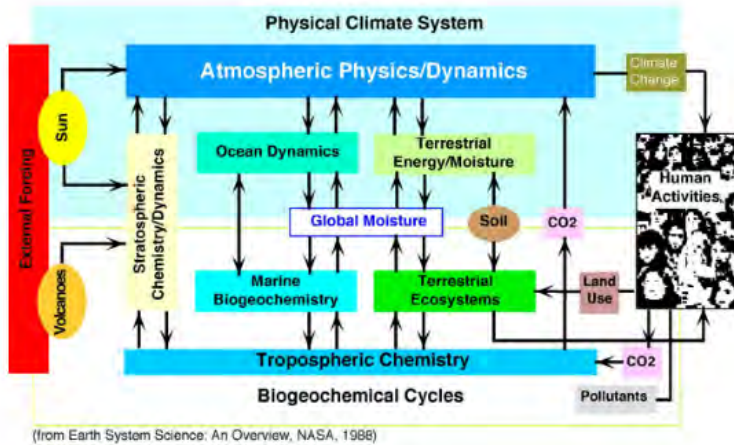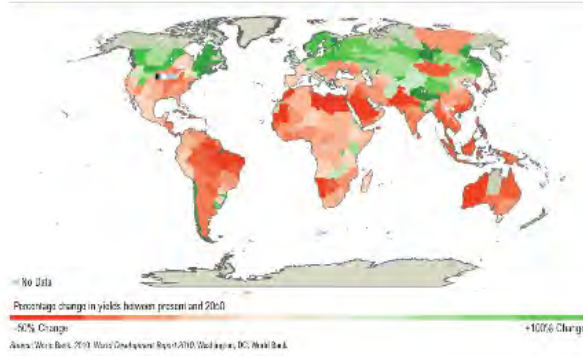Cyberinfrastrucure and Water Resources in the Lower Mekong Region

Figure 2 | Climate Change Is Projected to Impact Crop Yields (3° C World)

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# The New Geopolitics of Food

From the Middle East to Madagascar, high prices are spawning land grabs and ousting dictators. Welcome to the 21st-century food wars.

BY LESTER R. BROWN | MAY/JUNE 2011

In the United States, when world wheat prices rise by 75 percent, as they have over the last year, it means the difference between a $2 loaf of bread and a loaf costing maybe $2.10. If, however, you live in New Delhi, those skyrocketing costs really matter: A doubling in the world price of wheat actually means that the wheat you carry home from the market to hand-grind into flour for chapatis costs twice as much. And the same is true with rice. If the world price of rice doubles, so does the price of rice in your neighborhood market in Jakarta. And so does the cost of the bowl of boiled rice on an Indonesian family's dinner table.

How can the world feed more than 9 billion people by 2050 in a manner that advances economic development and reduces pressure on the environment?

Source: WRI (Searchinger et al 2013)

**Figure 1 | 37% of Earth's Landmass (Ex-Antarctica) is Used for Food Production (100% = 13.3 billion hectares)**

- Cultivated Crops
- Pastures and Meadows
- Other Grasslands/ Woodlands
- Forests
- Sparsely Vegetated/ Barren*
- Inland Water
- Urban

*Percentages shown: 2%, 1%, 12%, 22%, 25%, 28%, 9%*
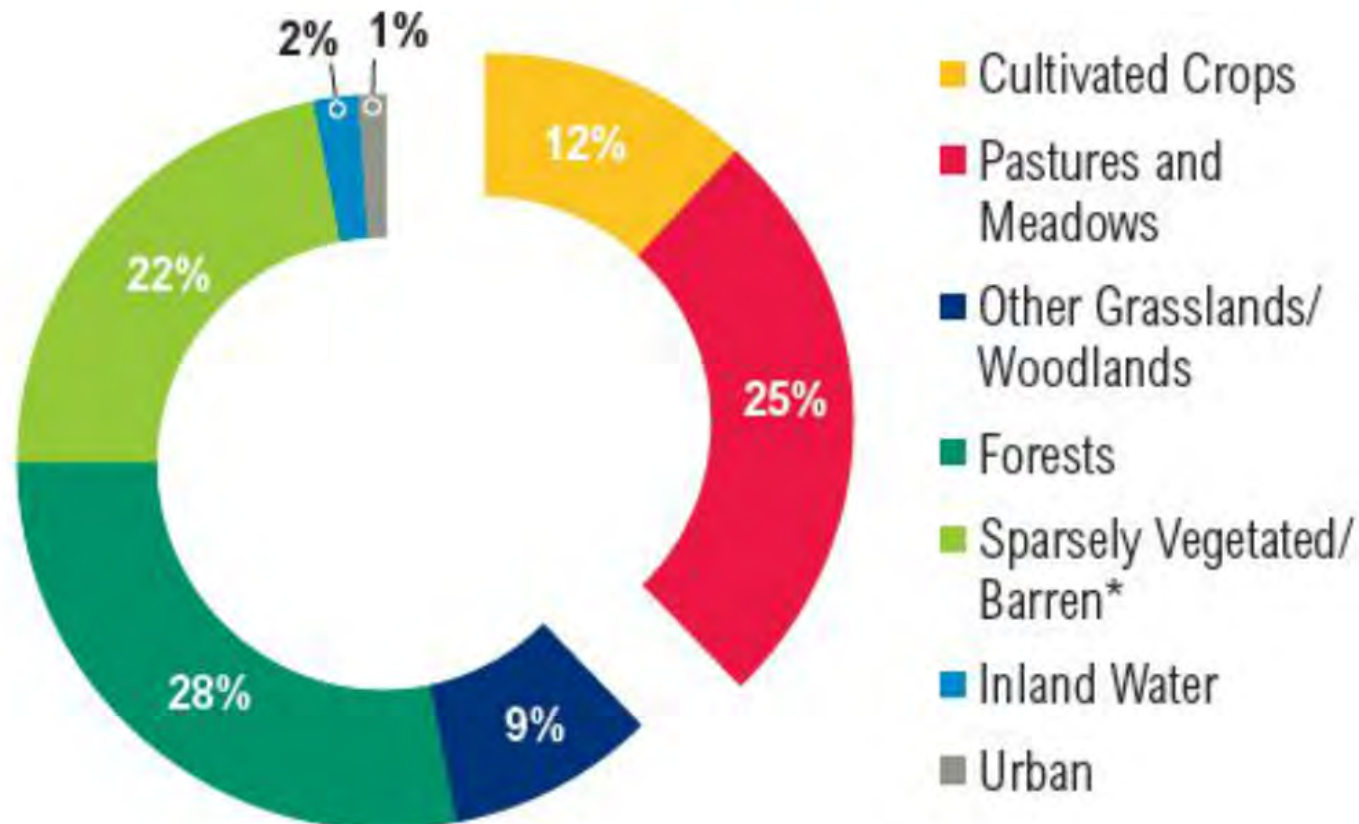
\* Permanent ice cover, desert, etc.

Note: Figures may not equal 100% due to rounding.

Source: FAO. 2011. *The State of the World's Land and Water Resources for Food and Agriculture*. Rome. FAO.

Figure 2 | **Climate Change is Projected to Impact Crop Yields (3° C World)**

No Data

Percentage change in yields between present and 2050

-50% Change                                                                 +100% Change
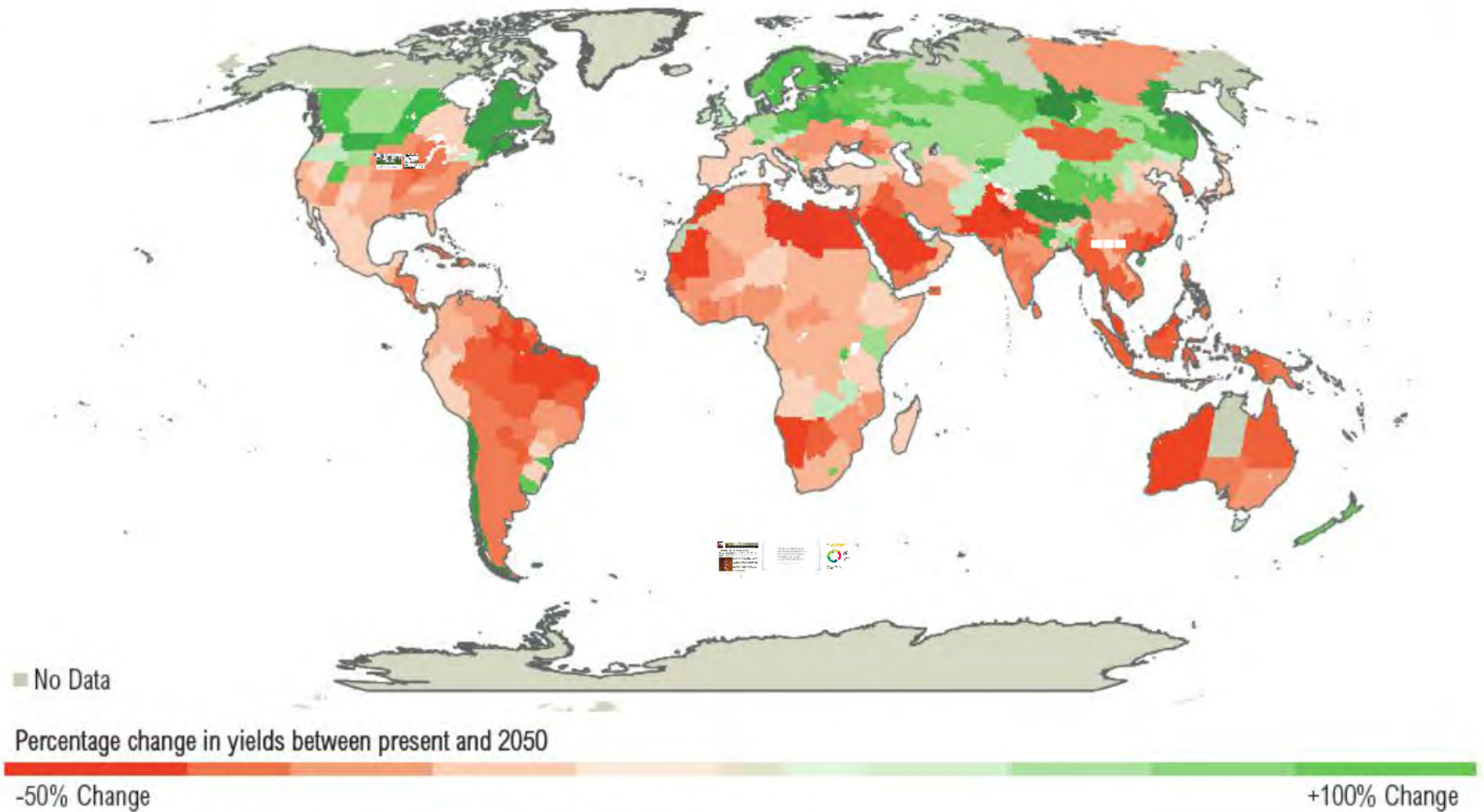
Source: World Bank. 2010. *World Development Report 2010*. Washington, DC: World Bank.
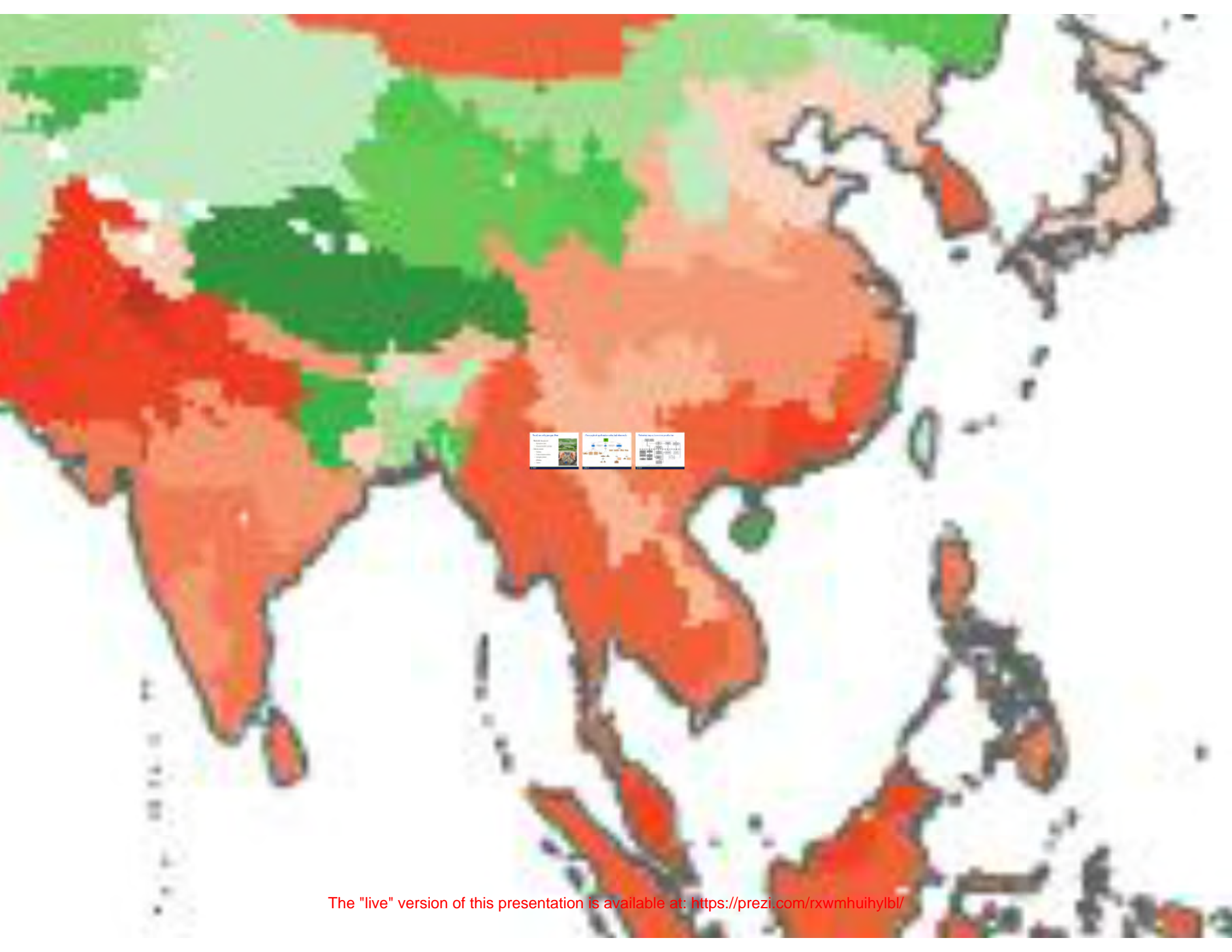
# Food security perspective

- ## Next slide focuses on:
    - ### Agriculture (rice)
    - ### Aquaculture (fish, shrimp)
- ## Not discussed:
    - ### Nutrition
    - ### Transportation systems
    - ### Storage systems
    - ### Wastage
    - ### Others

# Conceptual synthesis – selected elements
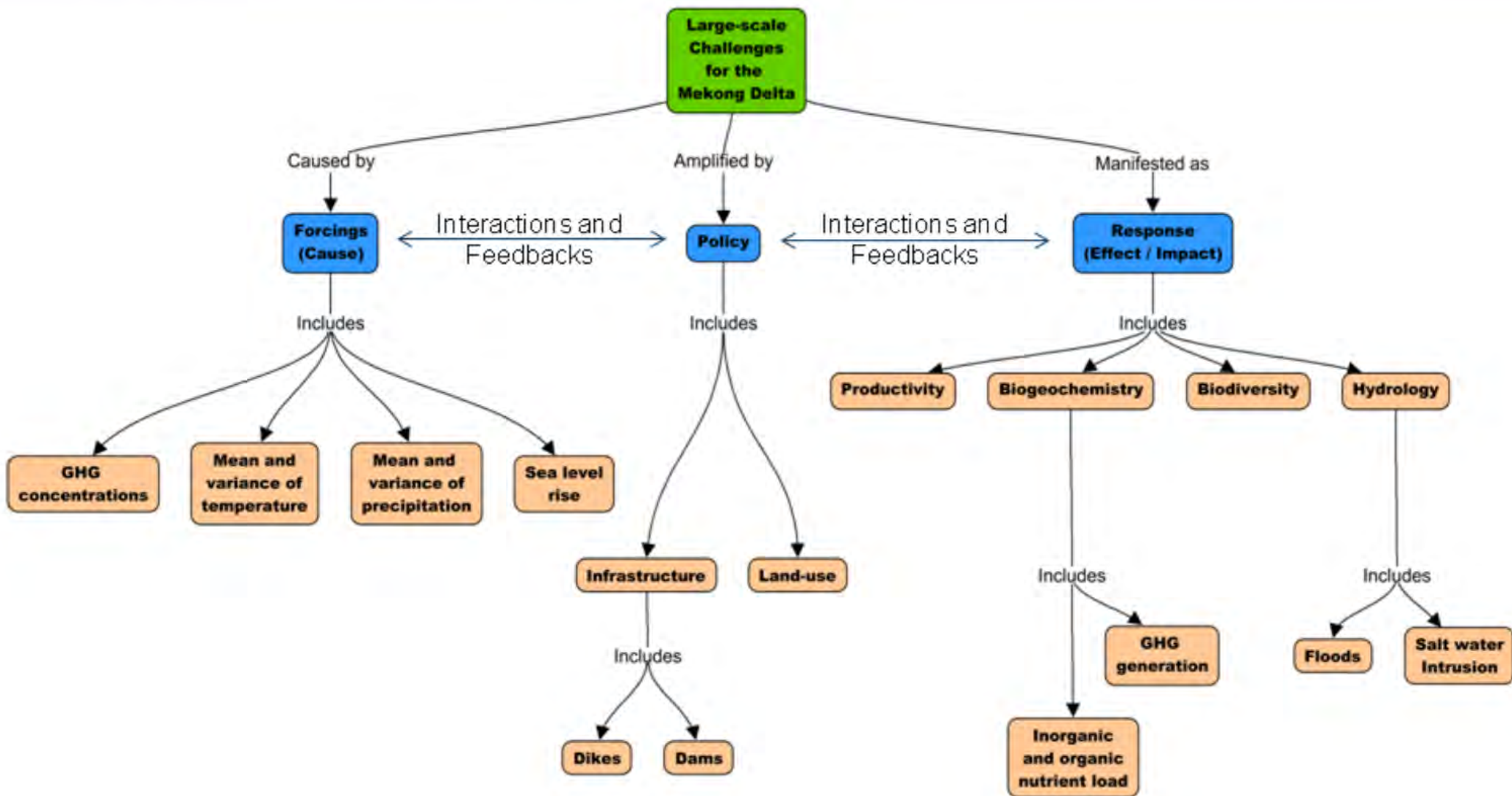
# Potential impacts on rice production
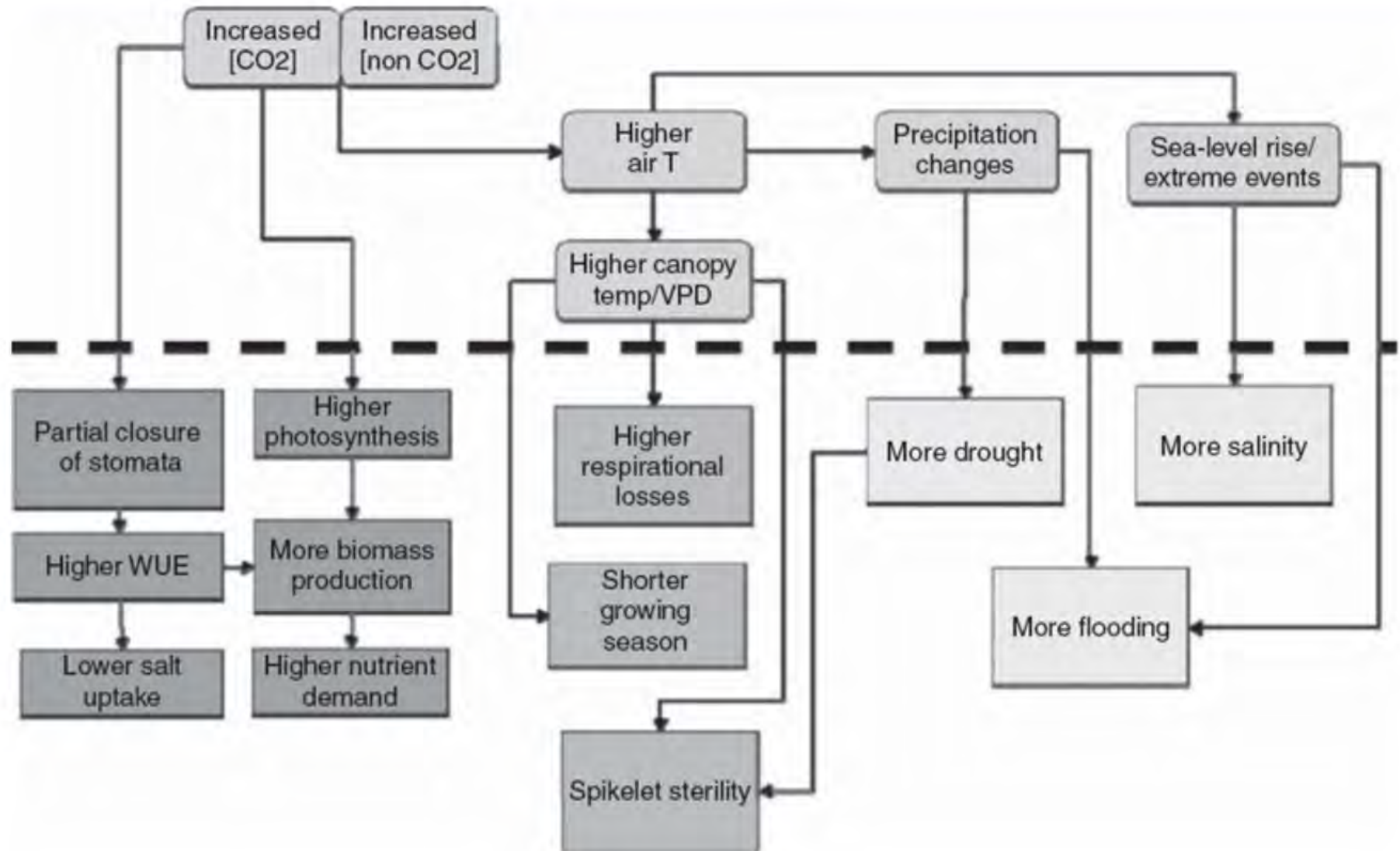


Source: Wassmann et al 2009; DOI: 10.1016/S0065-2113(09)01003-7
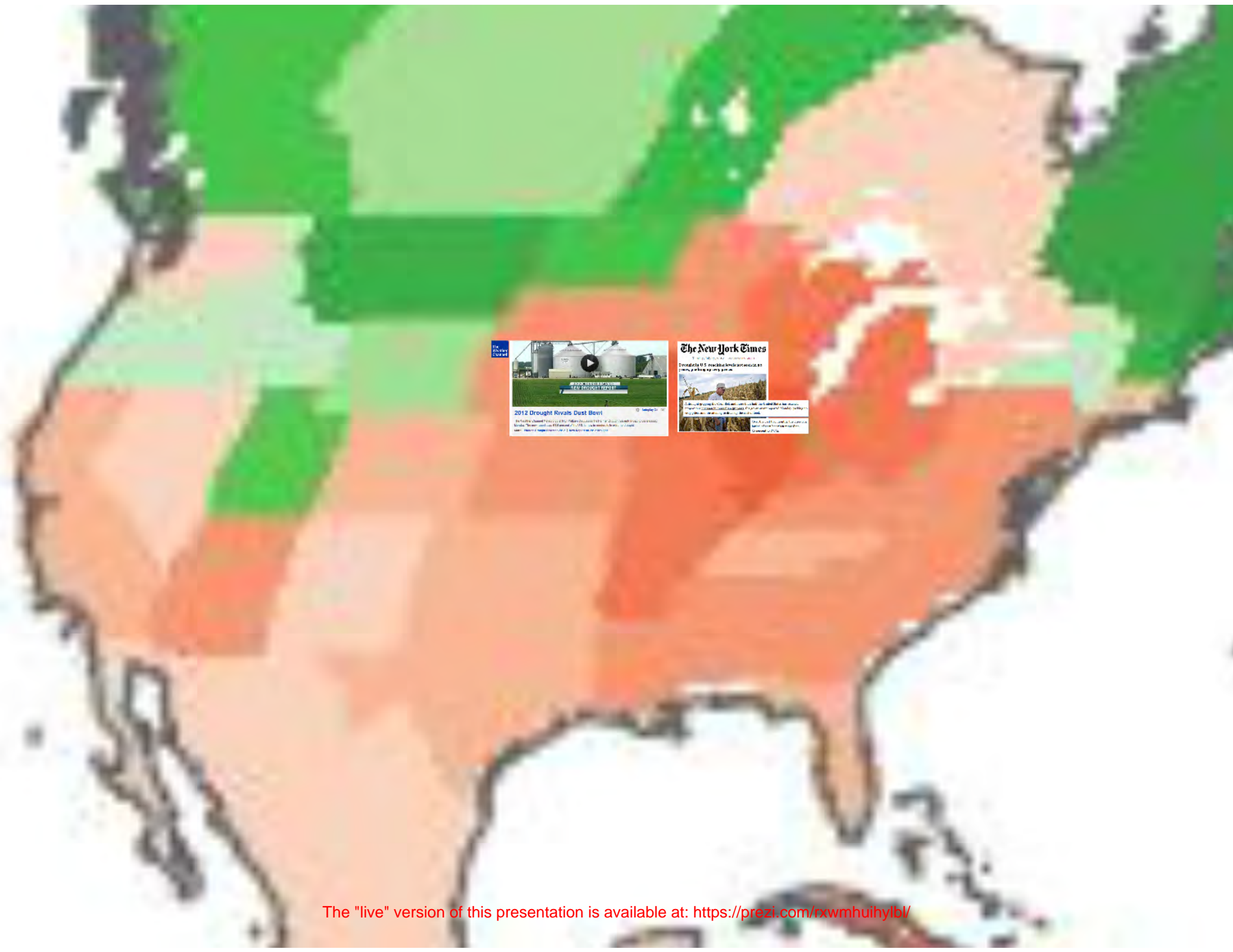
2012 Drought Rivals Dust Bowl

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**The Weather Channel**

**2012 DROUGHT DISASTER**
**NEW DROUGHT REPORT**

Autoplay On | Off

# 2012 Drought Rivals Dust Bowl

The Weather Channel Meteorologist Nick Wiltgen discusses the Palmer Drought Severity Index, to be released Monday. The new report says 54.6 percent of the U.S. is now in moderate to extreme drought.

More:  Photos: Drought Disaster 2012 | New Report on 2012 Drought

The "live" version of this presentation is available at: https://prezi.com/rxwmhuihylbl/

# The New York Times

Tuesday, July 17, 2012    Last Update: 8:59 AM ET

## Drought in U.S. reaching levels not seen in 50 years, pushing up crop prices



A drought gripping the Corn Belt and more than half the United States has reached proportions not seen in more than 50 years, the government reported Monday, jacking up crop prices and threatening to drive up the cost of food.

Over the past two months, the price of a bushel of corn has risen more than 50 percent to $7.72.

**Environmental Stressors**

Large-scale environmental stressors like climate-change, land-use change, and invasive species <u>impact</u> the nation's natural, managed, and urban landscapes.

*Complex interactions between stressors and impacts*

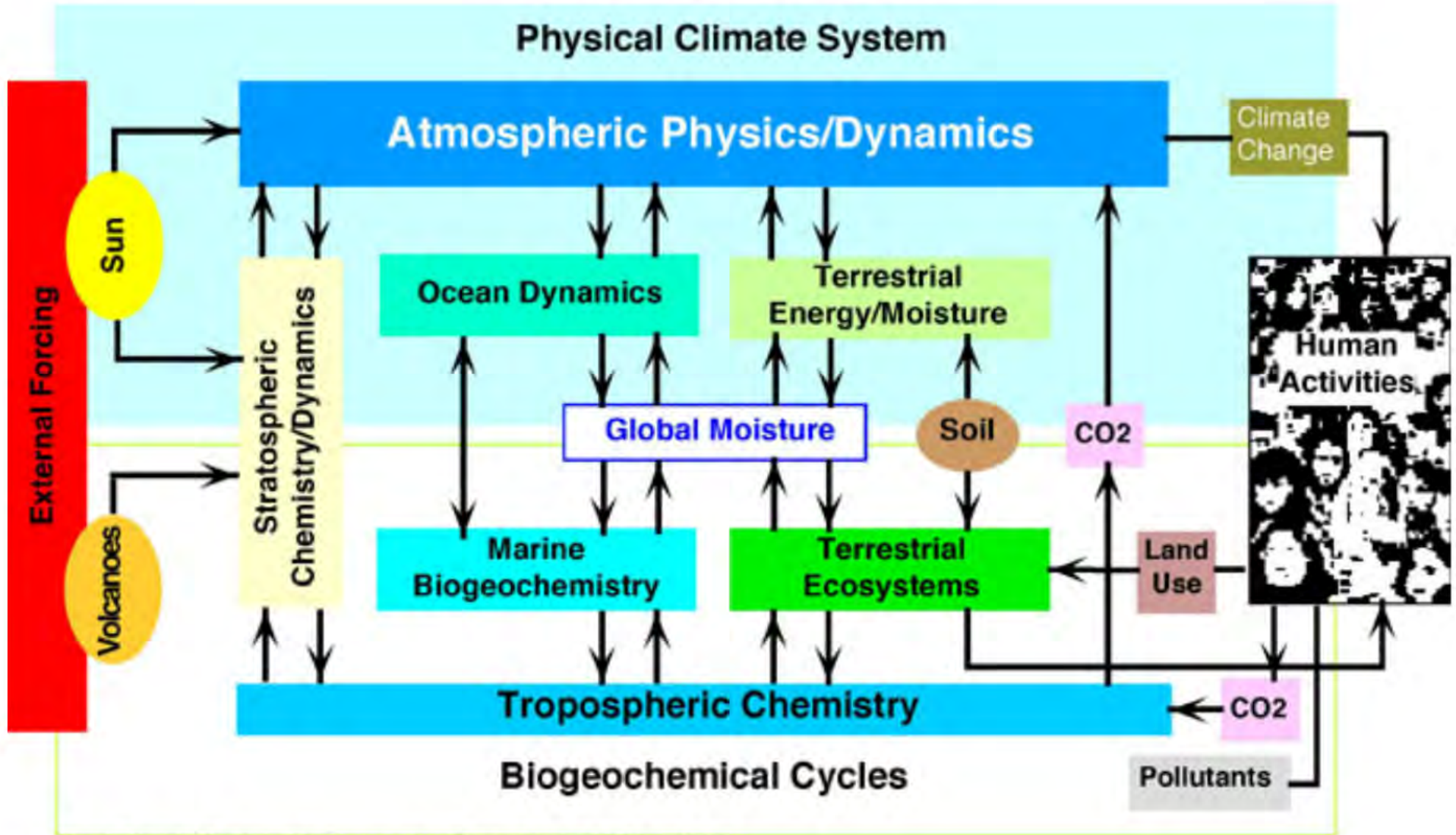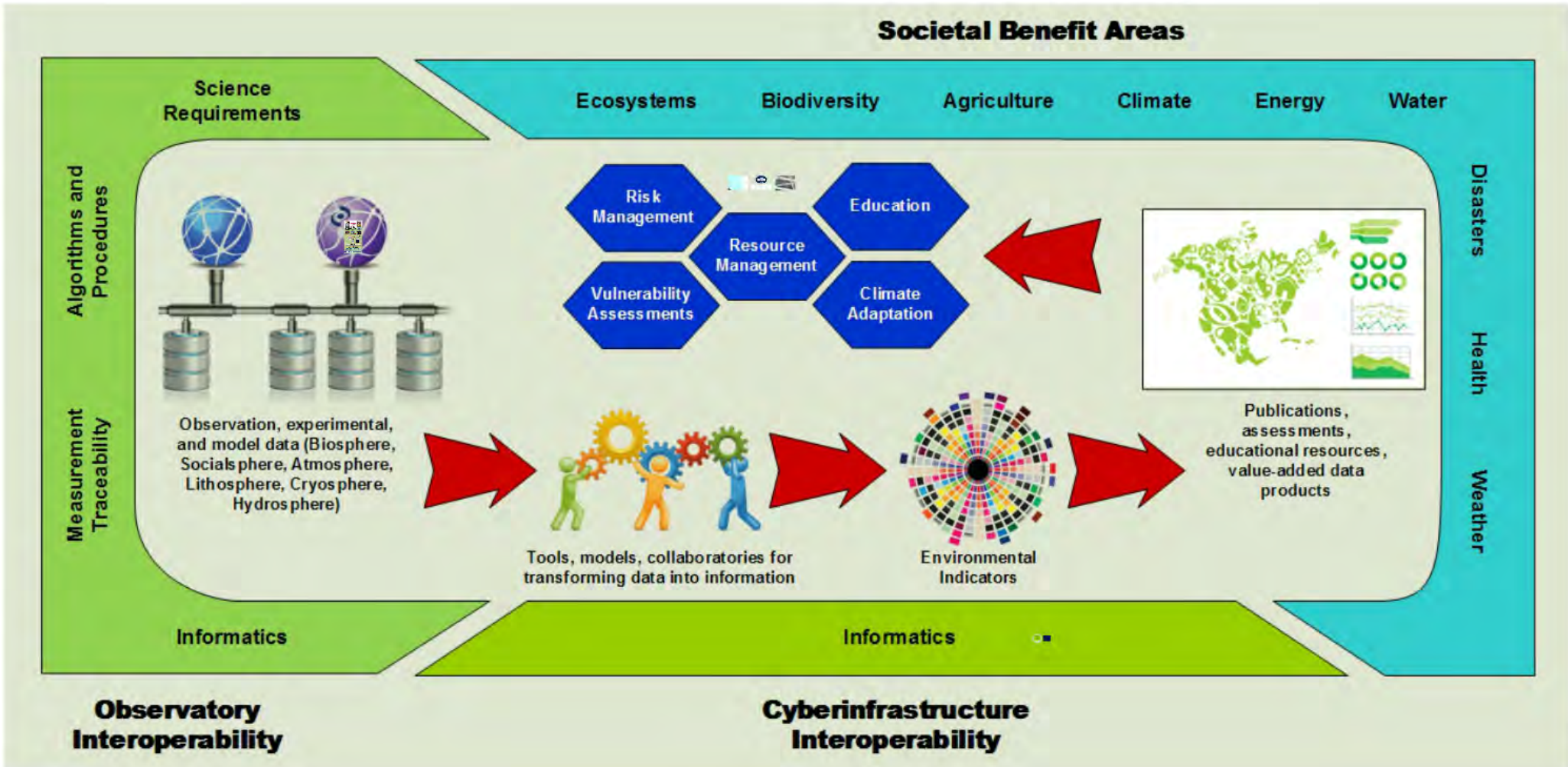These landscape impacts <u>modify</u> the strength and nature of the stressors through perturbations in land-surface reflectivity, water cycles, nutrient cycles, natural and anthropogenic gaseous emissions, and others.

Measurements of these stressors, their impacts, and the complex <u>interactions</u> between them, are captured by NEON's integrated observing infrastructure.

**Landscapes**

**NEON Site Constellation**

**NEON Airborne Platform**

**Existing Satellite Platforms**

Site-based measurements are used to calibrate and validate airborne measurements, and to produce regional-scale data.

Site-based and airborne measurements are used to calibrate and validate space-borne measurements, and to produce continental-scale data.

**NEON Data Products**

**Data Products from Credible Sources**

**INTEROPERABILITY**
Data, Tools, Workflows, Documentation

Data to support forecasting and decision making across a number of applications, like those stipulated in the Global Earth Observation System of Systems (GEOSS) Societal Benefit Areas:

Disasters   Health   Energy   Climate   Water   Weather   Ecosystems   Agriculture   Biodiversity

**THE PLANNED LIFETIME OF NEON**

| CONCEPT & DESIGN | SITES BUILT OUT | DATA COLLECTION |
|---|---|---|
| 2004-2011 | 2012 - 2017 | 2017 - 2046 |

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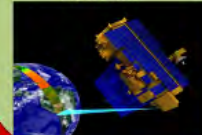
**Landscapes**

**NEON Site Constellation**

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## NEON Site Constellation
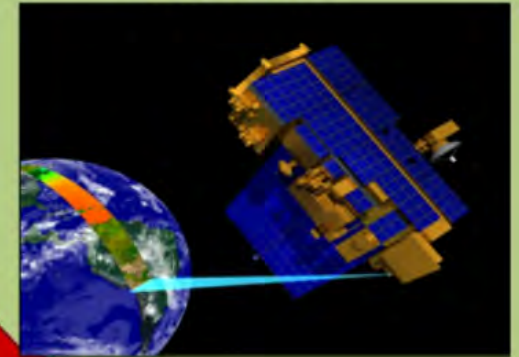
## NEON Airborne Platform

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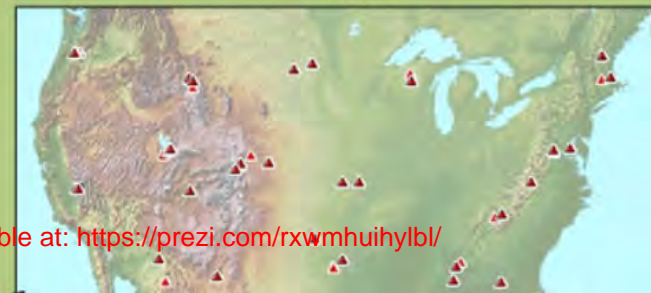
# NEON Science Strategy

**NEON Core** ● **NEON Relocatable** ▲ **NEON Aquatic** ● **NEON STREON** ■ **LTER Sites** ◆

The "live" version of this presentation is available at: https://prezi.com/rxwmhuihylbl/

# Terrestrial Instrument Measurements

Atmospheric measurements include:

- Key climate inputs

- Bioclimate variables

- Chemical climate inputs

- Carbon cycle changes

- Water cycle and surface energy balance

Soil observations include:

- Temperature profiles

- Soil moisture profiles

- Carbon dioxide

- Root growth and phenology

# Terrestrial Organismal Sampling

- Plant biodiversity
- Plant biomass, leaf area, and chemical composition
- Plant phenology
- Birds
- Ground beetles
- Mosquitoes
- Small mammals
- Infectious disease
- Biogeochemistry
- Soil microbes
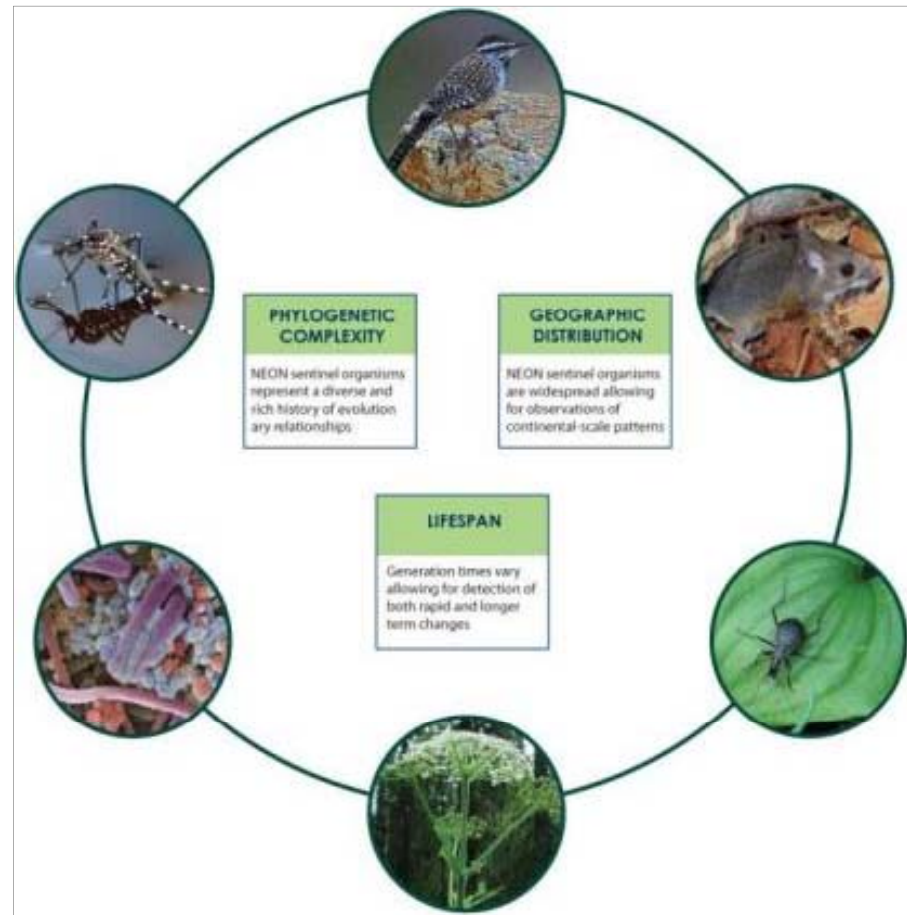
# Aquatic Sampling

- Algae
- Aquatic macrophytes, bryophytes, and lichens
- Aquatic microbes
- Isotopes
- Aquatic invertebrates and zooplankton
- Fish
- Surface-water and ground-water
- Sediment
- Aquatic habitat

# NEON Airborne Observations

## 1. Spectrometry
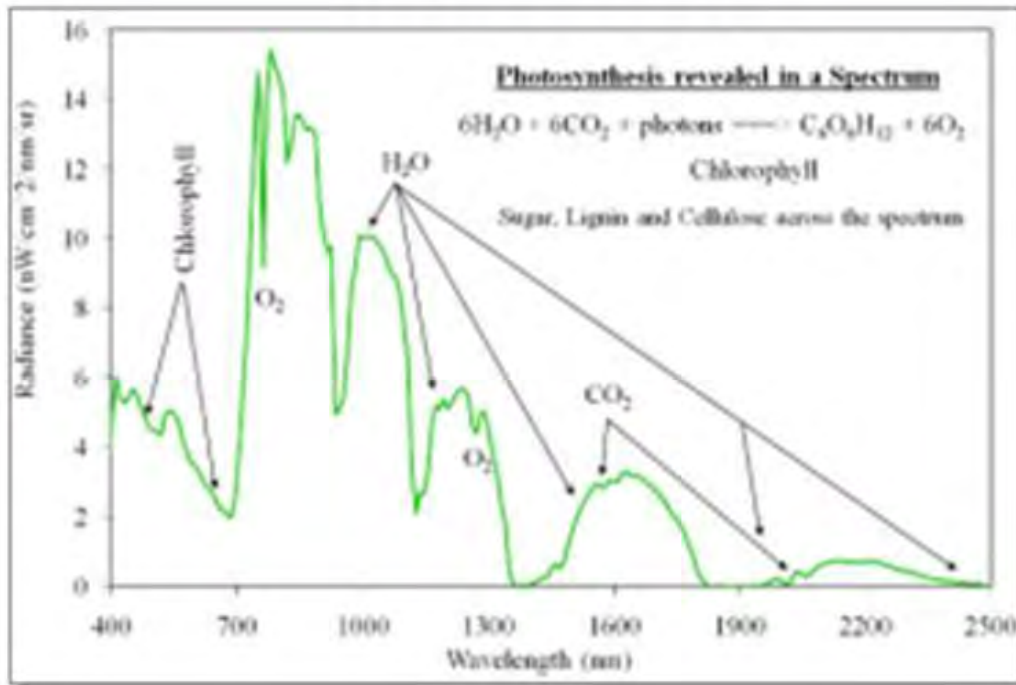


## 2. LiDAR altimetry
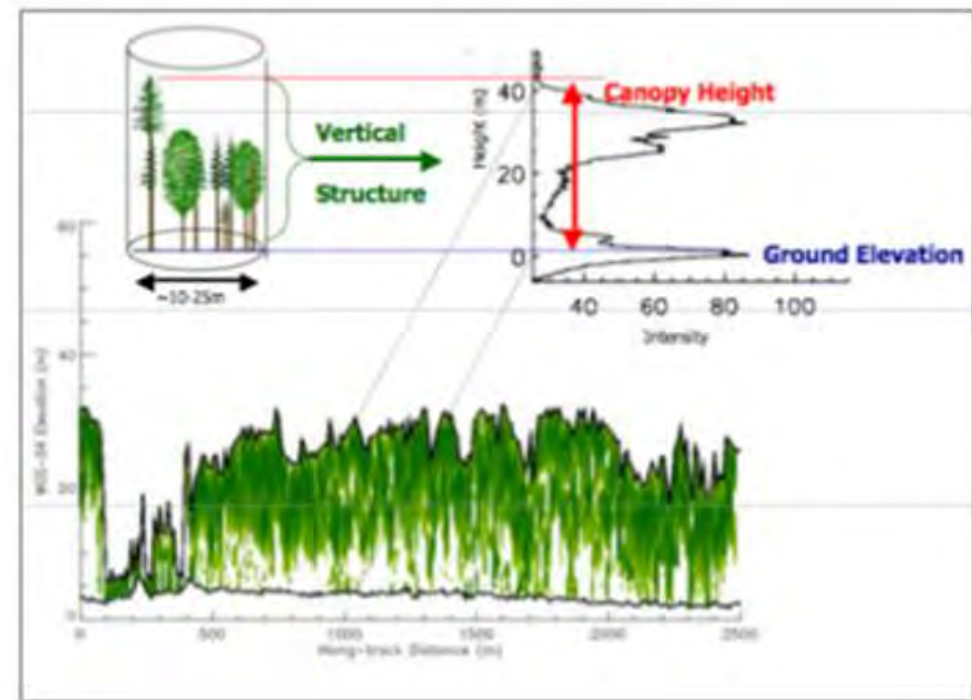


## 3. High-resolution visible wavelength
### (not shown)

# A Snapshot

Spectrometer data overlaid on Lidar point cloud (4x vertical enhancement)
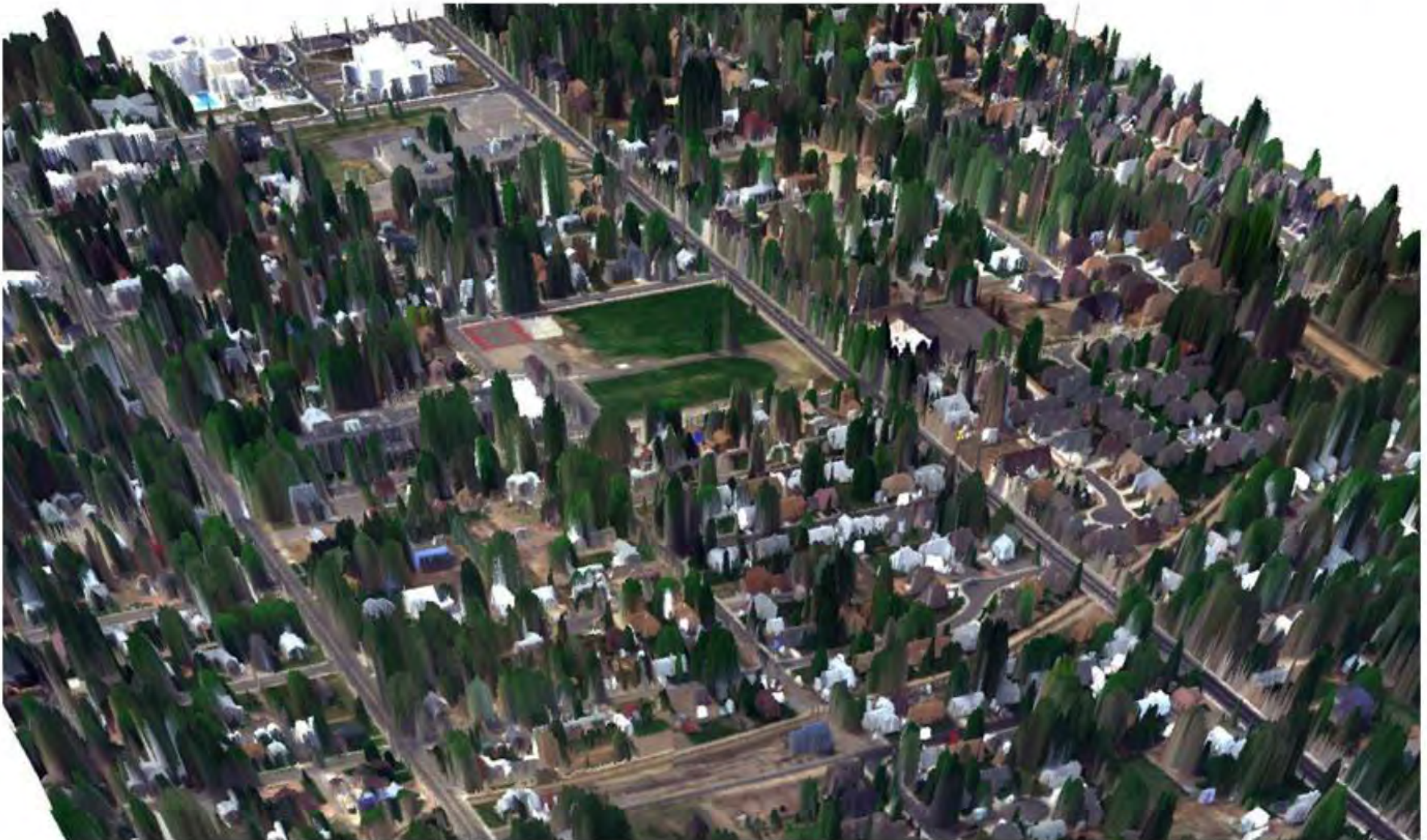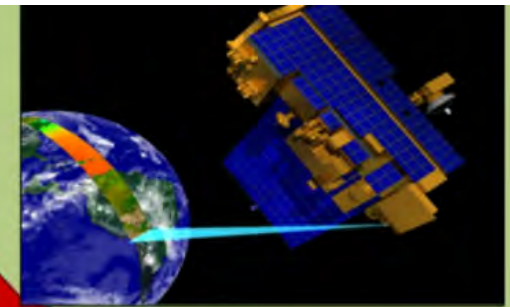
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**NEON Data Products**

**Data Products from Credible Sources**

# INTEROPERABILITY

Data, Tools, Workflows, Documentation

# NEON Data Products

**Level 1-3 Products**

Winds, $CO_2$ concentration, $H_2O$ vapor concentration

Human observers, canopy photography

Small mammal species ID, small mammal age, small mammal gender

Flux assimilation model

Image analysis calibration

Mark-recapture model

**Level 4 Products**

Carbon and water fluxes and parameters (e.g. gross primary productivity, water-use efficiency)

Plant phenology

Population parameters: abundance, survival, recruitment, fecundity
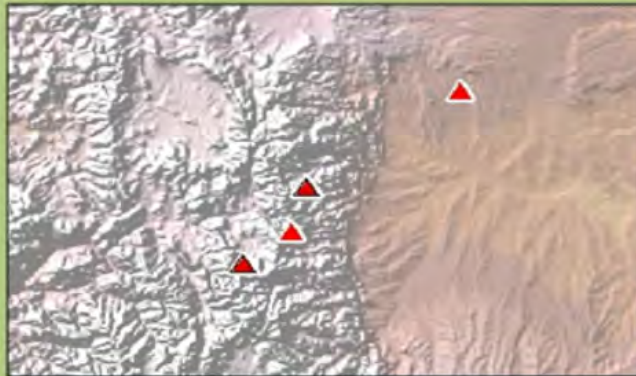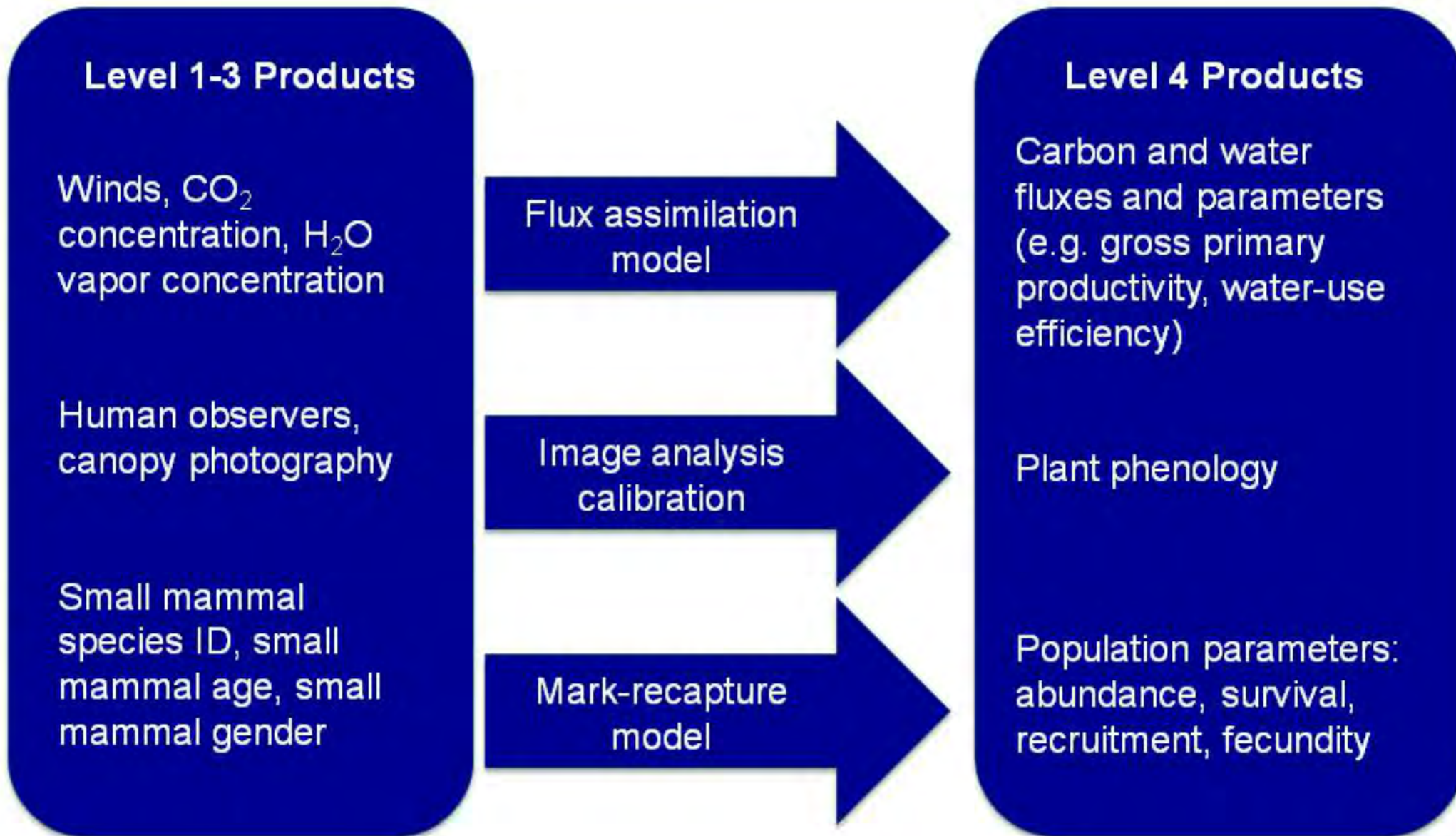
# Breakdown of Data Products

~ 1600 Level 0 (primary observations)

Raw voltages from sensors
Captured flora/fauna
External DNA analysis
Raw LiDAR returns

~ 540 Level 1 (QA/C, minimally processed)

One-minute average air temperature
Site-level species demography
Georectified, radiometrically-corrected LiDAR

~ 75 Level 2 (rectified) & Level 3 (common gridded)

Gridded canopy nitrogen estimate (L3)
Gap-filled one-minute air temp (L2)

~ 120 Level 4 (high-level)

Net ecosystem exchange
Canopy nitrogen
Microbial diversity
Aquatic-terrestrial nutrient flux

~700 data products (Levels 1 through 4) that are freely web accessible

# NEON EDUCATION
Creating data-driven educational resources
to support and build a more informed society

**Science**

Engaging scientists with continental-scale data

**NEON DATA**

Free & accessible NEON data

Online learning modules for students & educators

Undergraduate research experiences program

Internship program

Graduate field and analysis course

Postdoctoral research program

Workshops, seminars, courses

Citizen science

Professional development and training

Museum projects

Public engagement activities

Building a more informed community

**Society**

NEON's data-driven educational resources support a scientifically-literate society by engaging scientists, students, educators, citizen scientists, and decision makers in exploring continental-scale ecological questions and contributing to new scientific discoveries.

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Data to support forecasting and decision making across a number of applications, like those stipulated in the Global Earth Observation System of Systems (GEOSS) Societal Benefit Areas:

Disasters    Health    Energy    Climate    Water    Weather    Ecosystems    Agriculture    Biodiversity

THE PLANNED LIFETIME OF NEON

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# USDA – NEON Connection: LTAR

- *"Hoping to emulate the success and ambition of ecological research networks, such as NEON, the U.S. Department of Agriculture (USDA) is creating a network of long-term agricultural research sites."* **Science, September 2012**

- Long-term Agroecosystem Research (LTAR) network

- As of January 2014: 18 sites across the United States

# USDA LTAR will help the US...



- ...understand how key agricultural system components **interact at larger scales**

- ...anticipate the environmental effects of **shifting agricultural practices**;

- ...improve the **effectiveness** of conservation programs;

- ...identify the broader **societal benefits** of modern agriculture (e.g., bio-energy production; carbon sequestration).

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# LTAR – NEON Interoperability Approach

- NEON: 7 agriculture-themed terrestrial sites

- LTAR-NEON sites:
  - Three co-located
  - Three others in close proximity

- Strategy:
  - Common measurements
  - Comparable protocols
  - Discoverable data

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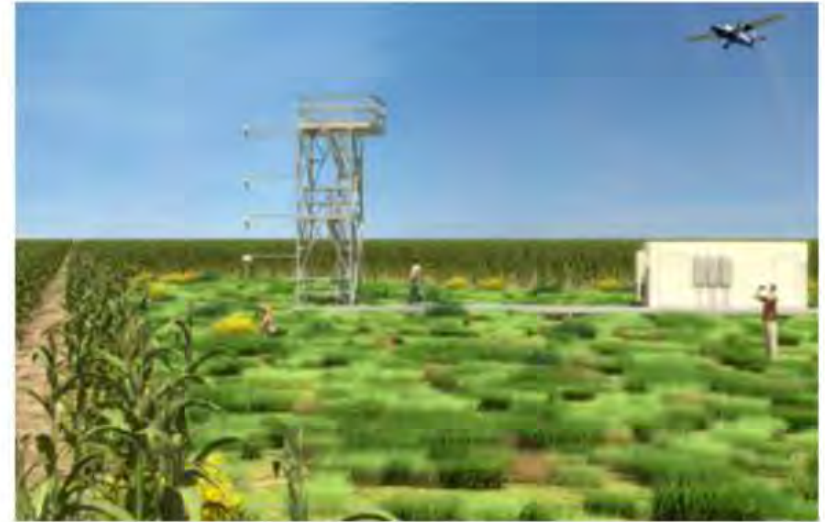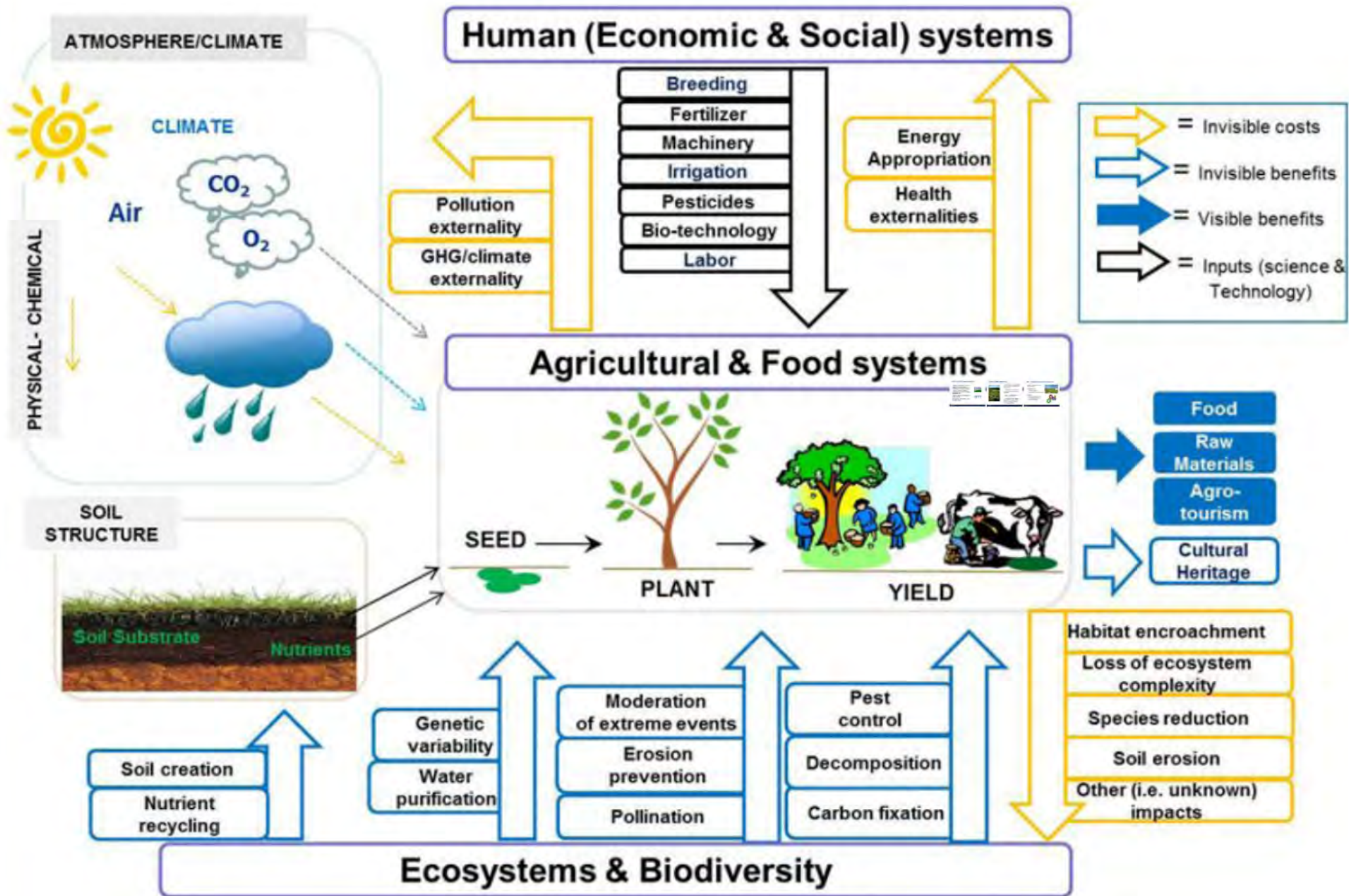
**Figure 1    TEEBAF schematic to characterize the eco-agri-food system complex**

REPORT TO THE PRESIDENT
SUSTAINING ENVIRONMENTAL
CAPITAL: PROTECTING SOCIETY
AND THE ECONOMY

Executive Office of the President
President's Council of Advisors
on Science and Technology

JULY 2011

**2013-05-09 Executive Order on Open Data**
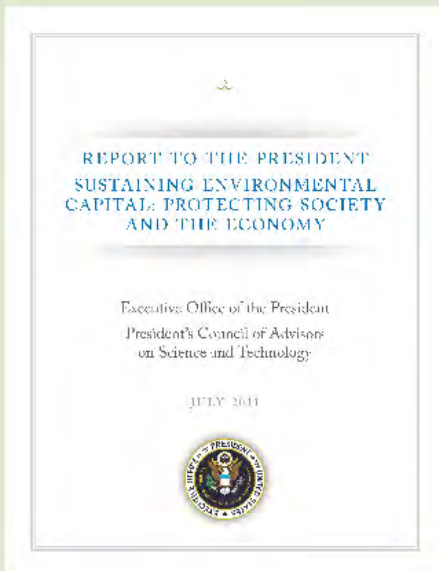
- "Making Open and Machine Readable the New Default for Government Information"
- POTUS order states:
  - "... making information resources easy to find, accessible, and usable can fuel entrepreneurship, innovation, and scientific discovery that improves Americans' lives and contributes significantly to job creation."
  - "... the default state of new and modernized Government information resources shall be open and machine readable."

THE PRESIDENT'S CLIMATE ACTION PLAN

Executive Office of the President

June 2013

NATIONAL PLAN FOR
CIVIL EARTH OBSERVATIONS

PRODUCT OF THE

National Science and Technology Council
Executive Office of the President

July 2014

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# THE PRESIDENT'S CLIMATE ACTION PLAN

Executive Office of the President

June 2013

THE WHITE HOUSE
WASHINGTON

# US Response to Climate Change

- June 2013: President Obama announces **Climate Action Plan** (CAP) as a response to the threat of climate change

- February 2014: USDA announces Regional Climate Hubs as part of CAP

- March 2014: White House launches **Climate Data Initiative** under CAP
  - Climate.data.gov: open government data
  - Foster public-private partnerships around data
  - To eventually include food-security related data and resources

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# USDA Regional Climate Hubs

- Seven locations to translate science and research into information for:

  - Farmers

  - Ranchers

  - Forest landowners

- To address increasing risks like:

  - Fires

  - Invasive species

  - Floods, droughts
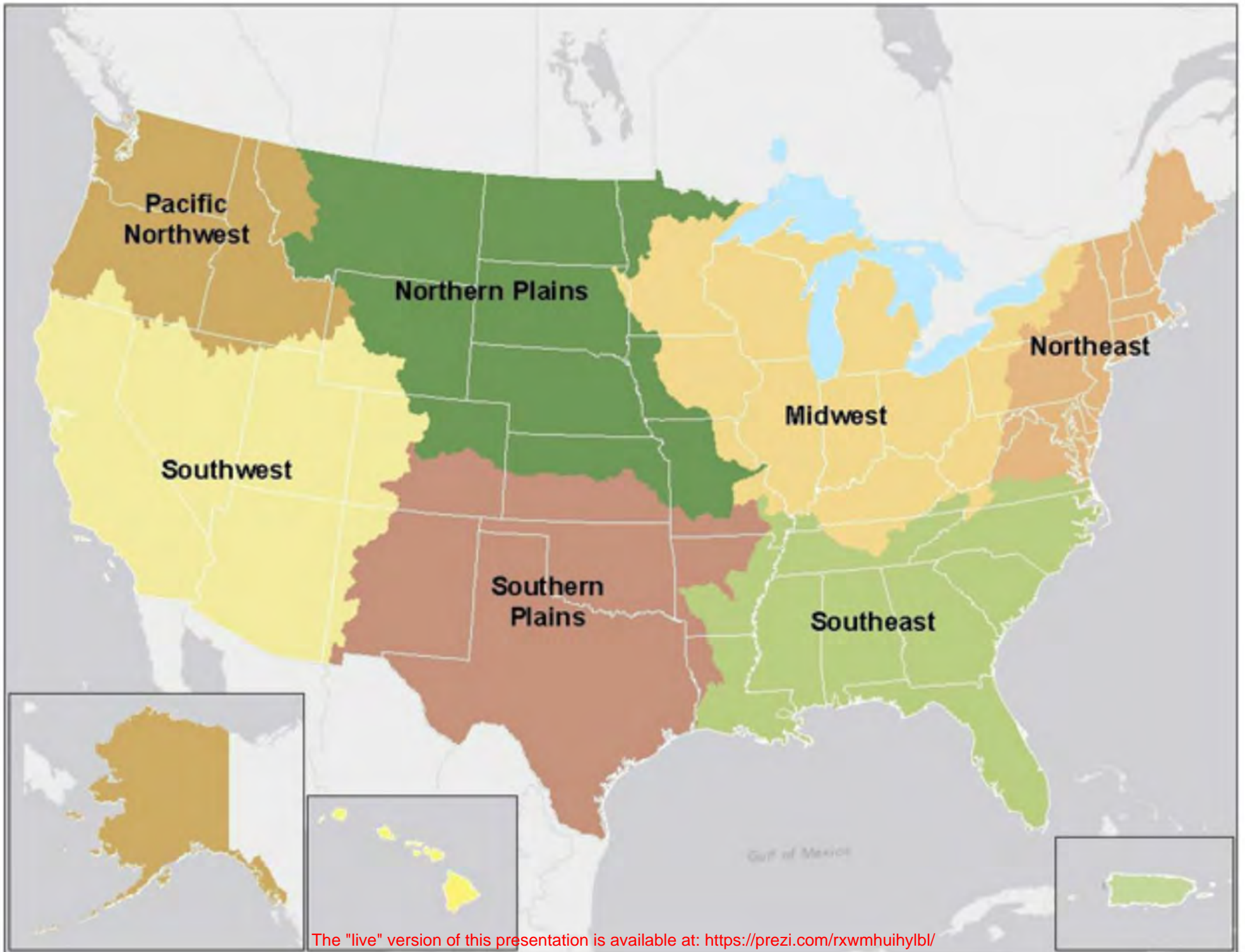
Pacific Northwest

Northern Plains

Southwest

Southern Plains

Midwest

Northeast

Southeast

# NATIONAL PLAN FOR
# CIVIL EARTH OBSERVATIONS

PRODUCT OF THE

National Science and Technology Council
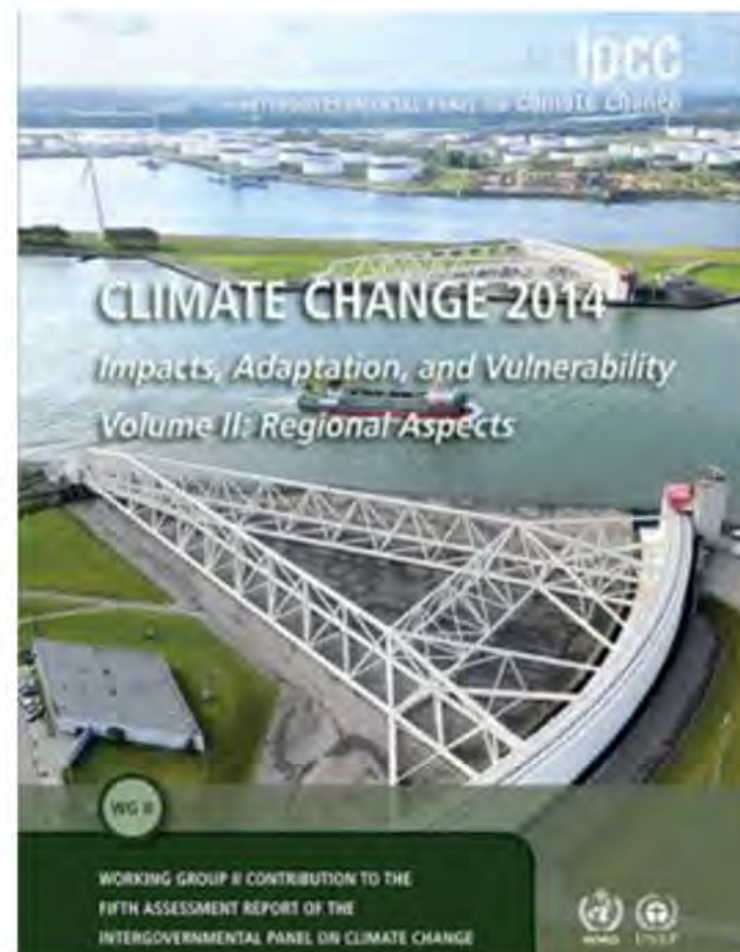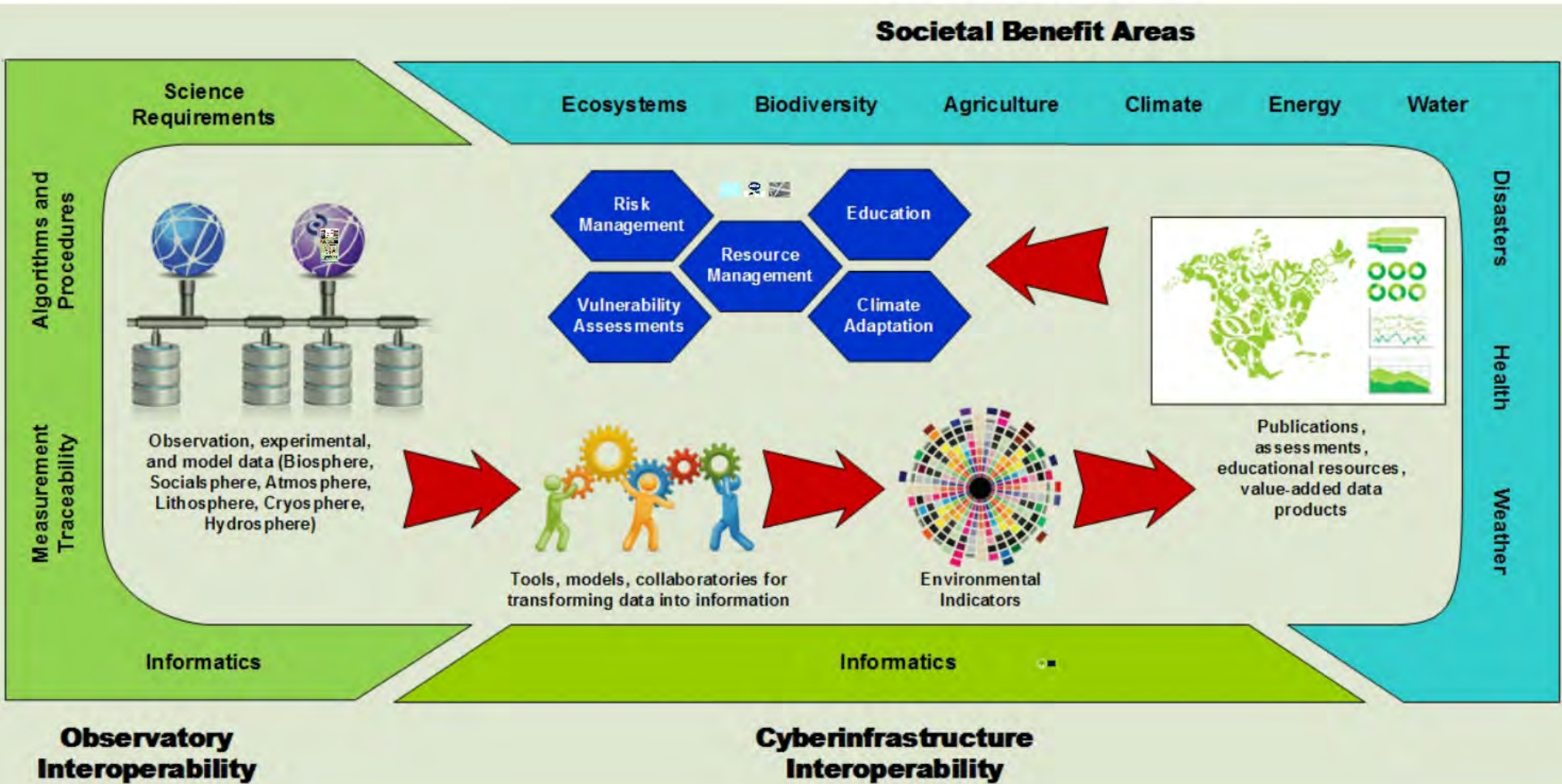Executive Office of the President

July 2014

| Observation System (Alphabetical Order) | Agency | Ag&Frst | BioDiv | Climate | Disasters | Ecosys | Energy | HumanHlth | Ocn&Cstl | Space Wx | Trans | WaterRes | Wx | RefMeas |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| High Frequency (HF) Coastal Radars | DOC/NOAA | | | | Moderate | | * | | | | Very High | | * | |
| International Doppler Radar | Non-USG | | | | | | | | | | High | | | |
| International Global Navigation Satellite Systems (GNSS) | Non-USG | | | | * | | | | | * | | | | Highest |
| International Magnetometers | Non-USG | | | | | | | | | Very High | | | | |
| Jet Propulsion Lab MODIS/ASTER airborne simulator (JPL MASTER) | NASA | | | | | | Very High | | | | | | | |
| Lightning Data Buy | DOC/NOAA | | | | High | | | Moderate | | | High | * | | |
| Long-Term Ecological & Agroecosystem Research Networks & International LTER (LTER/LTAR/ILTER) | NSF, USDA | | Moderate | Moderate | | Highest | * | | | | | | | |
| Low Level Windshear Alert System (LLWAS) | DOT/FAA | | | | | | | | | | High | | | |

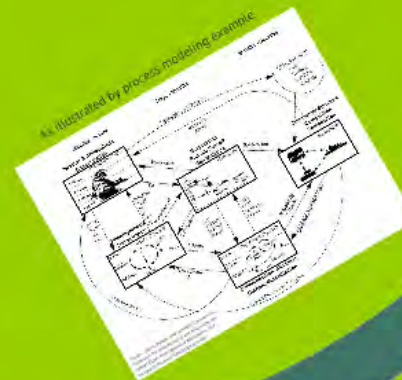Impact:   *   Contributes   Moderate   High   Very High   Highest

# Policy recommendations from IPCC AR5 WG2

- Transboundary climate change adaptation for the Lower Mekong River Basin:

    - Shared (high-resolution) climate projection

    - Linked, traceable, climate change adaptation planning at different scales

    - Integrate transboundary policy into national plans and policies

    - Improved domestic alignment within each country



IPCC

CLIMATE CHANGE 2014
Impacts, Adaptation, and Vulnerability
Volume II: Regional Aspects

WG II

WORKING GROUP II CONTRIBUTION TO THE
FIFTH ASSESSMENT REPORT OF THE
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

Why is technical interoperability (harmonization) so difficult?

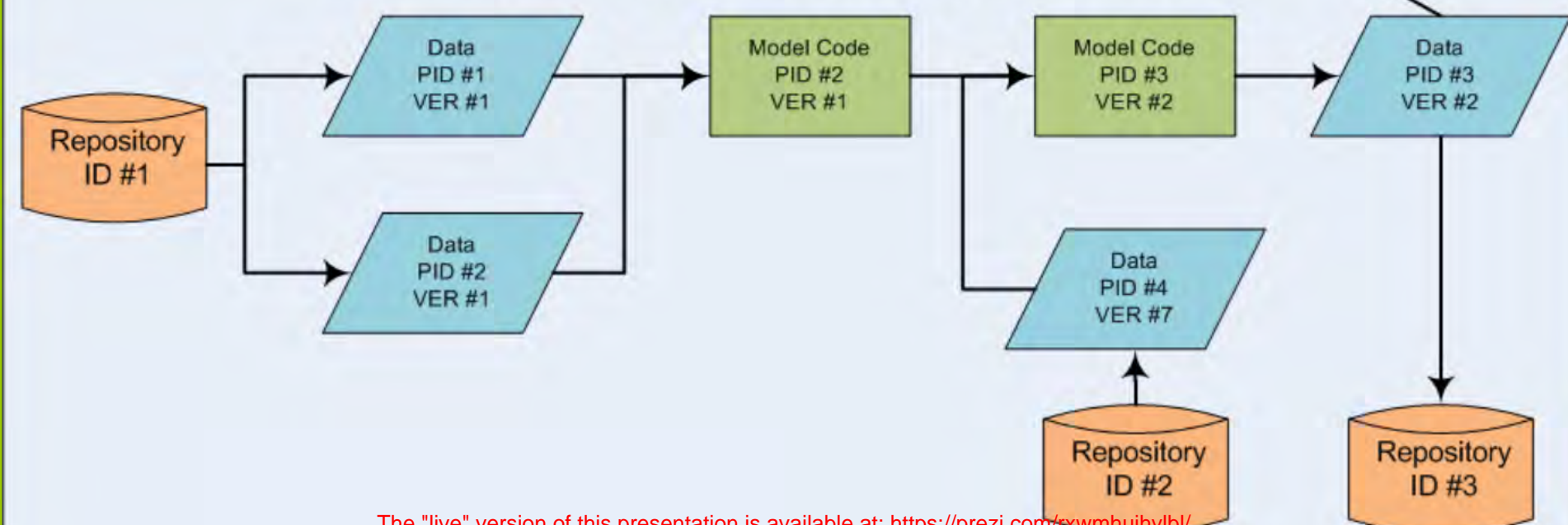# As illustrated by traceability example
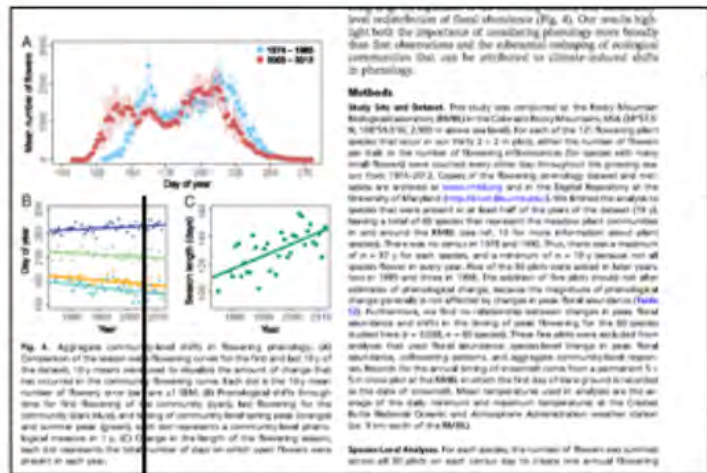


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**Workflow Associated with Data Plot in Publication**

| | |
|---|---|
| Repository ID #1 | |

Data PID #1 VER #1

Data PID #2 VER #1

Model Code PID #2 VER #1

Model Code PID #3 VER #2

Data PID #3 VER #2

Data PID #4 VER #7

Repository ID #2

Repository ID #3

# As illustrated by process modeling example
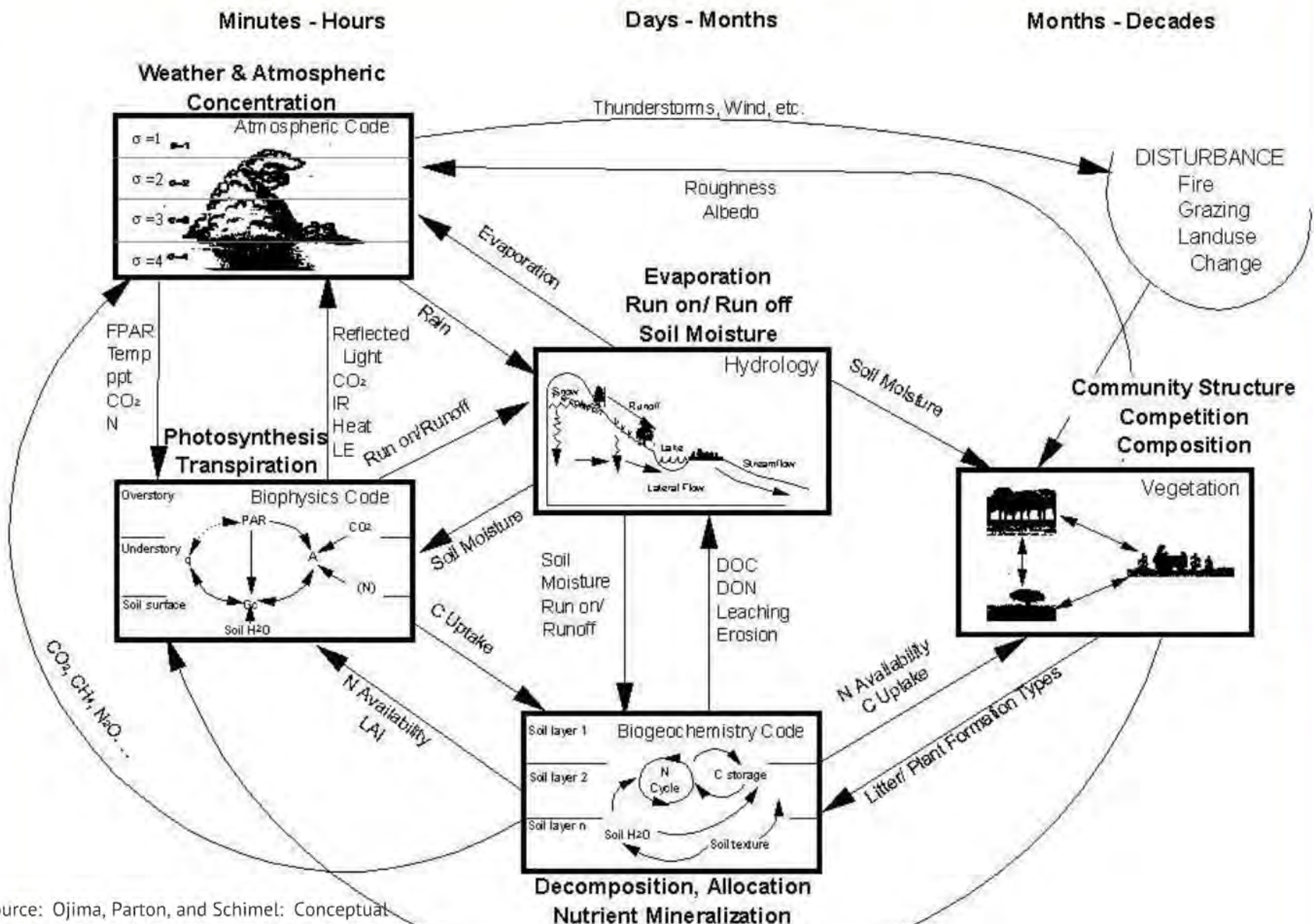


Source: Ojima, Parton, and Schimel: Conceptual framework for understanding and evaluating net carbon fluxes from terrestrial ecosystems, NSF Integrated Research Challenge proposal

# Informatics Challenges

**Data Access and Preservation:**

- Authentication
- License, policy
- Discovery
- Access
- Archival Policies
- Provenance
- Persistent Identifiers

**Data Integration:**

- Data formats / schemas
- Metadata standards
- Coordinate reference system
- Taxonomic naming conventions
- Protocol registry
- Semantics

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# The Interoperable* Next-Generation Scientist



- **Science, Technology, and Policy ninjas** who:

  - Adopt systems and computational thinking

  - Perform interdisciplinary science (particularly: integrating natural-social sciences)

  - Integrate data (and code) intensive approaches

  - Interface with decision / policy professionals

*Half-joking   **Female and male*

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