Sustainability Metrics and Life Cycle Assessment in Agriculture:
Uses, Limitations and the Need for Standardization

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General Outline

- Sustainable Agriculture: The Need
- Measuring Sustainability with LCA
- Incorporating LCA into Sustainability Decision Tools

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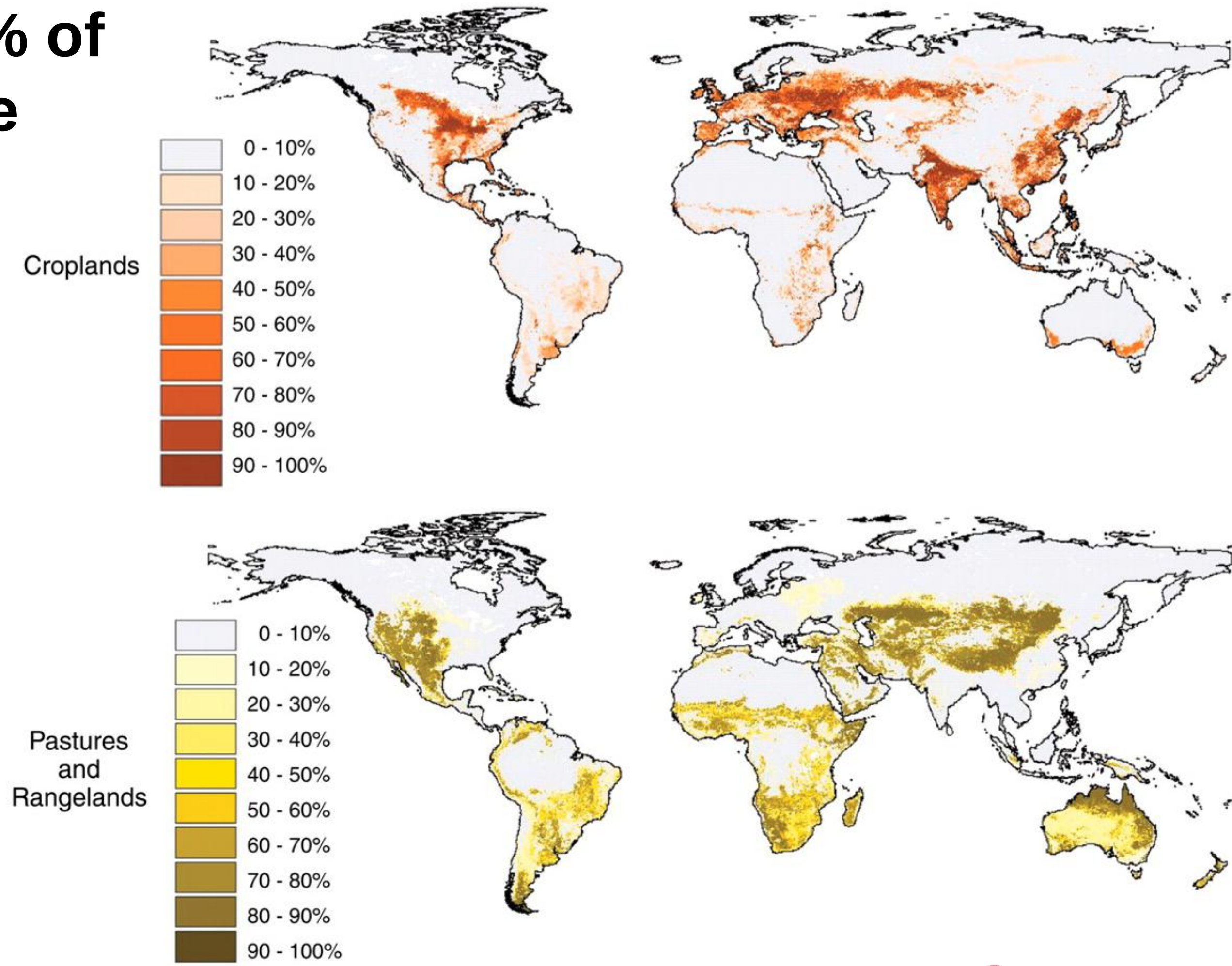
Sustainability 2050: The Challenge

- We live in a prosperous world
  - –Hunger has been reduced
  - –Literacy is increasing
  - –Mean annual incomes are increasing
  - –Access to clean water is increasing
- We know how to improve life for people
- However, the rate of population growth threatens these gains

Human Activities Dominate Earth

Croplands and pastures are the largest terrestrial biome, occupying over 40% of Earth's land surface



Science
AAAS

J. A. Foley et al., Science 309, 570 -574 (2005)

Published by AAAS

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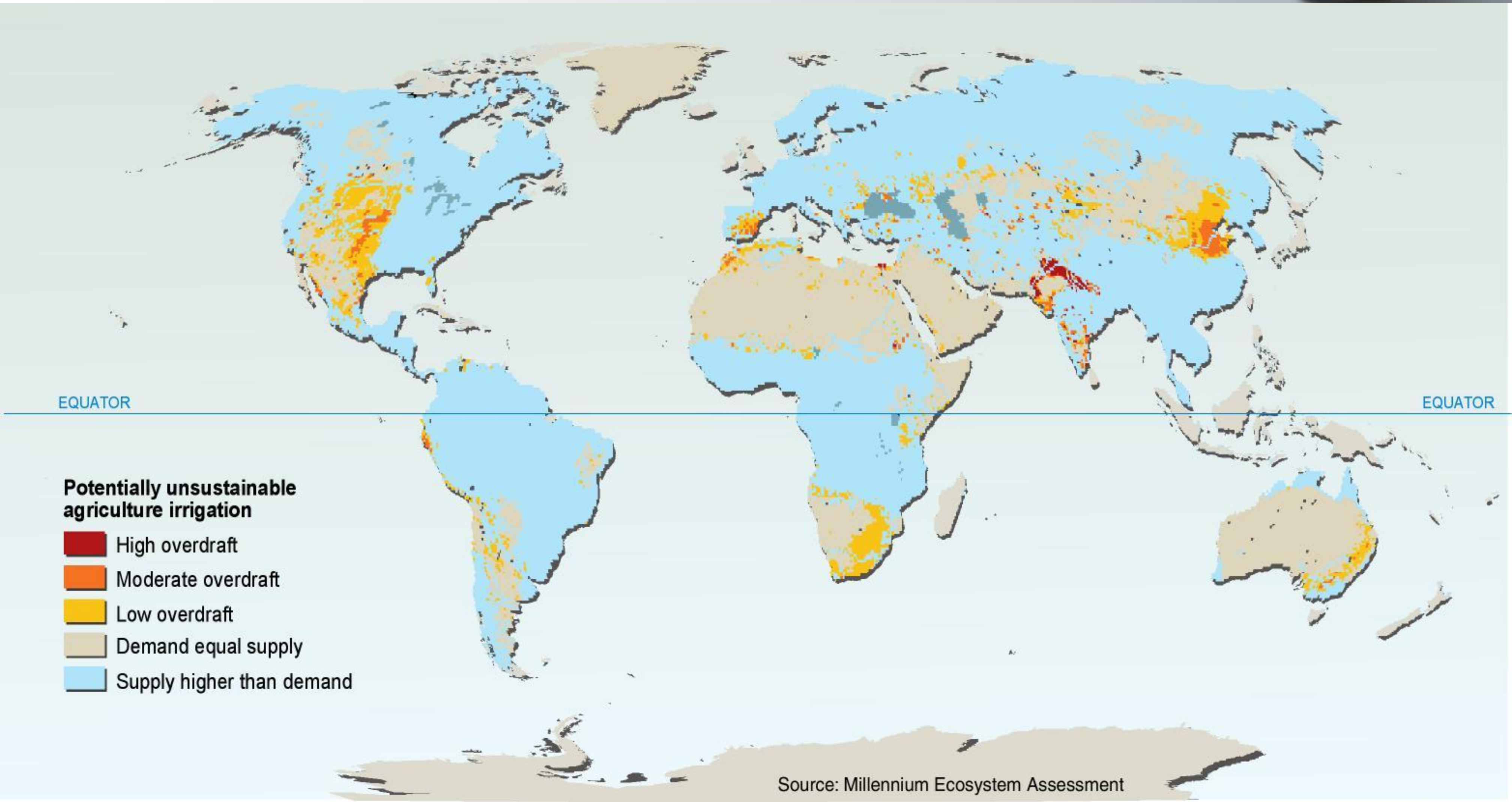
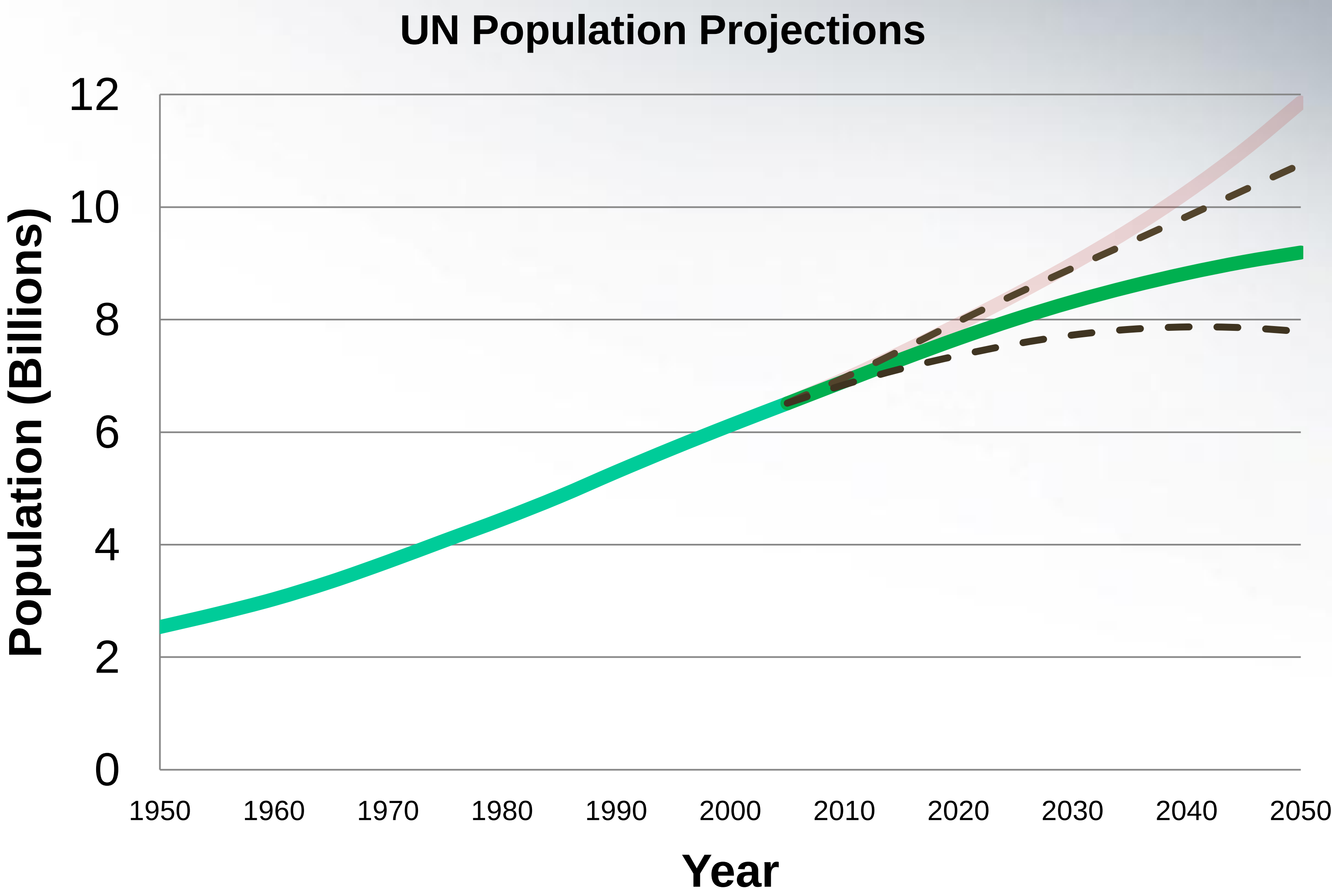
Water Resources and Prosperity



Water Resources and Prosperity

- 5 to possibly 25% of global freshwater use exceeds long-term accessible supplies (*low to medium certainty)*
- 15 - 35% of irrigation withdrawals exceed supply rates and are therefore unsustainable (*low to medium certainty)*

Sustainability 2050: The Challenge



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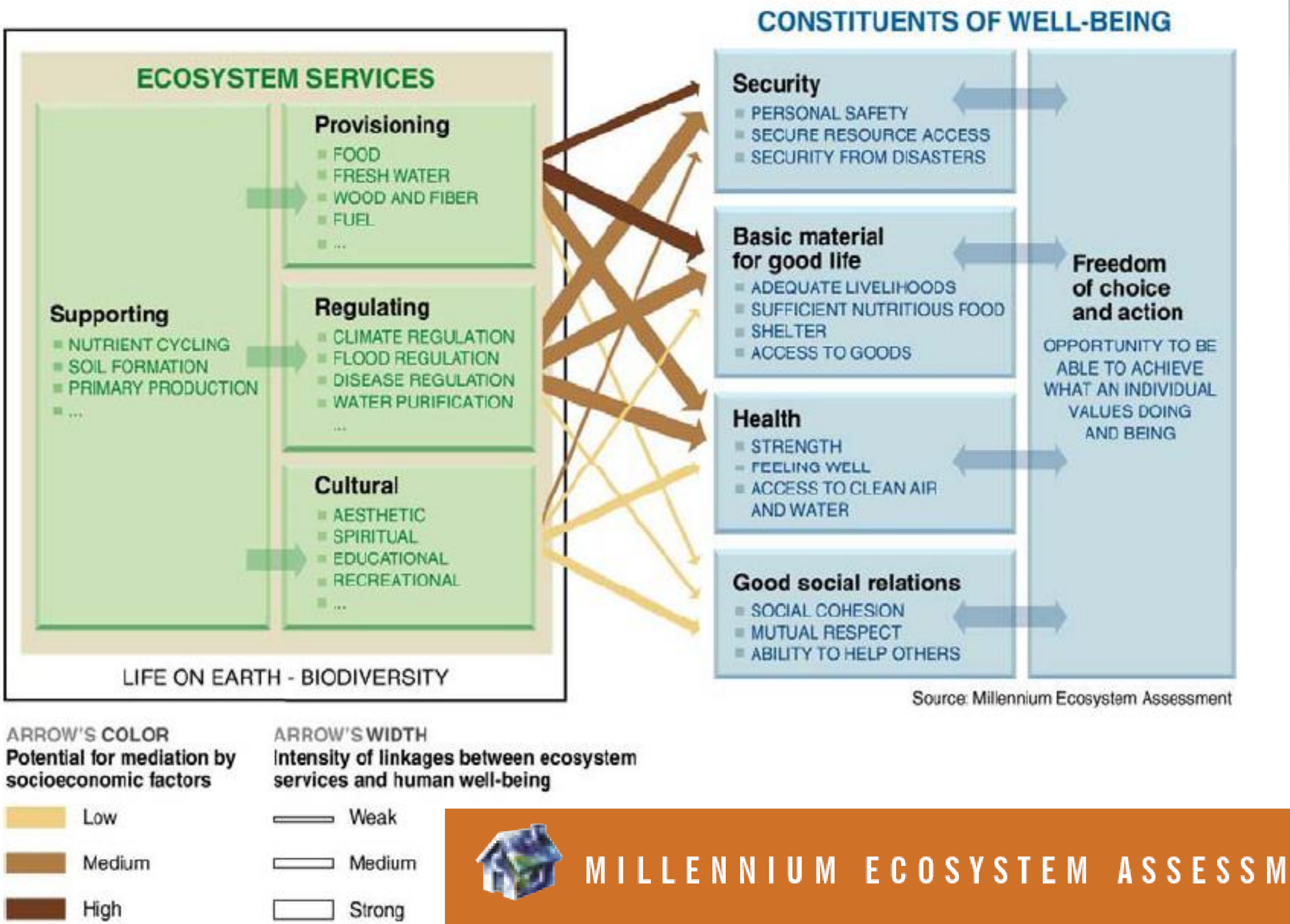
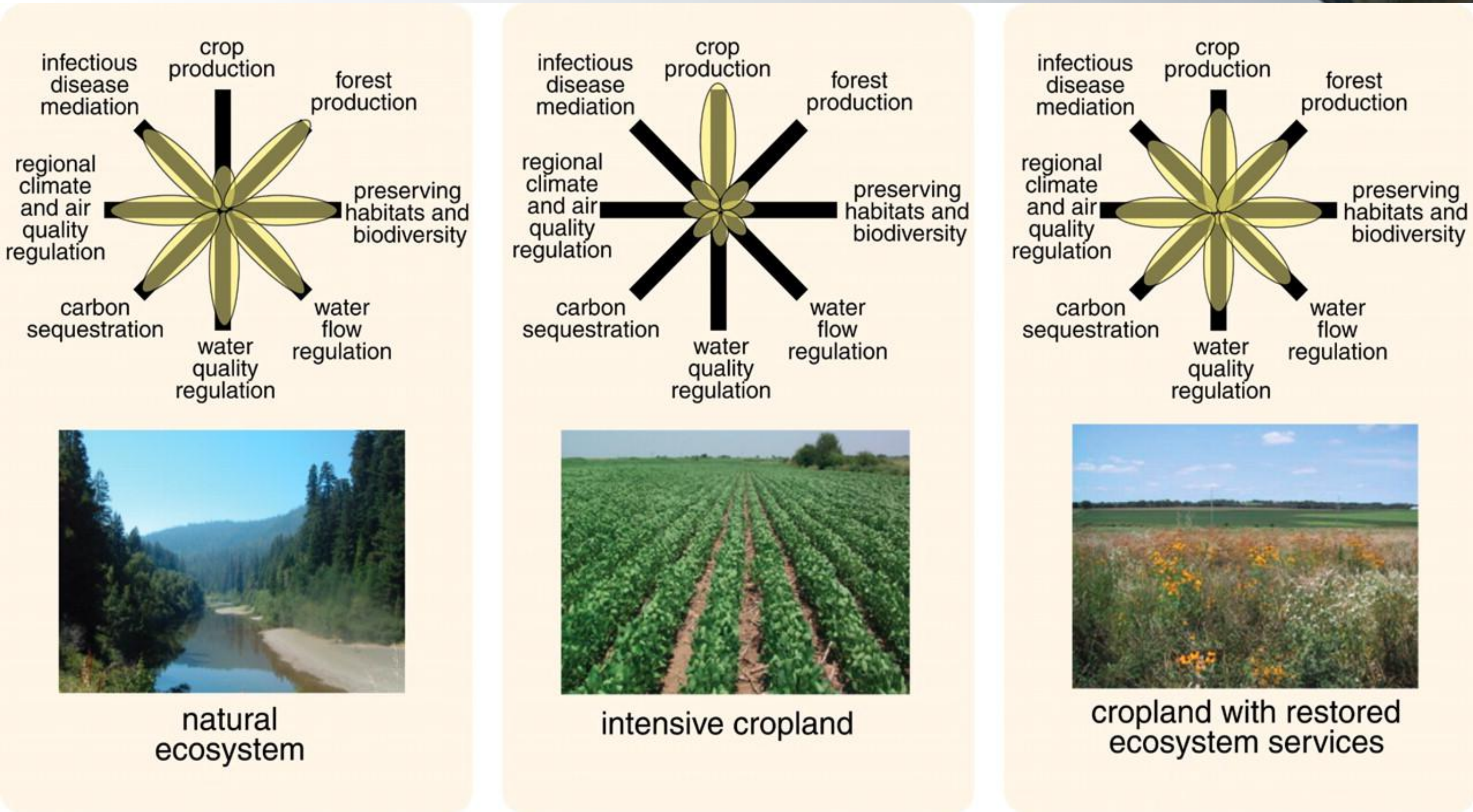
Ecological Services



MILLENNIUM ECOSYSTEM ASSESSMENT

Conceptual framework for comparing land use and trade-offs of ecosystem services



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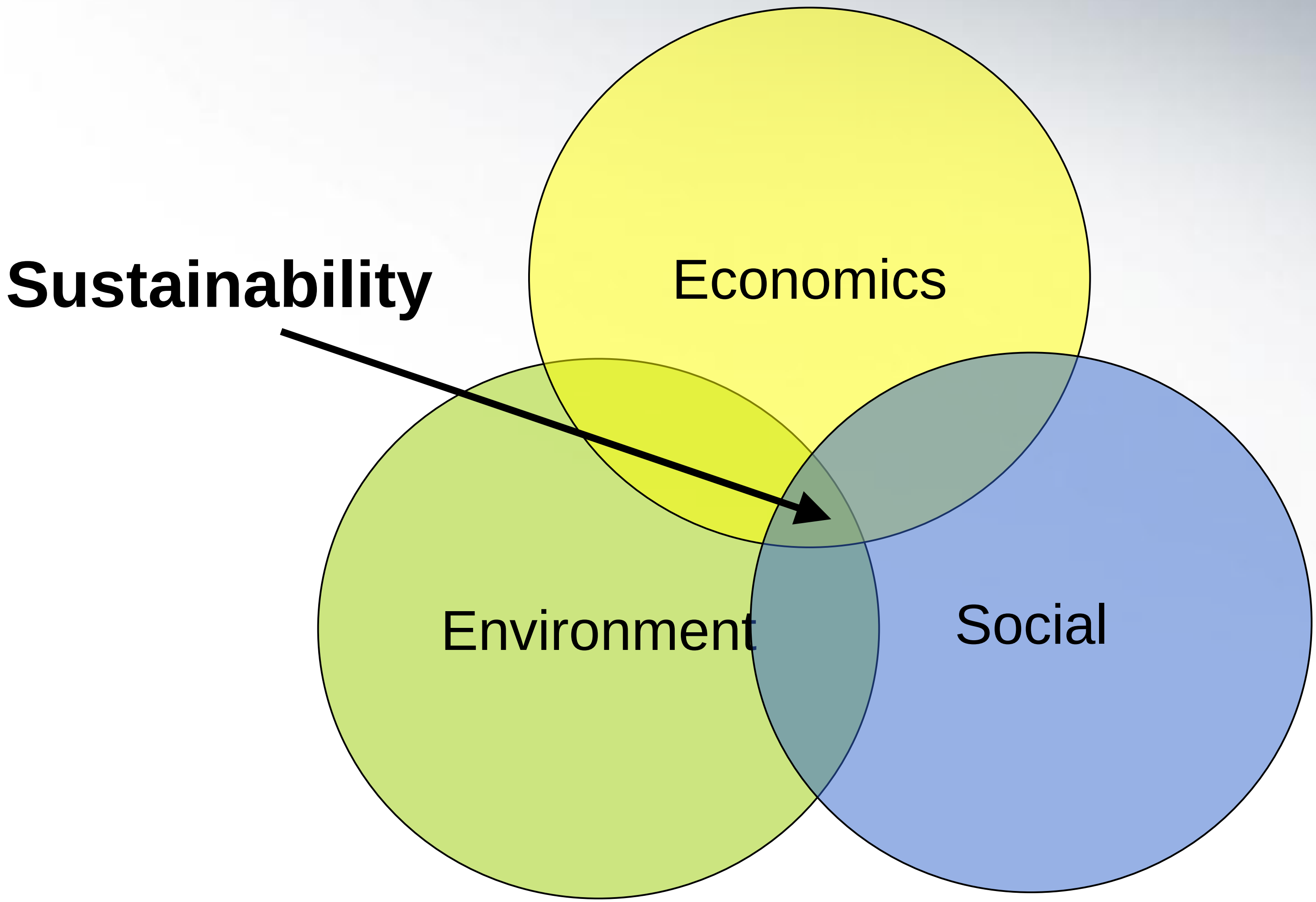
Taking Action: Choosing Sustainability



How Do We Make Sustainable Decisions?

Consumers: What To Buy?

Producers: What to Make?
How to Make it?

Government: What Policies to Enact?

Information Overload

- We receive more information than we know what to do with
  - And we are receiving more and more every year.

- We must make quick decisions based on limited information.
  - How do we filter all of this information?

Labeling, Standards and Metrics

Labels help us make quick decisions
But, are they the right decisions?

Who Here Purchases Products
Based On the Organic Label?

Who Here Knows What The USDA
Organic Standard Actually Is?

Labeling, Standards and Metrics

Should We Buy Certified Organic Tomatoes from Mexico at Whole Foods

WHOLE FOODS MARKET

USDA ORGANIC

Or

Or Should We Buy Uncertified Local Tomatoes from Farmer's Market?

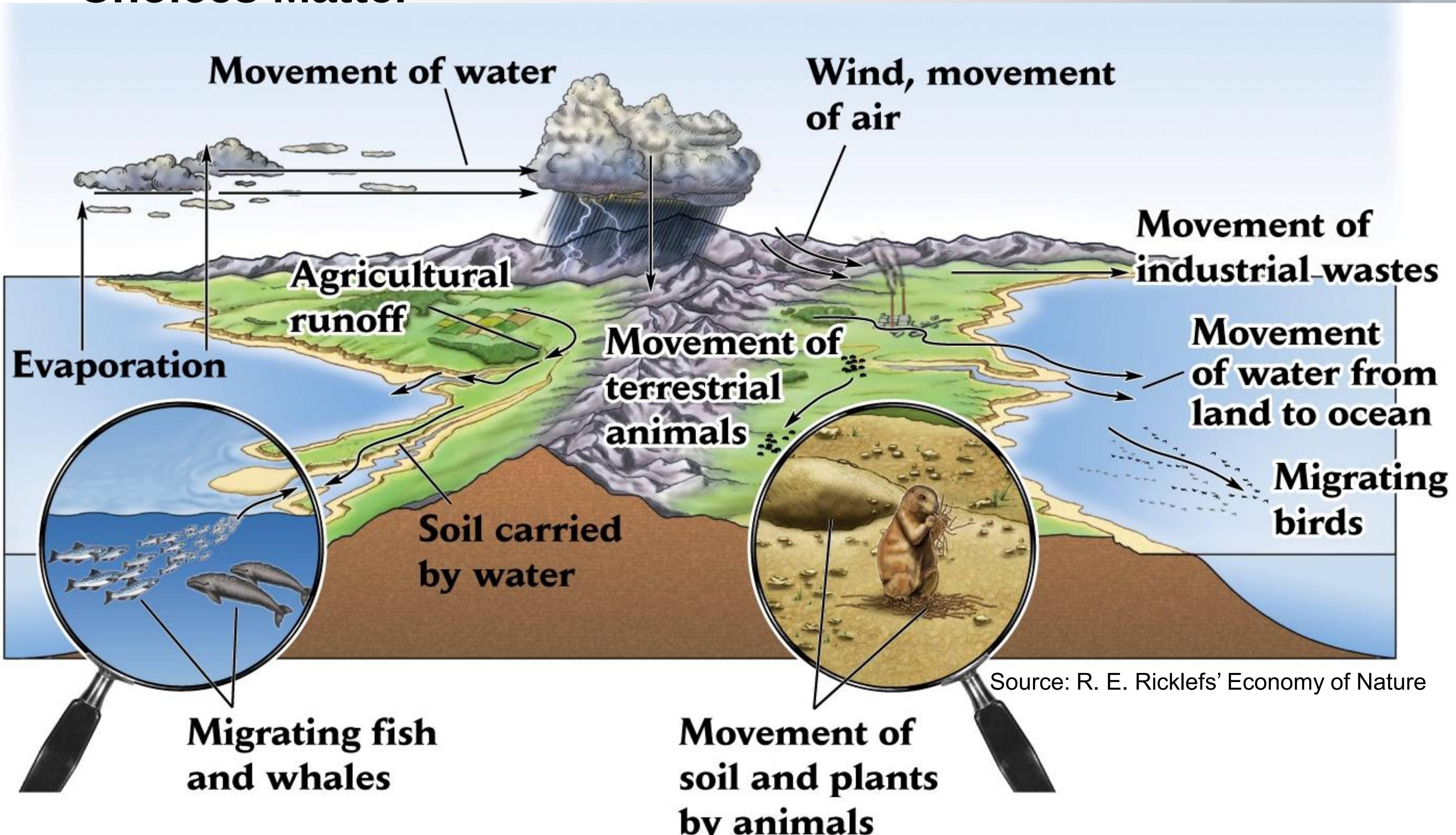
Not All Labels Are The Same

Labels help us make quick decisions
But, are they the right decisions?

- Organic
- Sustainable
- Green
- Natural / Naturally Grown
- Locally Grown
- Shade Grown
- Fair Trade
- Pesticide Free
- Hormone Free
- Free Range
- Fresh
- Healthy

Everything is Connected
Whether measurable or not

Choices Matter



Source: R. E. Ricklefs' Economy of Nature

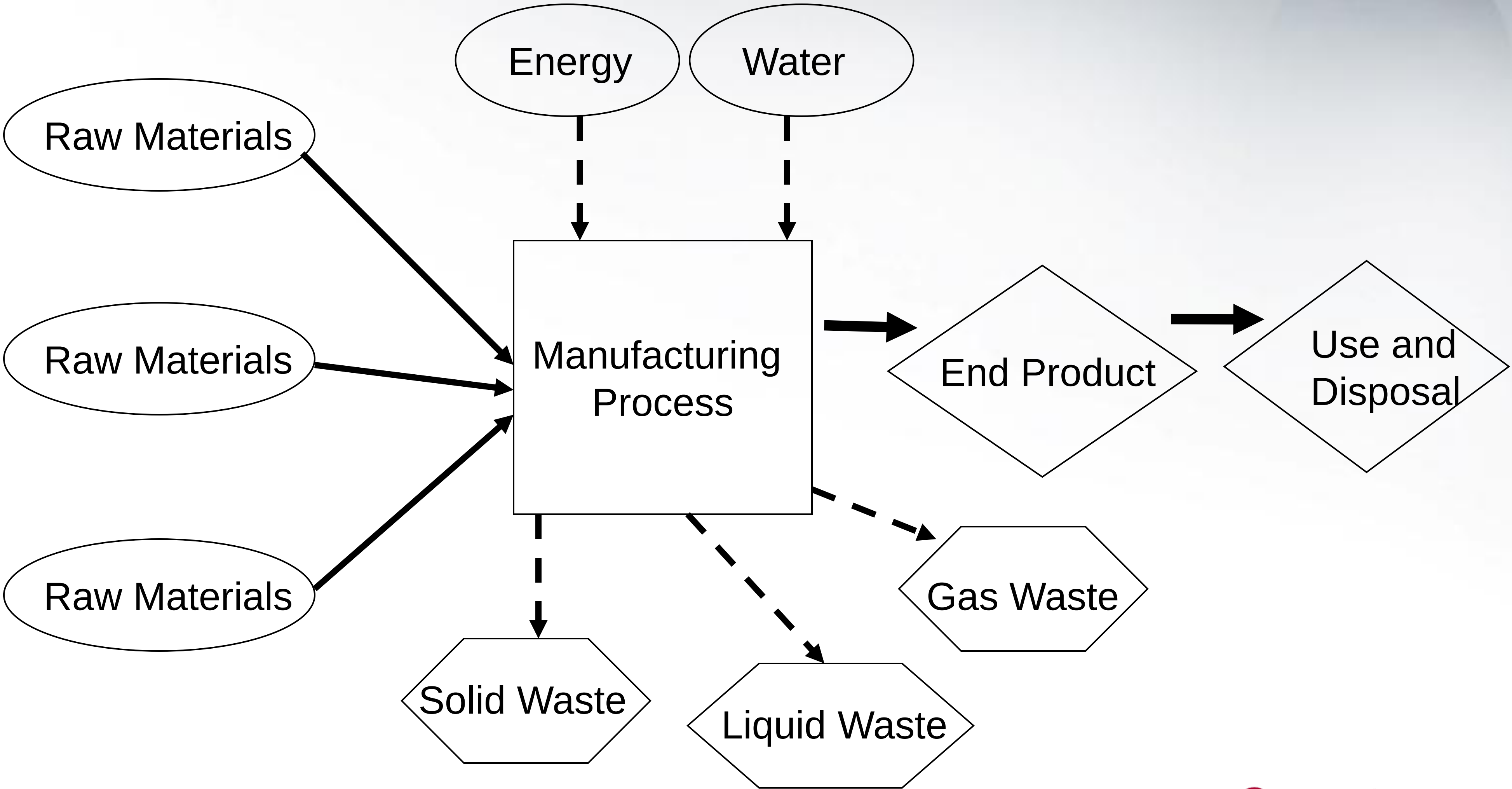
Assessing Sustainability

1. Determine Metrics We Care About
    - Global Warming
    - Water Quality
    - Water/Natural Resource Depletion
    - Ecotoxicty, etc
    - Social/Economic Welfare

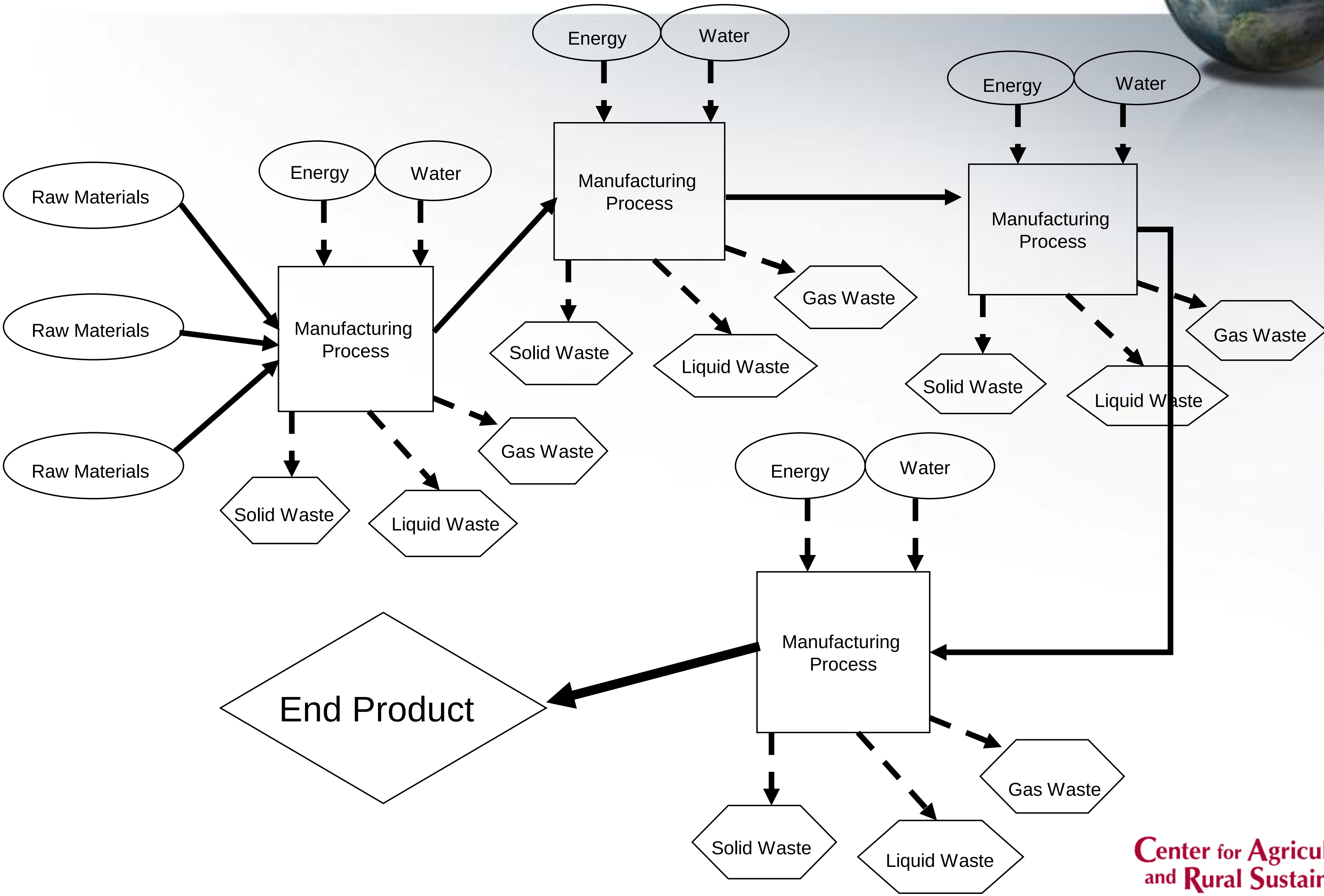
2. Determine Method of Measurement
    - Life Cycle Assessment is One Scientific Method

3. Determine Method for Analyzing and Comparing Metrics
    - Indicators and Indices

Every process has inputs and outputs



The more processes, the more complexity



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Life Cycle Assessment: Quantifies Processes

Goal: Quantify inputs and outputs for a system in terms of a standardized unit of measure.

The scope and structure of the LCA are directly dependent upon the unit of measure (functional unit):

1. Energy embodied in a single product;
2. Greenhouse gasses produced per unit product;
3. Tons of carbon produced per volume of product;
4. Volume of water consumed per mass of product…

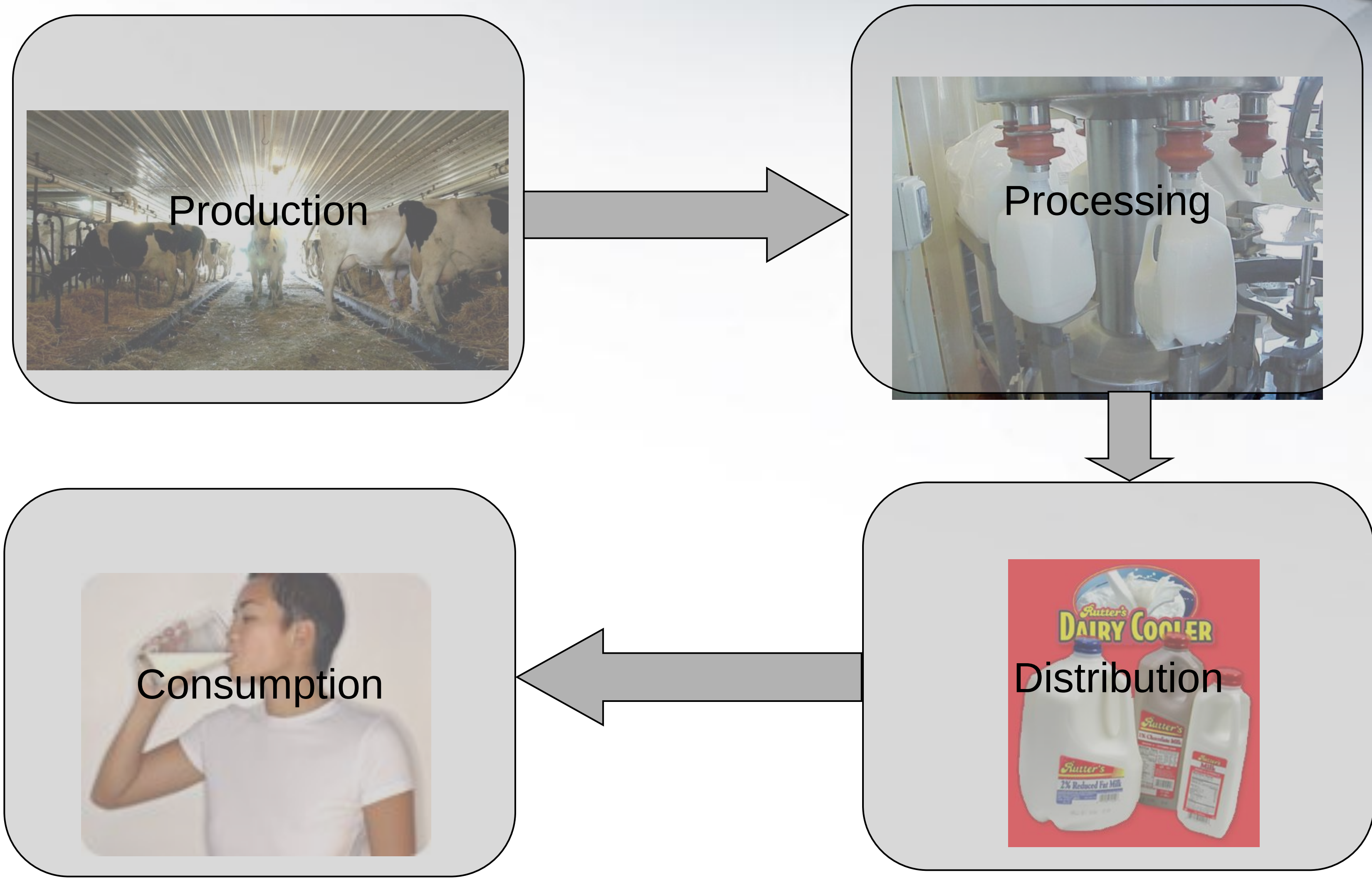
Goal and Scope of LCA must be formulated at the outset of the project, and the **functional unit must be defined**.

LCA Process is described in ISO 14040 and 14044 Standards.

University Of Arkansas: Agricultural LCA Work

1. Cotton Incorporated Life Cycle Assessment
   - Energy – farm gate
   - Greenhouse Gas Equivalents – farm gate
   - Toxicity (human and ecosystems) – farm gate
2. Dairy Management Incorporated Life Cycle Assessment
   - Liquid milk – entire supply chain
   - Cheese – entire supply chain
   - All milk products – entire supply chain
3. Sweet Corn Life Cycle Assessment
   - Energy – farm gate
   - Greenhouse Gas Equivalents – farm gate
4. Pork Industry Life Cycle Assessment
   - Energy – farm gate
   - Greenhouse Gas Equivalents – farm gate
5. Cocoa Life Cycle Assessment
   - Social and economic equity – entire supply chain (WCF and Gates Foundation)

Life Cycle Assessment Case Study: Carbon Equivalent GHG in Dairy



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Milk Processing

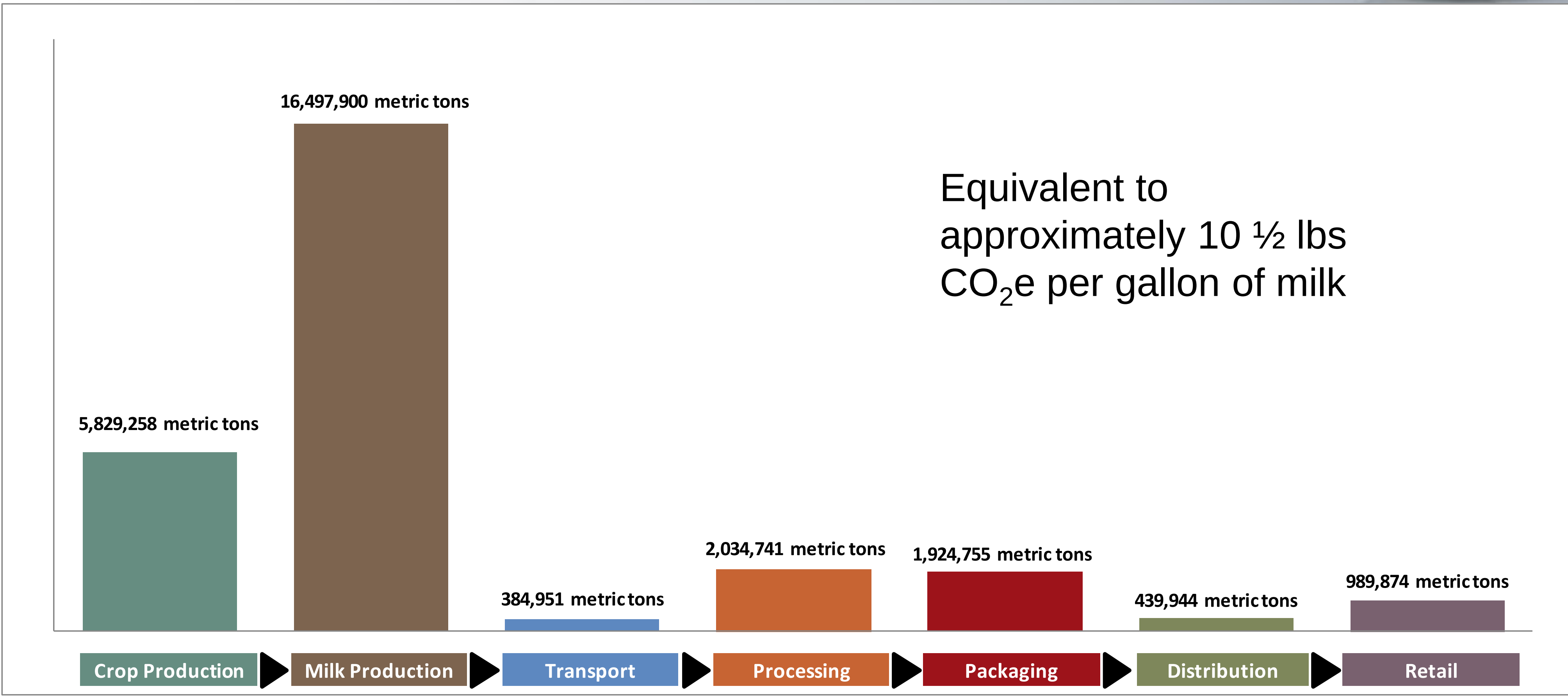
1. Comes Out at 100 degrees

2. Cool it 40 degrees to Ship to Processor

3. Heat it to 160 degrees to Pasteurize

4. Cool back down to 40 degrees to store it

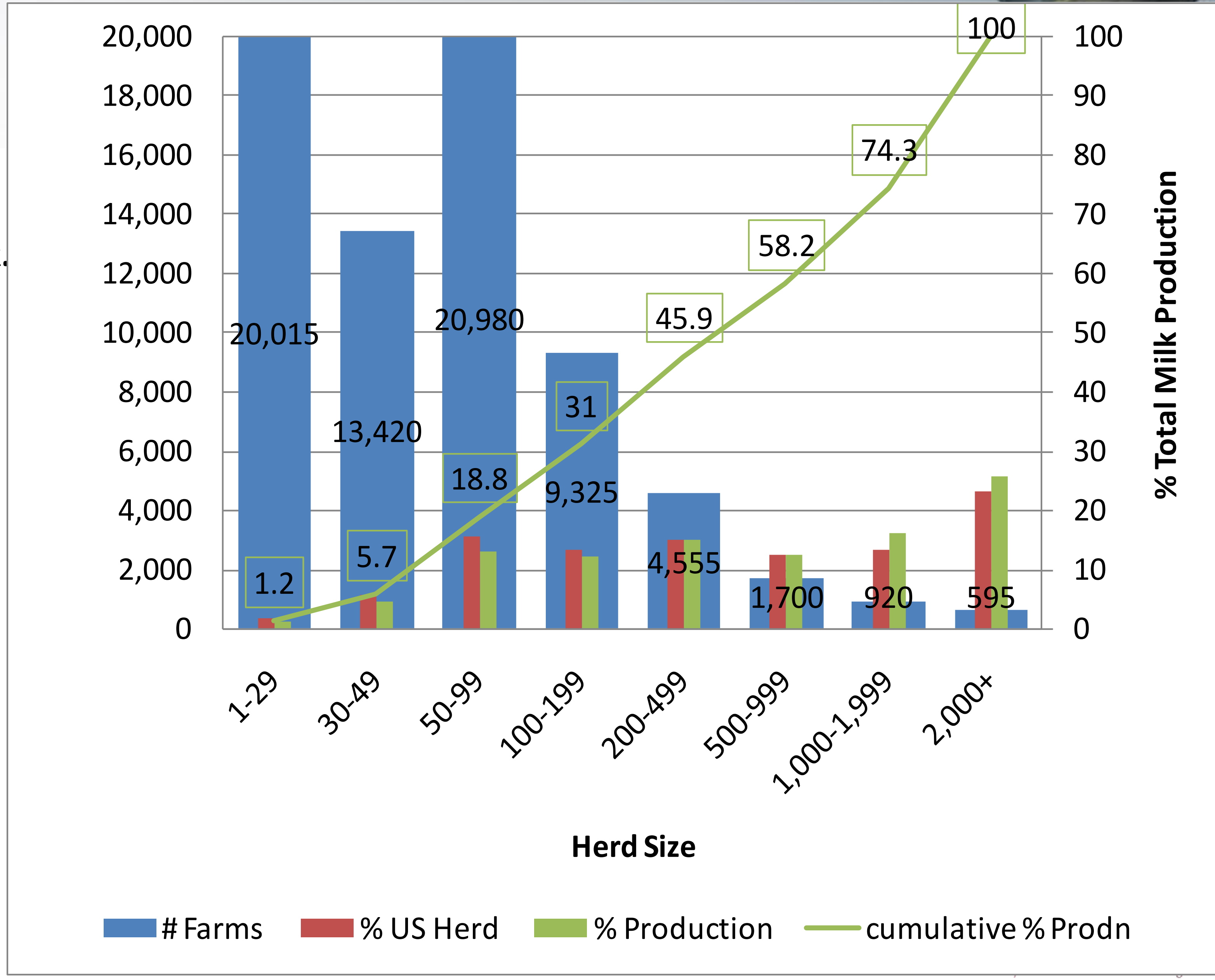
Scan level carbon footprint for Liquid Milk



Prepared for the Dairy Summit with Blu Skye Consulting from existing literature and national scale data.

US Dairy Demographics

Approximately 11% of largest farms produce 50% of milk. 47% of smallest farms produce less than 10% of all milk.



Source: NASS

Dairy LCA: Key Findings for GHG

1. Feed and dairy cattle matter
   - Fertilizer, N2O, Diesel: Crops
   - Enteric Methane and Manure
2. Transportation has little overall impact
   - “Local” doesn’t matter
3. Consumers have some of the largest impacts
   - Transportation to the store and back
   - 30% Waste
4. Model assumptions matter
   - How do you allocate impacts between beef and milk

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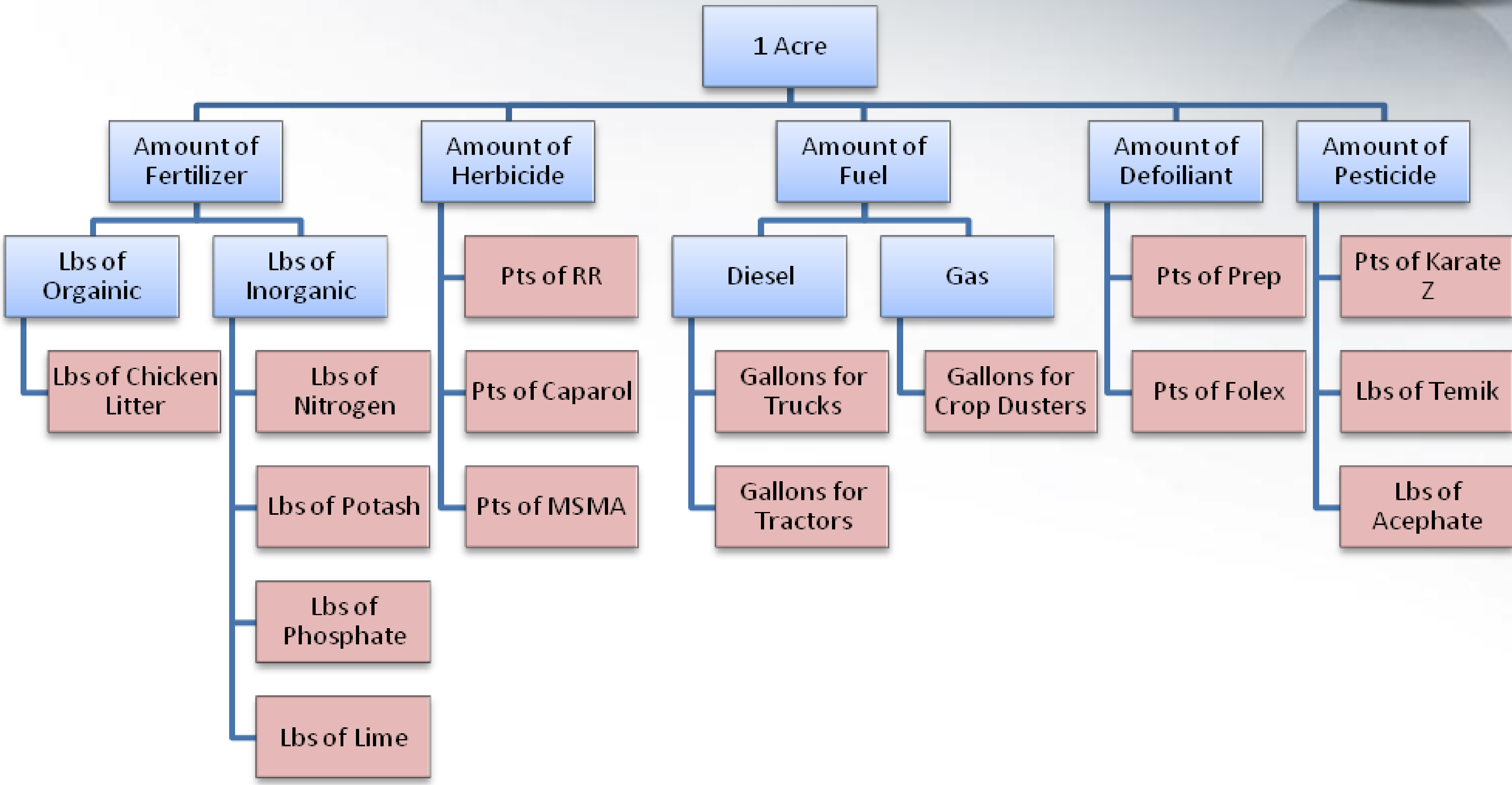
Cotton Life Cycle Assessment



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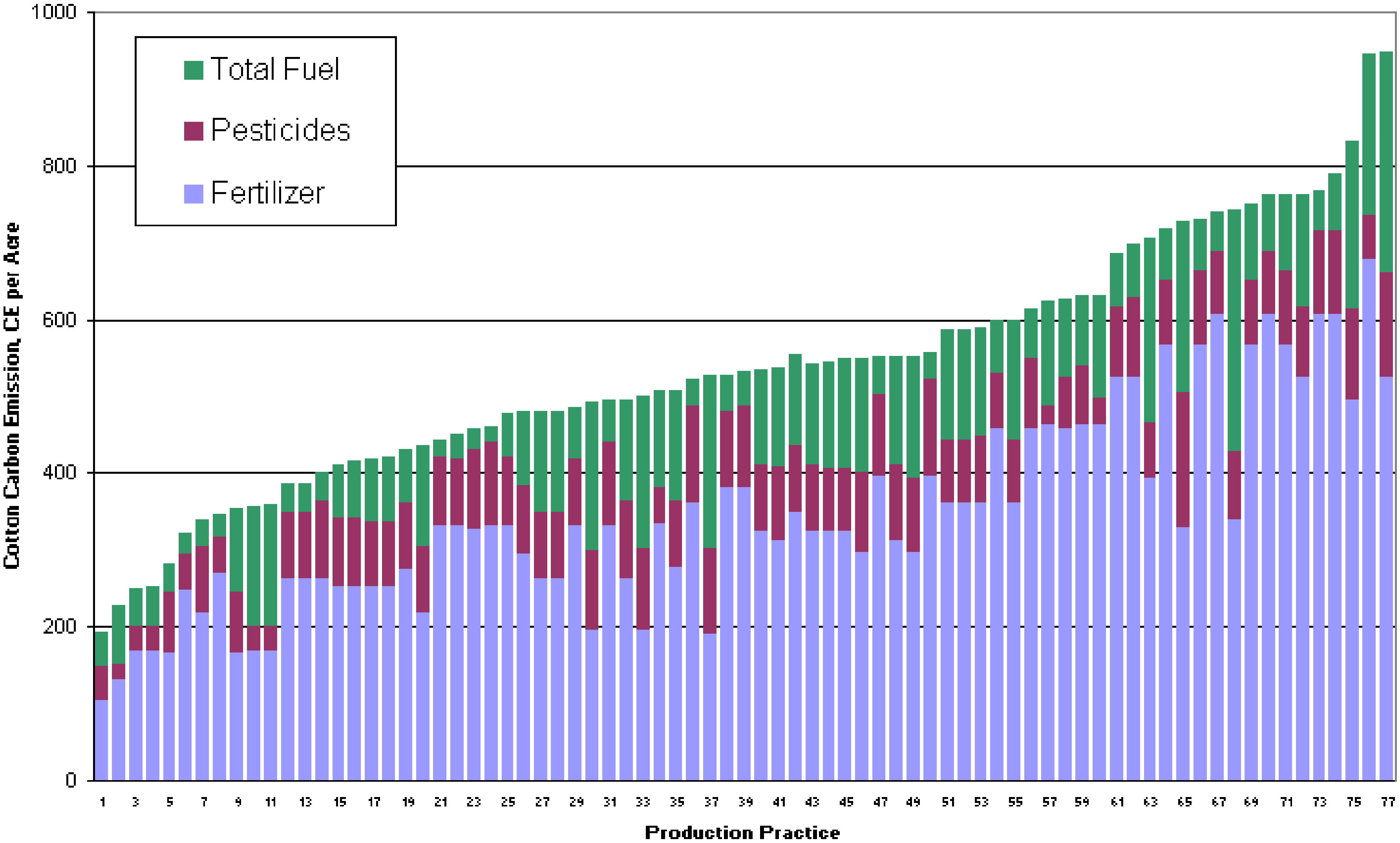
Carbon Emission
By Production Practice



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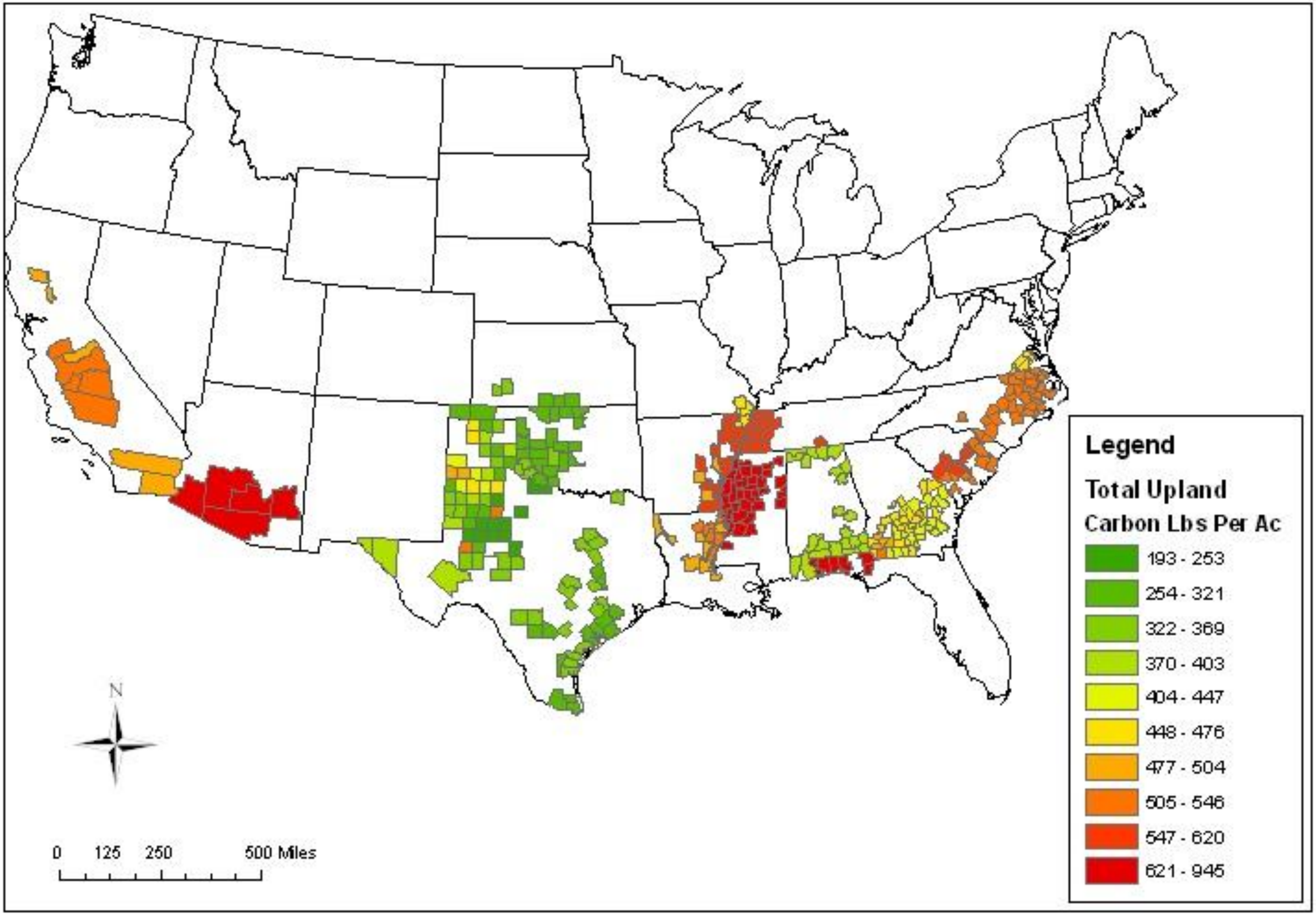
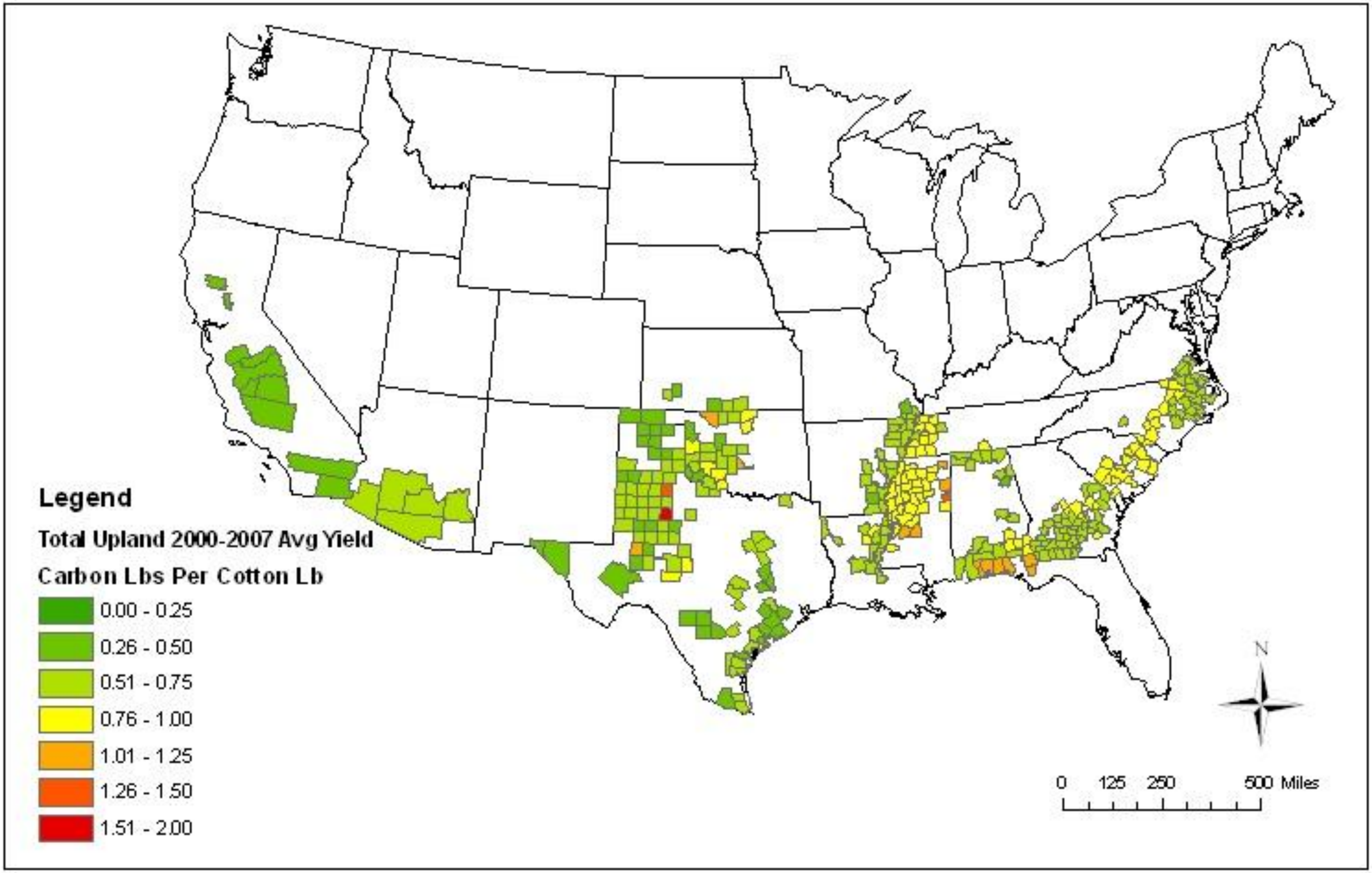
GHG Per Acre



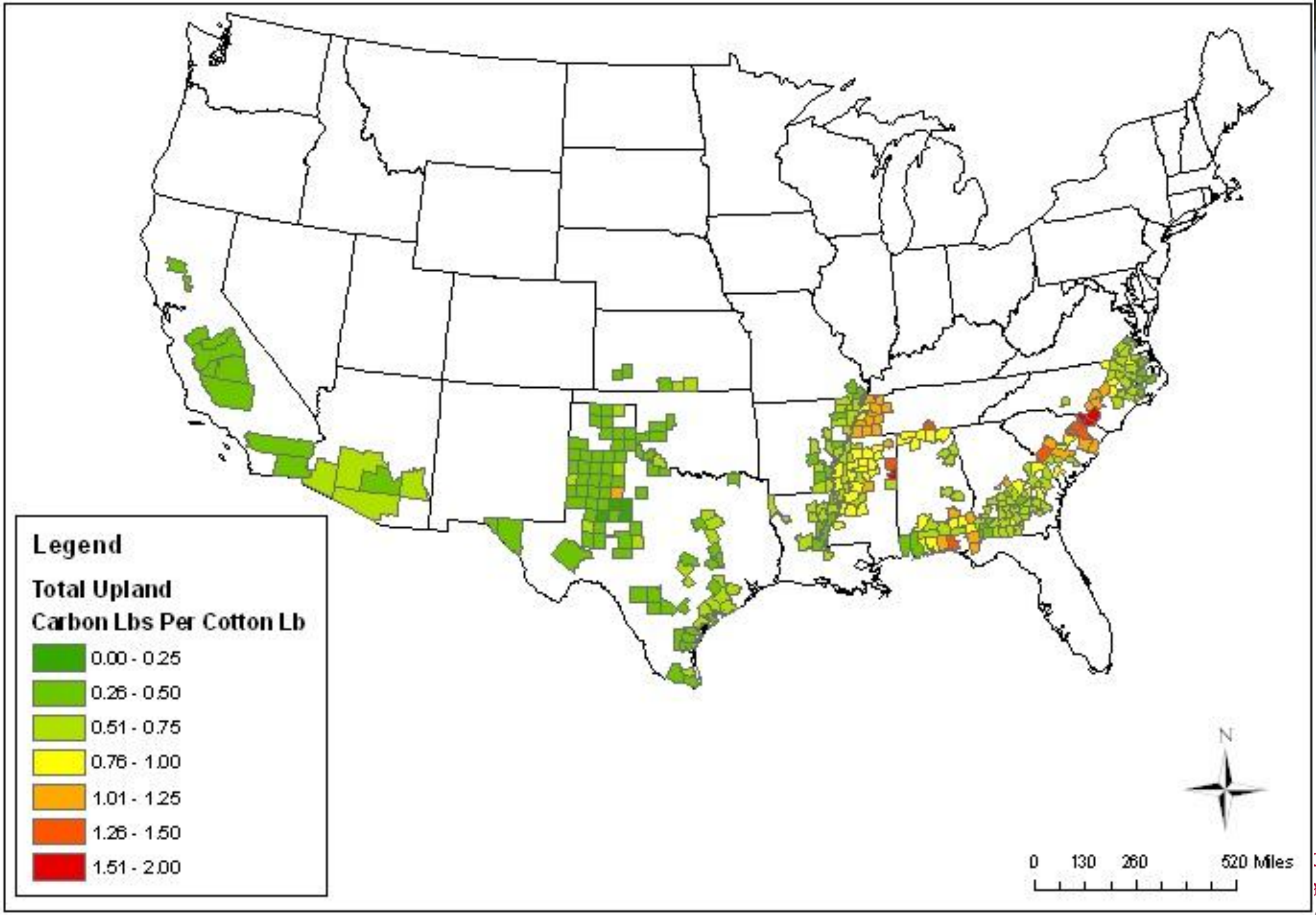
Legend
Total Upland Carbon Lbs Per Ac
193 - 253
254 - 321
322 - 369
370 - 403
404 - 447
448 - 476
477 - 504
505 - 546
547 - 620
621 - 945
N
0 125 250 500 Miles

Carbon Per Pound Cotton

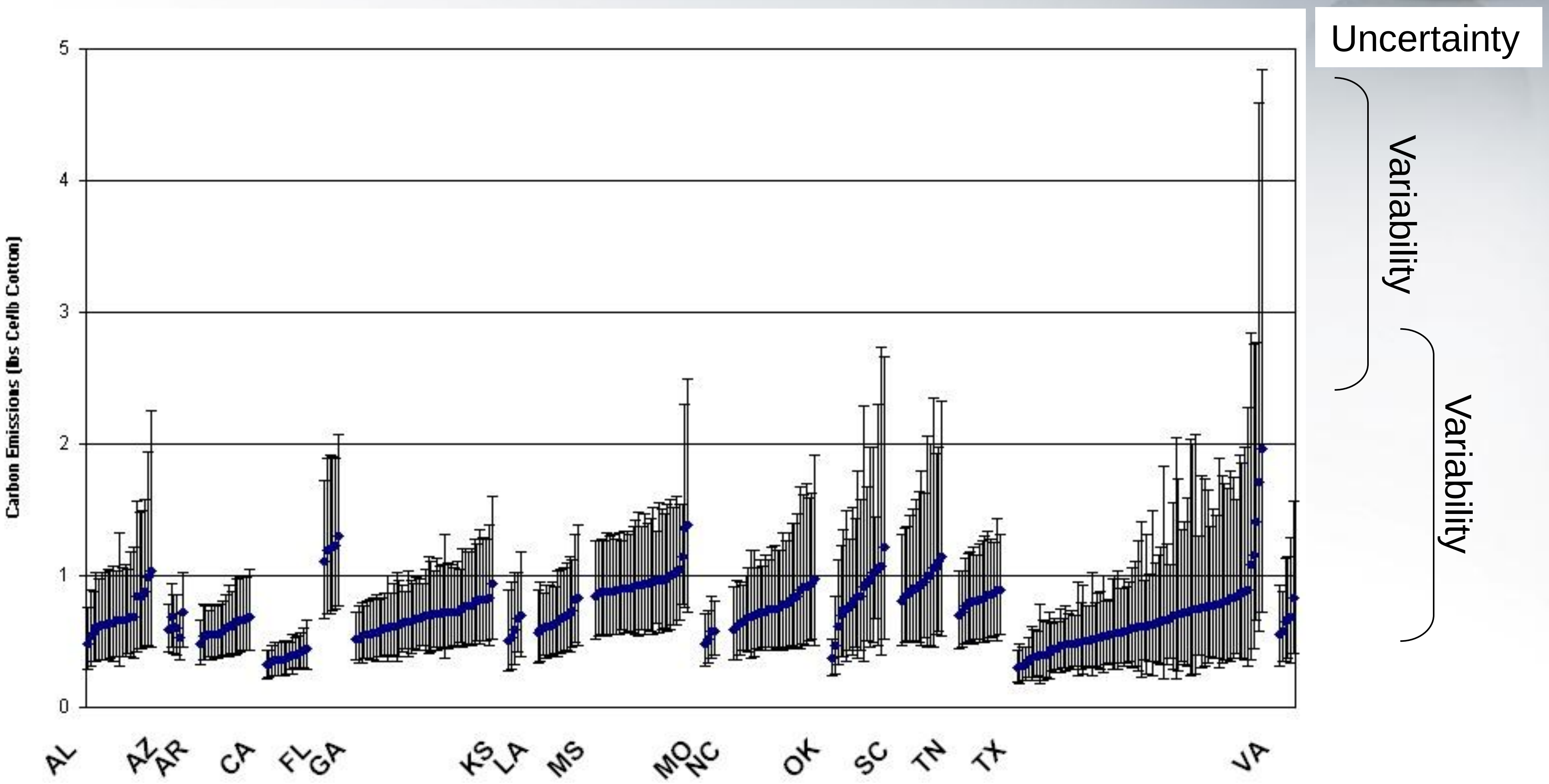
Based on 2000-2007 Avg Yield



2007 Numbers



Monte Carlo Simulation
Variability and Uncertainty



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Cotton LCA: Key Findings

1. Nitrogen Matters

- Fertilizer, N2O

2. Regionality Matters

- California Cotton is not the same as Florida Cotton

3. Yield Matters

- High outputs can outweigh high inputs

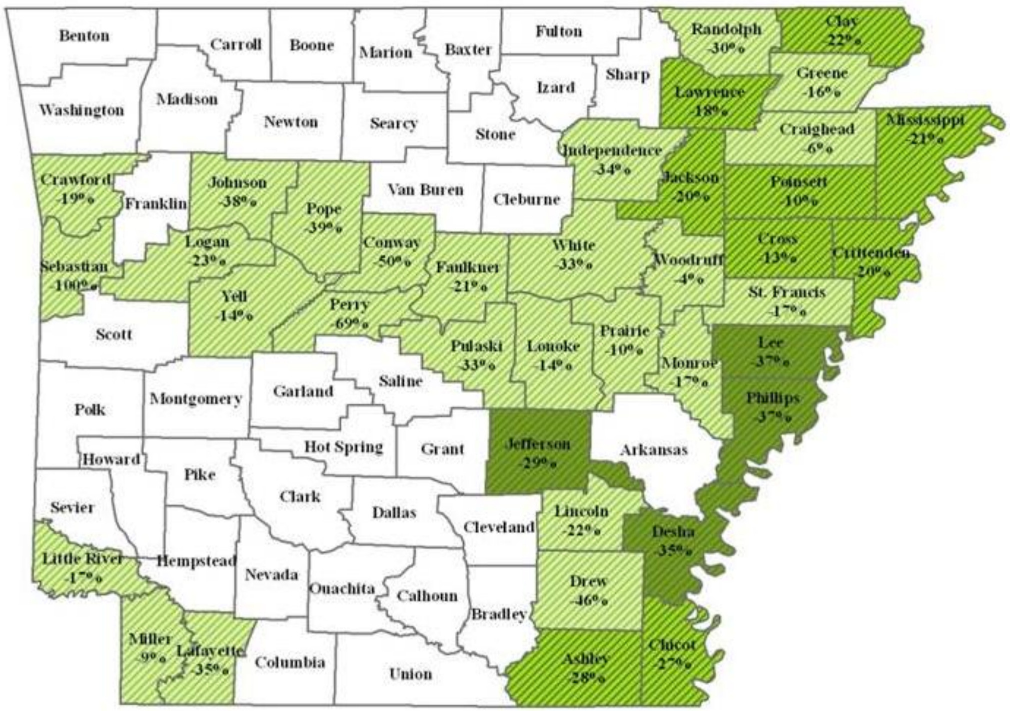
4. Assumptions, data and variability matter

- LCA's are more than just a number

US Cotton Green House Gas LCA
Waxman-Markey Bill

Carbon Policy Analysis: Change in Pounds of Carbon Emissions from 2008 Baseline to 20% Reduction in Carbon

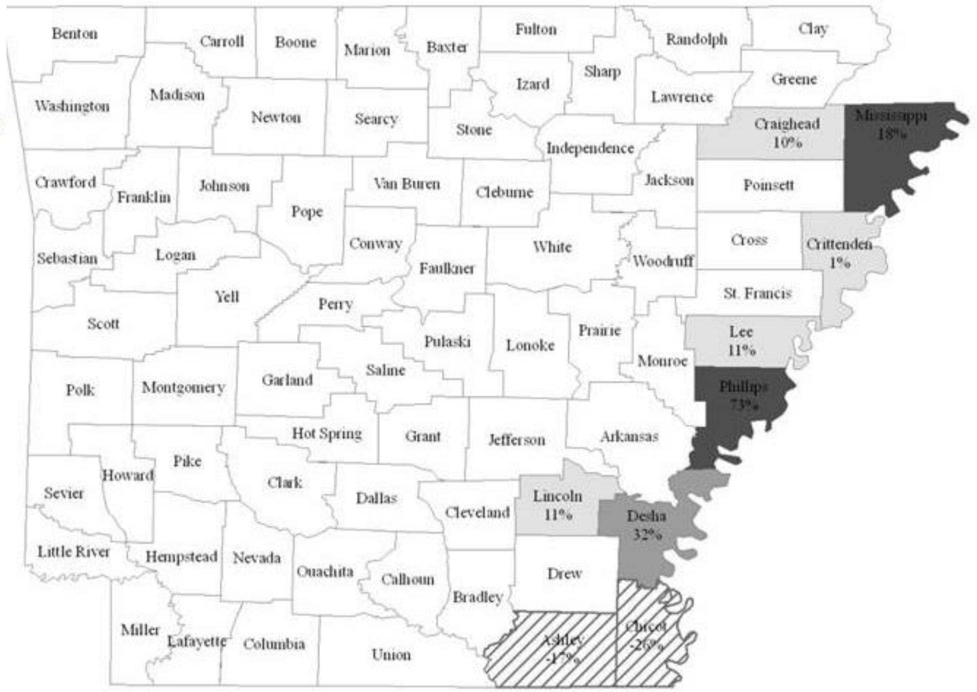
Nalley, L. and Popp, M. University of Arkansas, Forthcoming



Legend

Change in Pounds Carbon

- 0
- -1 to -12 million
- -12 to -24 million
- -24 to -36 million



Legend

Change in Acreage

- **-15,000 to -1**
- **0**
- **1 to 15,000**
- **15,001 to 30,000**
- **30,001 to 45,000**

LCA Can Transform Agriculture

- Data provide robust systems analysis for efficiencies:
  - ✓ Energy
  - ✓ Water
  - ✓ Land Use
  - ✓ Pollutants (GHG, sediment, etc)
- Scenarios allow for rapid adaptation to changing conditions:
  - ✓ Fuel costs
  - ✓ GHG policy
  - ✓ Water scarcity
  - ✓ Water quality concerns (TMDLs)

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Incentives for LCA Participation

- Many aspects of LCA generate positive financial returns for economic actors
  - Efficiency gains through reduced energy consumption, material waste, spoilage, etc.
  - Private funding for data collection and modeling is feasible

- Many elements of LCA involve public goods
  - Ecosystem services, biodiversity, etc.
  - Public funding for data collection is required
  - Agriculture is a key sector on multiple dimensions

Current Sustainability Metrics Initiatives in Agriculture

Field to Market – The Keystone Alliance

- Focused on Commodity Agriculture
- Metrics are outcomes based, technology neutral
- Metrics are national and regional in scale

ANSI Standard – Leonardo Academy

- Focused on ALL Agriculture at farm gate (Phase 1)
- Metrics are outcomes based, technology neutral
- Metrics are national, regional and local in scale?

Stewardship Index for Specialty Crops

- Focused on Specialty Crops
- Metrics are outcomes based, technology neutral
- Metrics are regional and local in scale

Walmart – Sustainability Index

Field to Market
Keystone Alliance for Sustainable Agriculture

Steering Committee Members and Participants

- American Farm Bureau Federation
- American Soybean Association
- Bayer CropScience
- Bunge
- Cargill
- Conservation International
- Conservation Technology Information Center
- Cotton Incorporated
- CropLife America
- CropLife International
- DuPont
- Fleishman-Hillard
- General Mills
- Grocery Manufacturers of America
- John Deere
- Kellogg Company
- Land O'Lakes
- Manomet Center for Conservation Science
- Mars, Incorporated
- Monsanto Company
- National Association of Conservation Districts
- National Association of Wheat Growers
- National Corn Growers Association
- National Cotton Council of America
- National Potato Council
- Syngenta
- The Coca-Cola Company
- The Fertilizer Institute
- The Nature Conservancy
- United Soybean Board
- World Resources Institute
- World Wildlife Fund
- University of Arkansas Division of Agriculture
- University of Wisconsin-Madison College of Agricultural and Life Sciences

Background: Field to Market

- **Field to Market is a collaborative stakeholder group** of producers, agribusinesses, food and retail companies, and conservation organizations that are working together to develop a supply-chain system for agricultural sustainability.

- **We are developing outcomes-based metrics**
  - We will measure the environmental, health, and socioeconomic impacts of agriculture first in the United States
  - We began with national scale environmental indicators for corn, soy, wheat, and cotton production in the U.S.

- The group was convened and is facilitated by **The Keystone Center**, a neutral, non-profit organization founded in 1975 to ensure that present and future generations approach environmental and scientific dilemmas and disagreements creatively and proactively.

Definition of Sustainable Agriculture

1. Meeting the needs of the present while enhancing the ability of future generations to meet their needs
2. Increasing productivity to meet future food demands
3. Decreasing impacts on the environment
4. Improving human health
5. Improving the social and economic well-being of agricultural communities

"Feeding 9.25 billion people without one hectare more of land or one drop more of water"

Field to Market
Keystone Alliance for Sustainable Agriculture

Environmental Indicator Report – Metrics 101

- **Overview**
  - National scale outcomes (US only)
  - Land use, soil loss, water use, energy use, and climate impact (greenhouse gas emissions)
  - On farm-production of corn, cotton, soybeans, and wheat
  - Results presented by crop: per unit of output (bushel or pound), per acre, and as annual totals
  - Utilizes publicly available data

- **Peer Review Process**
  - Conducted in May 2008
  - Feedback was incorporated into revisions of the current report

Field to Market

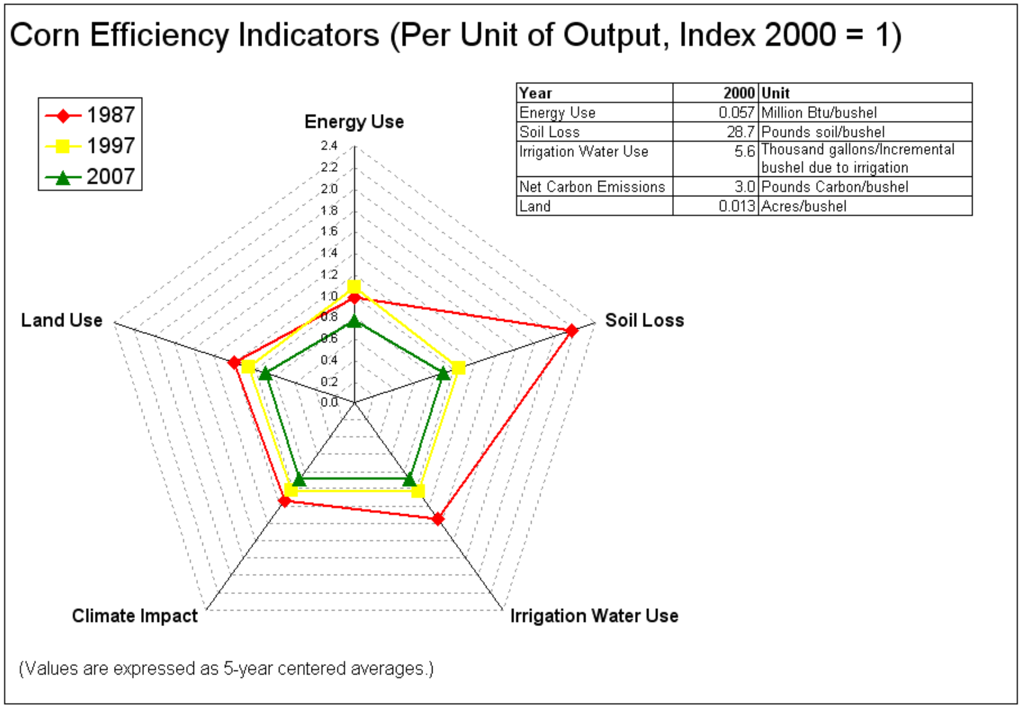
Components of a Sustainability Index

	Environmental Outcomes							Social and Economic Outcomes							Health and Safety Outcomes	
	Land	Soil	Water Use	Water Quality	Energy	Climate	Biodiversity	Producer Income	Labor	Productivity	Competing Land and product uses	Availability	Post Harvest Loss	Consumer Demand	Nutrition (access to calories, etc)	Safety
International Scale																
National Scale	x	x	X		x	x				x						
Regional Scale																
Local Scale																

Environmental Indicator Report
Corn: Summary of Results

Over the study period (1987-2007),

- **Productivity** (yield per acre) has increased 41 percent.
- **Land use** increased 21 percent. Land use per bushel decreased.
- **Soil loss** above T has decreased 43 percent per acre and 69 percent per bushel.
- **Irrigation water use** per acre decreased four percent. Water use per bushel has been variable, with an average 27 percent decrease over the study period.
- **Energy use** per acre increased three percent. Energy use per bushel decreased 37 percent.
- **Greenhouse gas emissions** per acre increased eight percent. Emissions per bushel decreased 30 percent.



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Field to Market

Components of a Sustainability Index

	Environmental Outcomes							Social and Economic Outcomes							Health and Safety Outcomes	
	Land	Soil	Water Use	Water Quality	Energy	Climate	Biodiversity	Producer Income	Labor	Productivity	Competing Land and product uses	Availability	Post Harvest Loss	Consumer Demand	Nutrition (access to calories, etc)	Safety
International Scale																
National Scale	x	x	X		x	x				x						
Regional Scale																
Local Scale																

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Ecological Indicators at the Watershed Scale

SCALE

Land Use

Agriculture | Forest | Urban

Watershed

Corn | Wheat | Soybean | Cotton

Ridge | Mulch | Reduced | Conventional

Stream Reach

Bank Erosion | Sediment Size | Riparian Cover

Site

EPT Taxa | O/E Ratio | Critical Species

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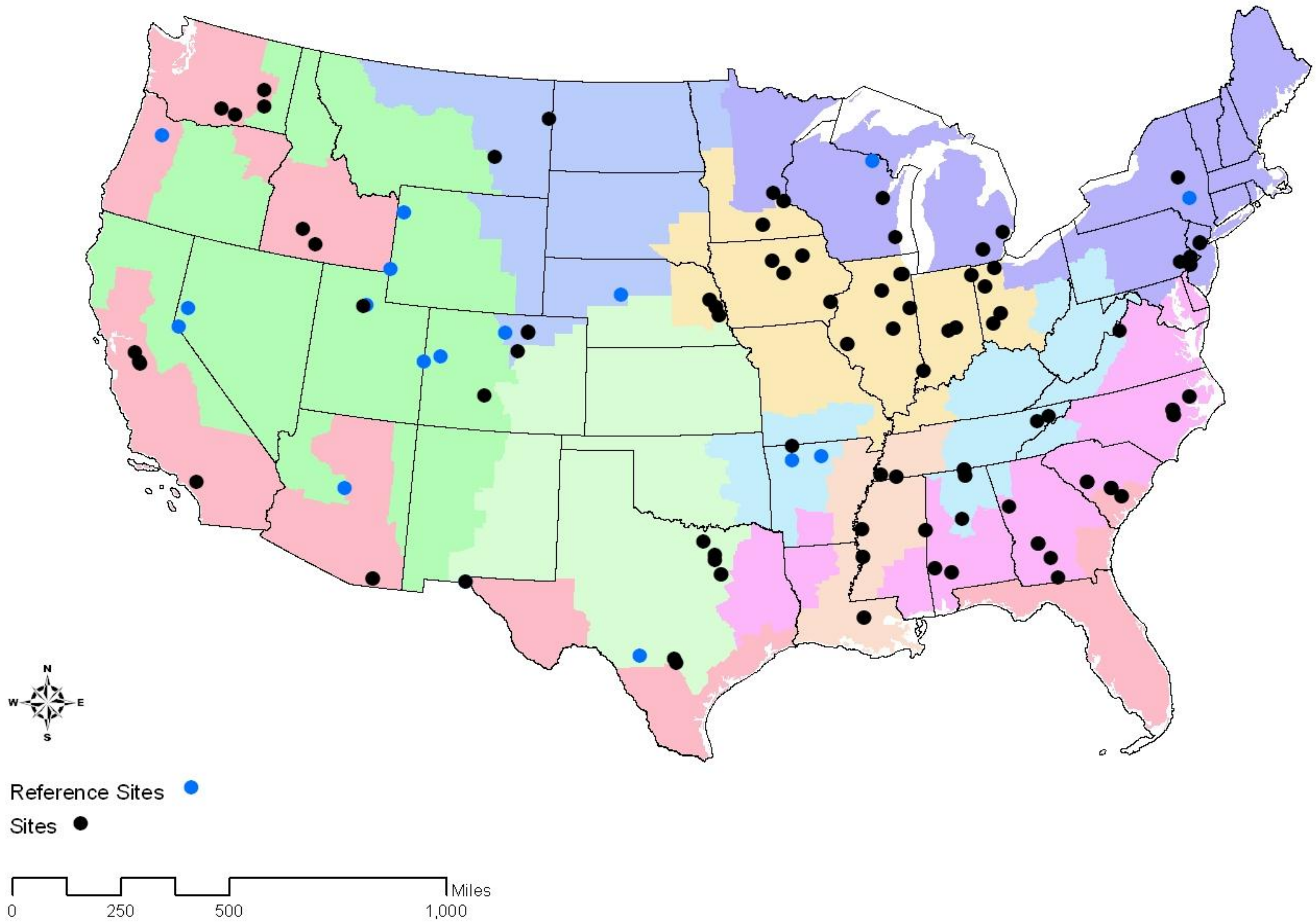
USGS NAWQA Sites, Reference Sites, and USDA ERS Regions



ANSI Standard for Sustainable Agriculture

Technical Committee recommended:

1. Standard Should End at the Farm Gate

   Addressing issues post farm gate would be overly cumbersome and would necessitate the inclusion of dozens of new members to the full committee in order to accurately address the issues facing these interests.

2. Standard Should Initially Be Limited to Crop Production

   The initial standard should not address livestock due to the complexity of the task; sustainable standards for livestock should be a high priority when the standards are expanded.

3. Standard Should be Performance Oriented

   Performance standards rely on measurable data to demonstrate the positive and negative effects of specific production practices, and will encourage producers to monitor their practices over time.

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Stewardship Index for Specialty Crops

- Multi-stakeholder initiative to develop a system for measuring sustainable performance throughout the specialty crop supply chain.
- The project will offer a suite of outcomes-based metrics to enable operators at any point along the supply chain to benchmark, compare, and communicate their own performance.
- The Stewardship Index will not seek to provide standards, but will instead provide a yardstick for measuring sustainable outcomes.
- May also provide tools and resources to help specialty crop companies advance sustainability goals.

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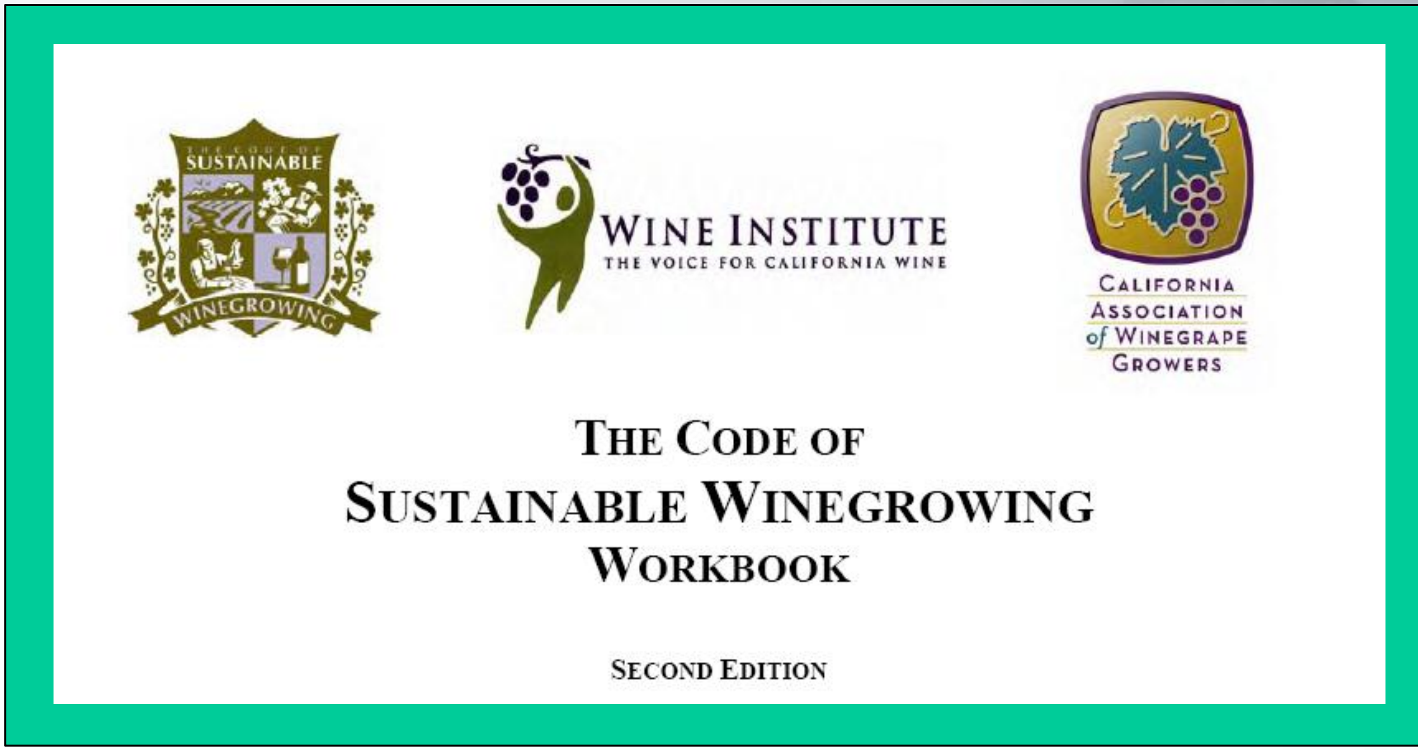
What does an Agricultural Sustainability Standard Look Like?

- Four categories of certification
- Requires external verification and audits
- Addresses one crop in one region
- More than 500 pages long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WINE INSTITUTE
THE VOICE FOR CALIFORNIA WINE
CALIFORNIA ASSOCIATION of WINEGRAPE GROWERS

THE CODE OF
SUSTAINABLE WINEGROWING
WORKBOOK

SECOND EDITION

Emerging Consensus on LCA Framework

- Need for comparable metrics that span sectors, industries and geographies
- Metrics should be grounded in scientific methodologies, namely Life Cycle Assessment
- LCA data (LCI) should be transparent, validated, widely available, inexpensive
- The same LCA data and models should be used by producers, retailers, policymakers, NGOs and consumers
- Sustainability Metrics, Indicators and Indices must be transparent