Sustainability Agriculture and Life Cycle Assessment

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General Outline

- Introduction
- What is Sustainable Agriculture?
- Measuring Sustainability with LCA
- Case Studies – Cotton and Milk
- Software Demo

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Sustainability

"I shall not today attempt further to define … and perhaps I could never succeed in intelligibly doing so. But ***I know it when I see it…"***

Justice Potter Stewart, Jacobellis v. Ohio, (1964)

Defining Sustainability

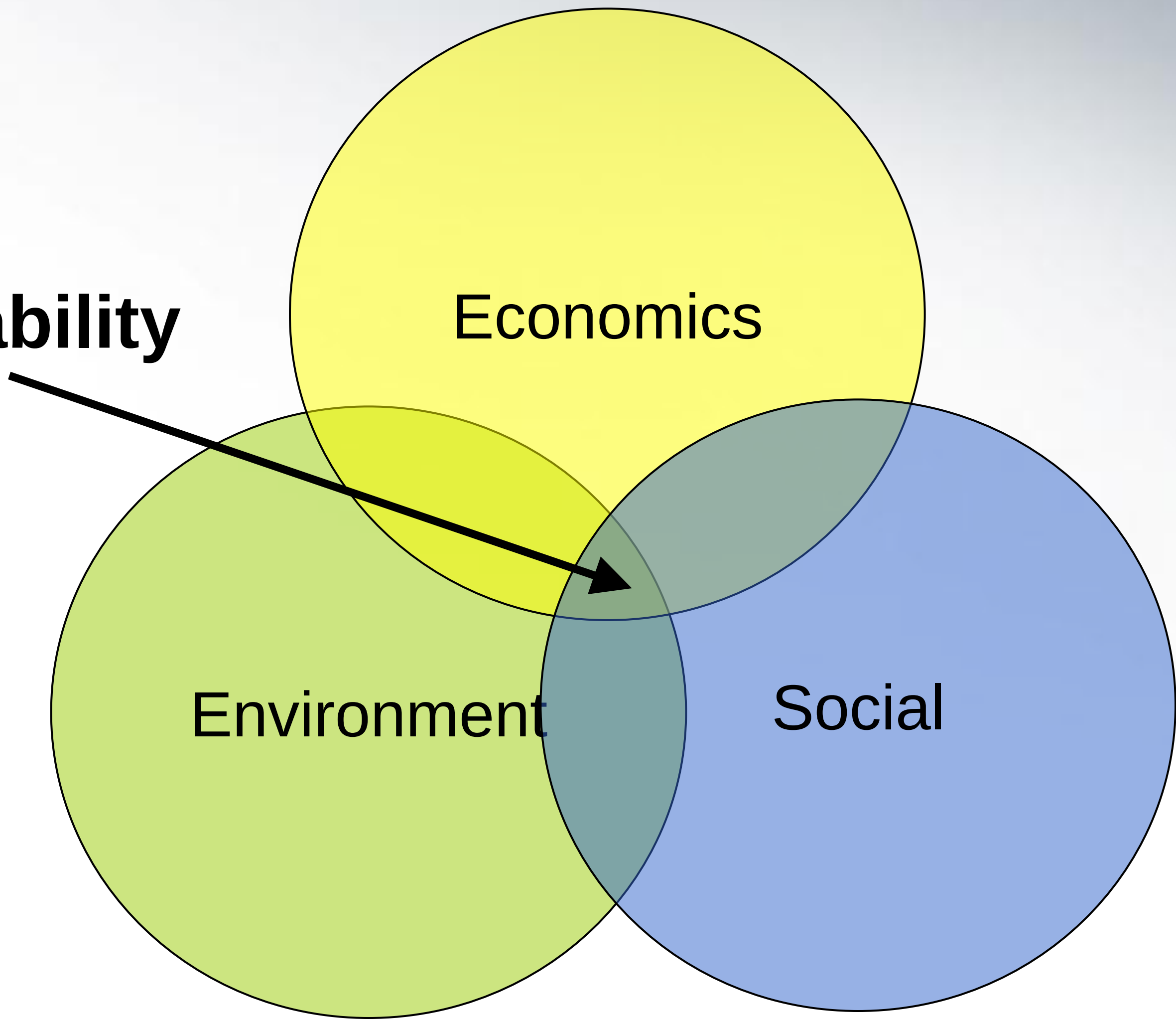
"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Brundtland Commission Report, 1987

Defining Sustainability may actually be easier than "knowing it when you see it." Sustainability needs to be measured.

Taking Action:
Choosing Sustainability

Sustainability



How Do We Make Sustainable Decisions?

Consumers: What To Buy?

Producers: What to Make?
How to Make it?

Government: What Policies to Enact?

Researchers: We Help Define What is Sustainable

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

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?

USDA ORGANIC

Free Range

THE CARBON STANDARD • CARBON NEUTRAL APPROVED

CERTIFIED NATURALLY GROWN

FAIRTRADE

Our Farmers' Pledge Not to use Artificial Growth Hormones

It's perfectly natural PESTICIDE FREE

buy local INDEPENDENT BUSINESSES SUPPORTING THE LOCAL ECONOMY 2007

rBGH FREE Our Private Dairy Herd is NOT treated with rBGH.

RAINFOREST ALLIANCE CERTIFIED EST 1987

Assessing Sustainability

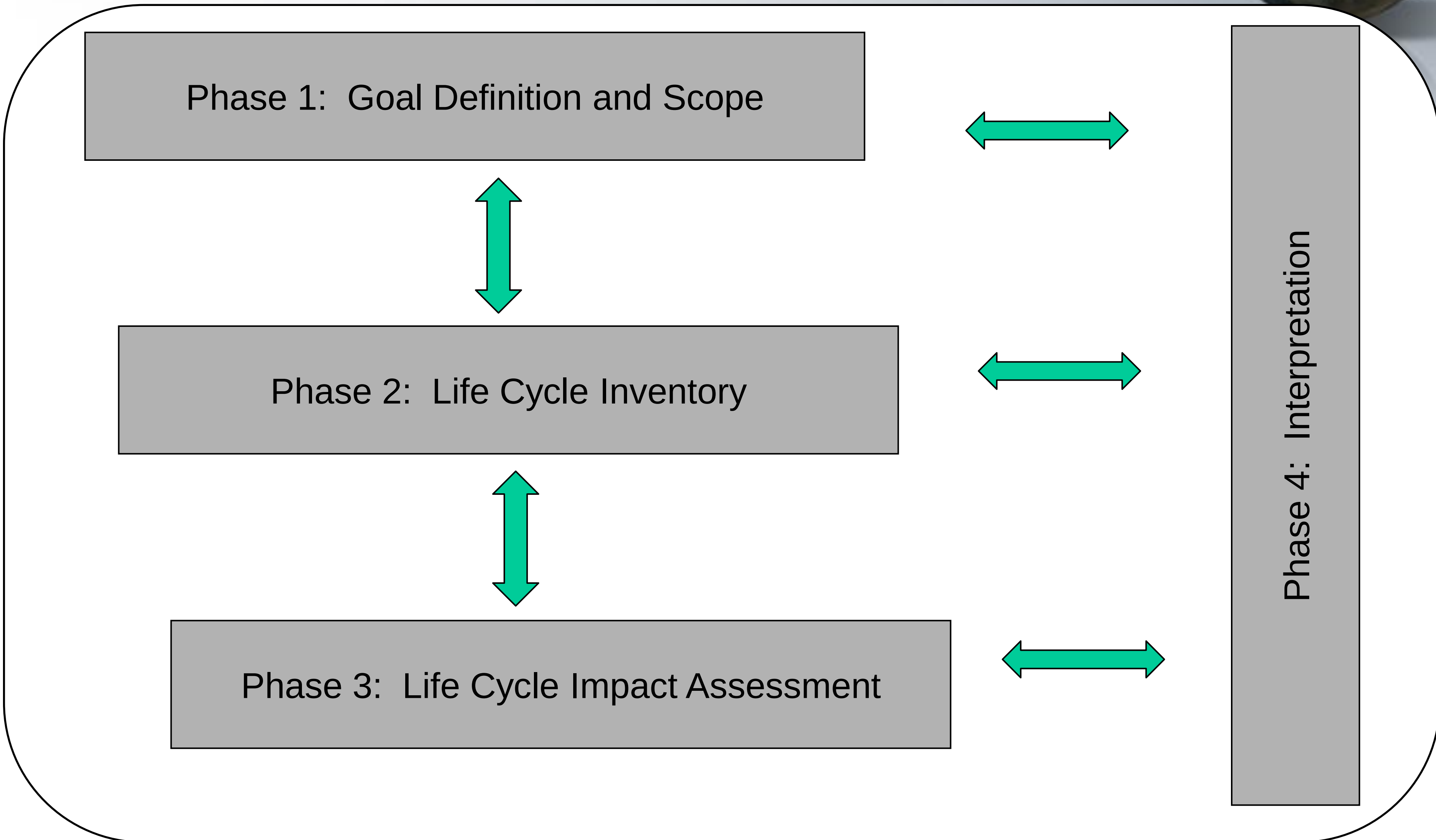
1. Determine Metrics We Care About
    - Global Warming
    - Water Quality
    - Water/Natural Resource Depletion
    - Ecotoxicty, etc
    - Social/Economic Welfare

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

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

Life Cycle Assessment Phases

An Iterative Process!



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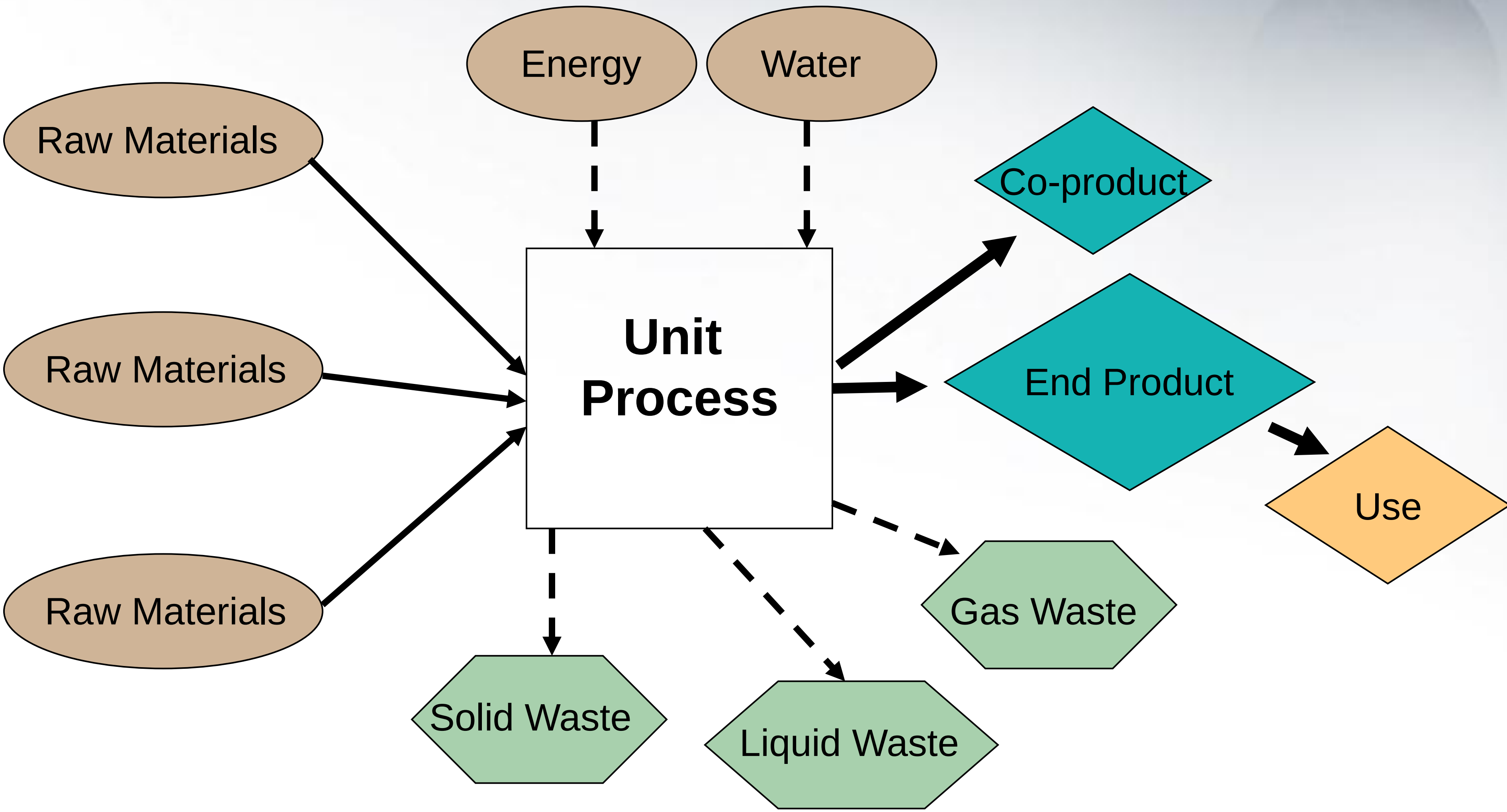
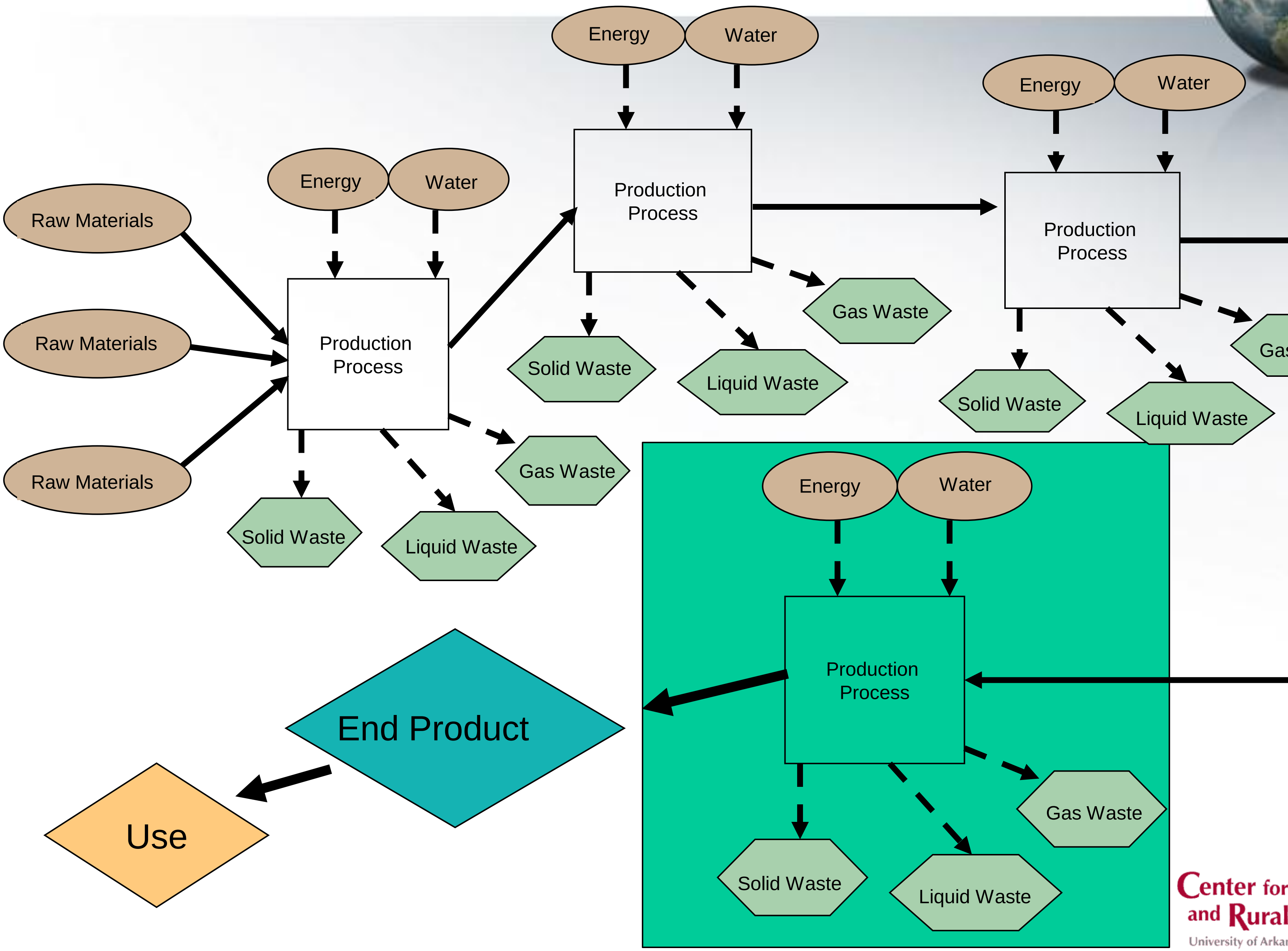
Every Process has Inputs And Outputs



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 Standards.

Scope

Determine What To Include and Exclude

EG: Cradle to Grave, Cradle To Gate, Gate To Gate, Etc

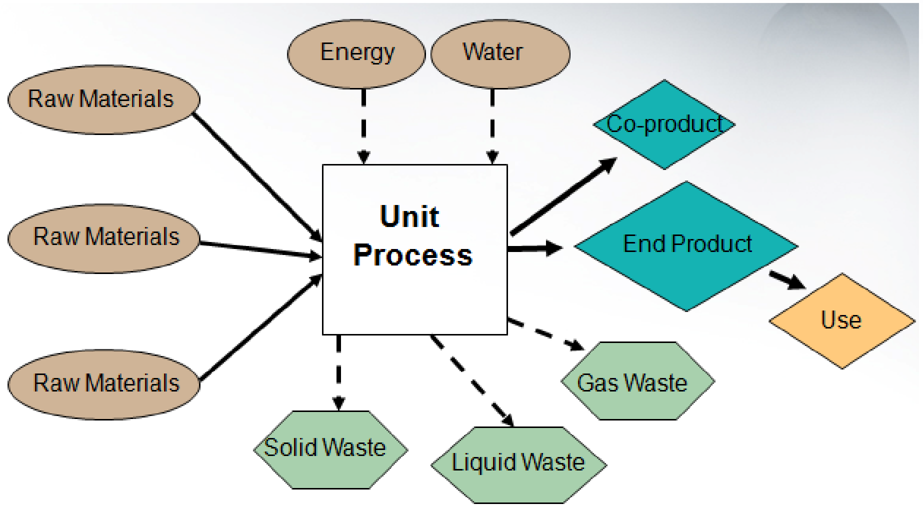
Impacts, Infrastructure, Use Phase, Waste/Recycle, Sequestration vs Emission, Labor, Co-Products, etc,

Life Cycle Inventory:
Data Collection and Data Sources

LCI: What goes in, and What Comes Out

Data Collection: Measurements, Survey and Literature,

Data Sources: EcoInvent, US LCI, EIO-LCA, EPA etc.



Life Cycle Impact Assessment:

Characterization: Summing All Features With Same Impact

Damage Assessment: “Emissions” to Damages e.g. DALY

Normalization: Compare to National Average

Weighting: Comparing Impacts DALY vs PDF*m2

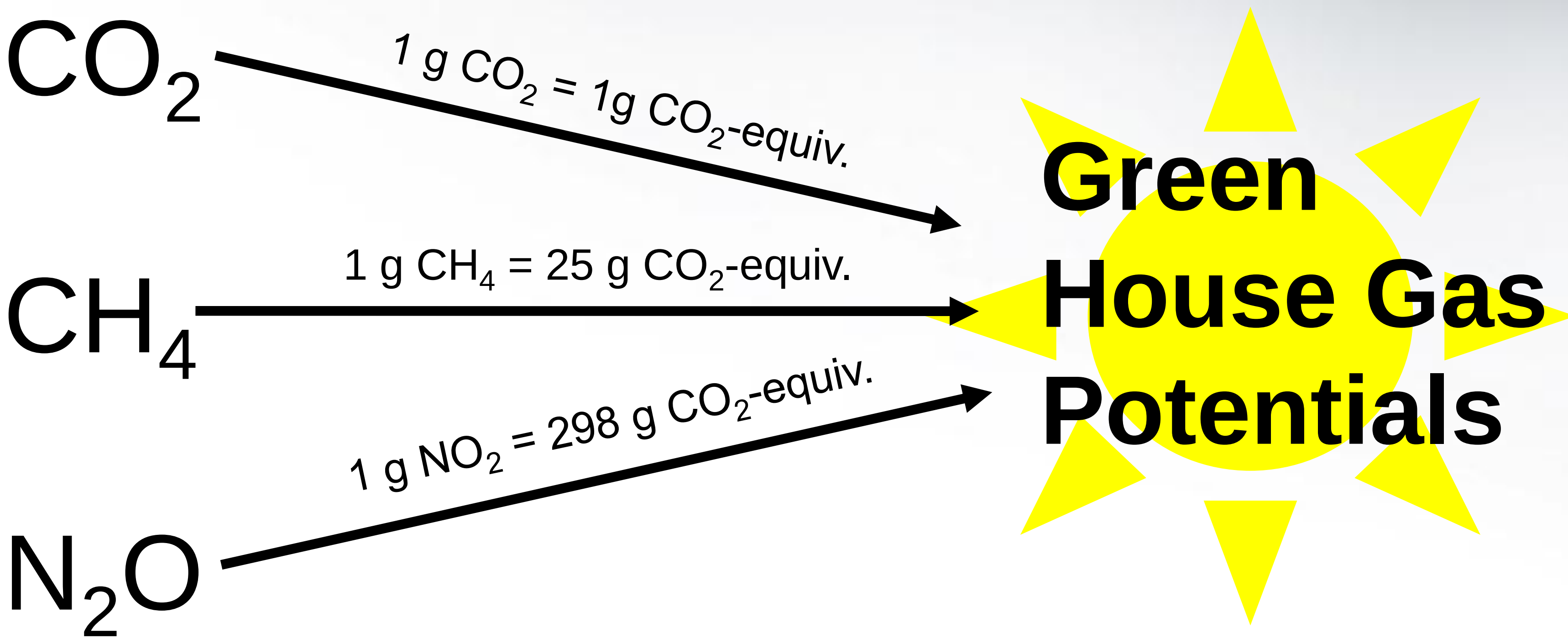
Single Score: Weighted “Final” Scores

Life Cycle Assessment:

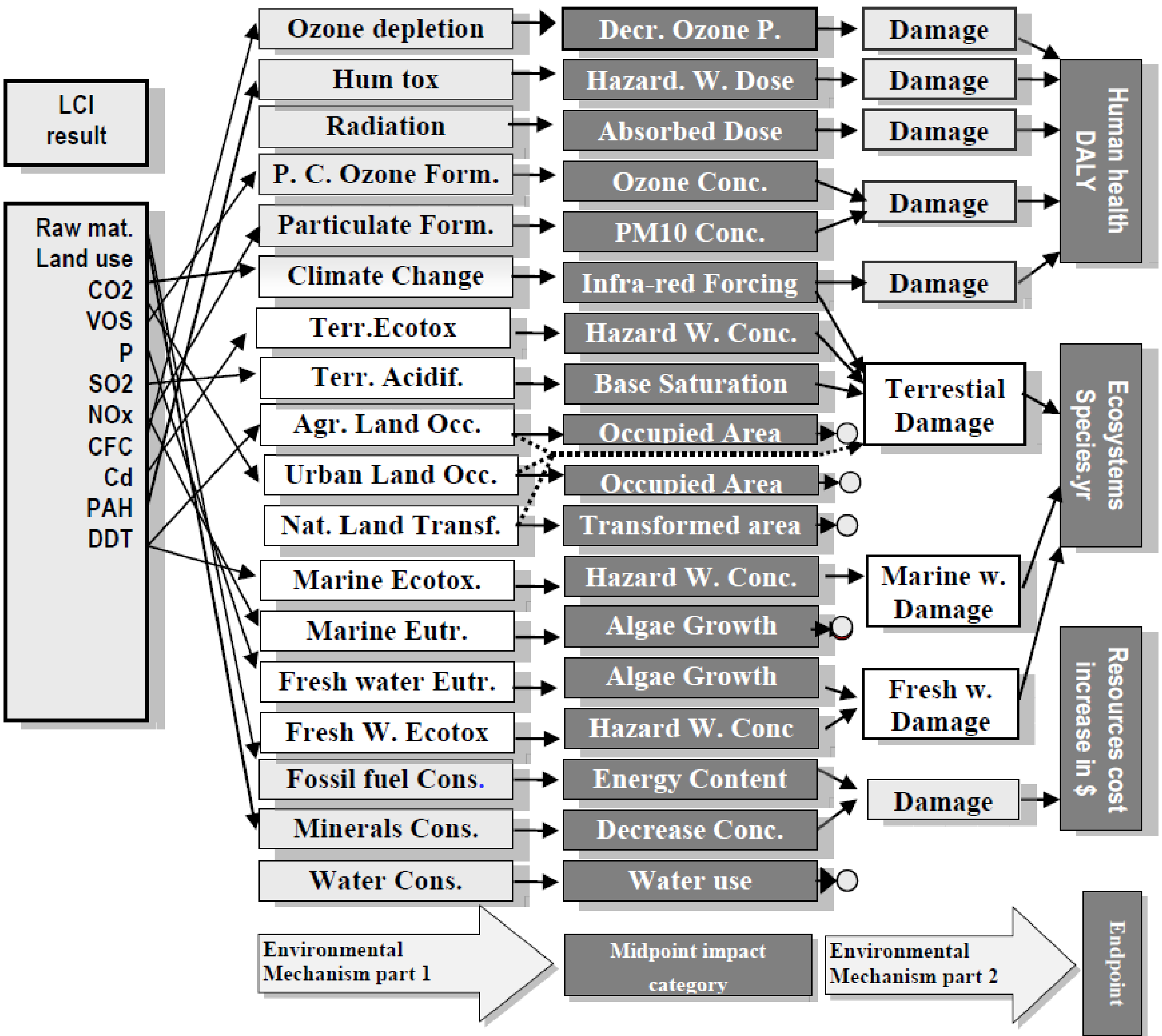
LCI Data		LCA Software Interface Tools		Impact Assessment Models
EcoInvent, USLCI, EIO-LCA	↔	Excel, SimaPro, GABI, Earthster, DairyGHG	↔	ReCiPe, Impact2002+, Ecoindicator, Etc.

Life Cycle Assessment: Reconciling Functional Units

Characterization



Midpoints, Endpoints and Damage



From ReCiPe

Impact Methods and Metrics

Methods

CML	**Impact 2002+**	**ReCiPe**	**TRACI**
Human Toxicity			
Human Toxicity *kg 1,4-DB eq*	Carcinogens Non-carcinogens *kg C2H3Cl eq / DALY*	Human Toxicity *kg 1,4-DB eq / DALY*	Carcinogens Non-Carcinogens *kg benzen/ toluen eq*
Ecological Toxicity			
Freshwater Aquatic Marine Aquatic Freshwater Sediment Marine Sediment Terrestrial *kg 1,4-DB eq*	Aquatic Terrestrial *kg TEG eq/ PDF*m2*yr*	Freshwater Marine Terrestrial *kg 1,4-DB eq / species.yr*	Ecotoxicity *kg 2,4-D eq*

1,4-DB: Para-dichlorobenzene
2,4-Dichlorophenoxyacetic acid
C2H3Cl: Vinyl Chloride
TEG: Triethylene-glycol

DALY: Disability Adjusted Life Year
PDF*m2*yr: Potentially Disappeared Fraction

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Dairy LCA:

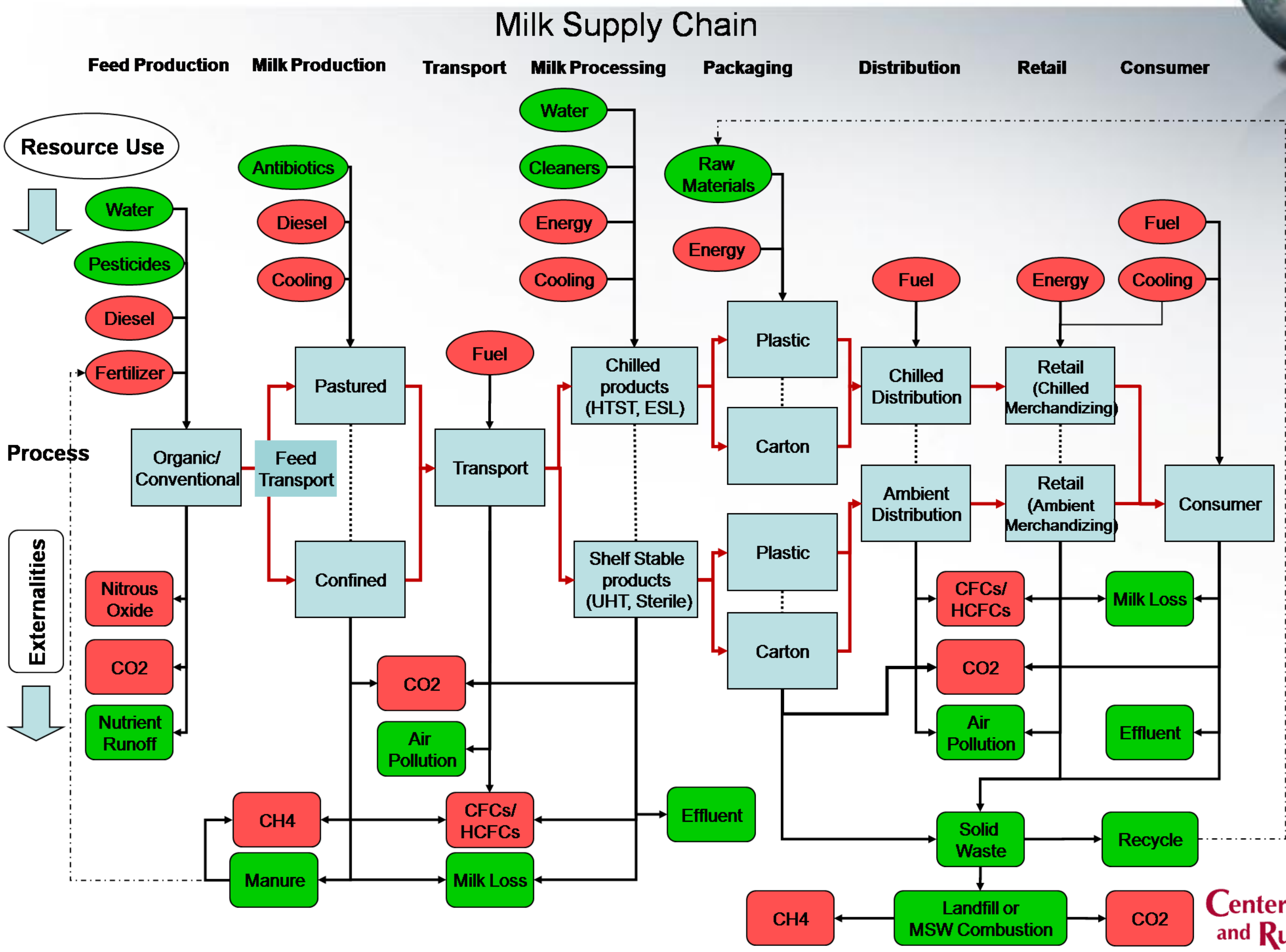
Goal & Scope

- Greenhouse Gas Emissions
- US and Regional Averages and Totals for 1 Gallon of Fat Corrected Milk From Feed Production to Consumer,
- Including Use and Waste

LCI: Literature Review, Production Budgets, Surveys

Impact Assessment: Used GHG/GWP as Impact Category

Life Cycle Assessment Case Study: Carbon Equivalent GHG in Dairy



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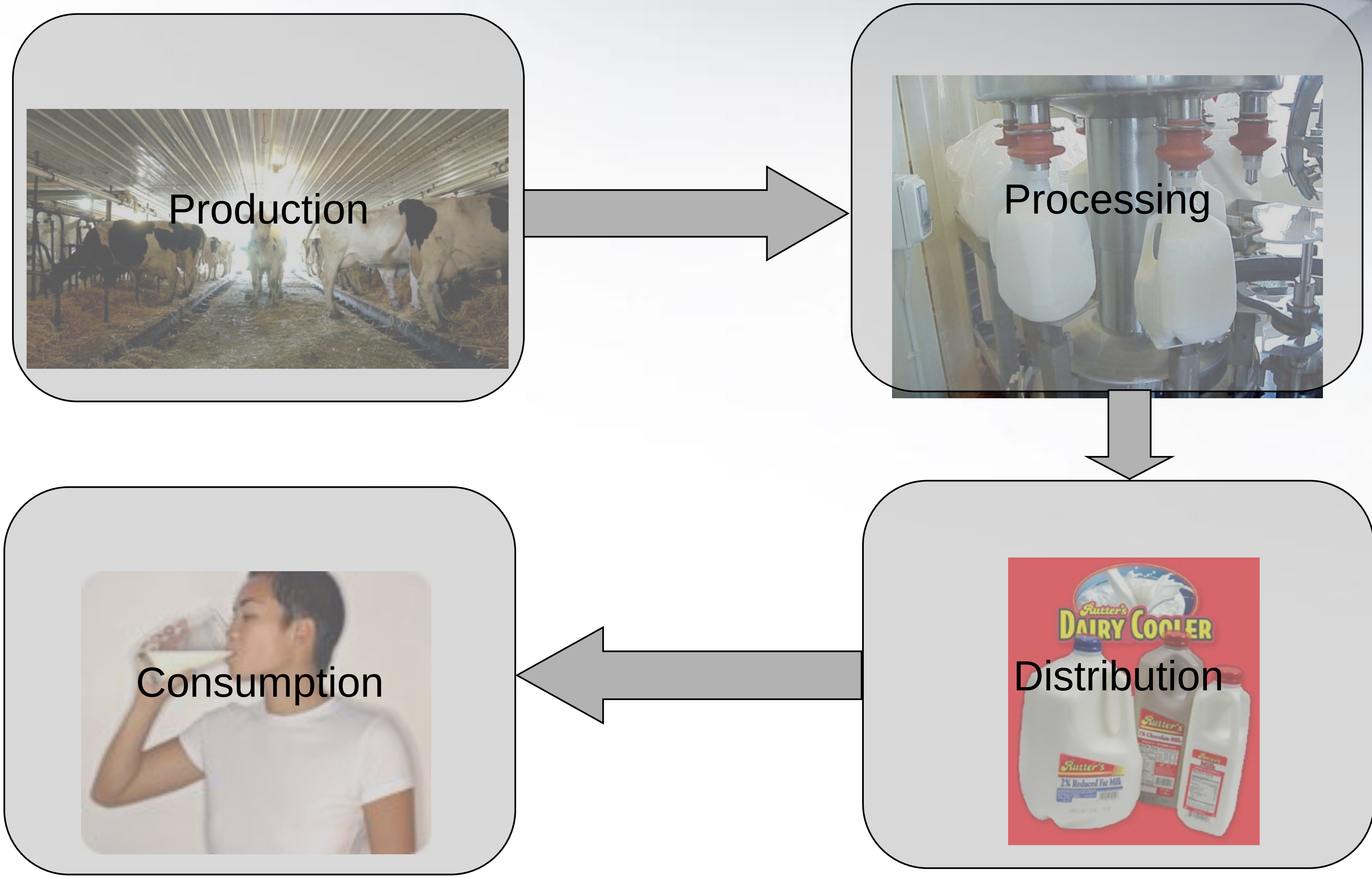
Life Cycle Assessment Case Study: Carbon Equivalent GHG in Dairy



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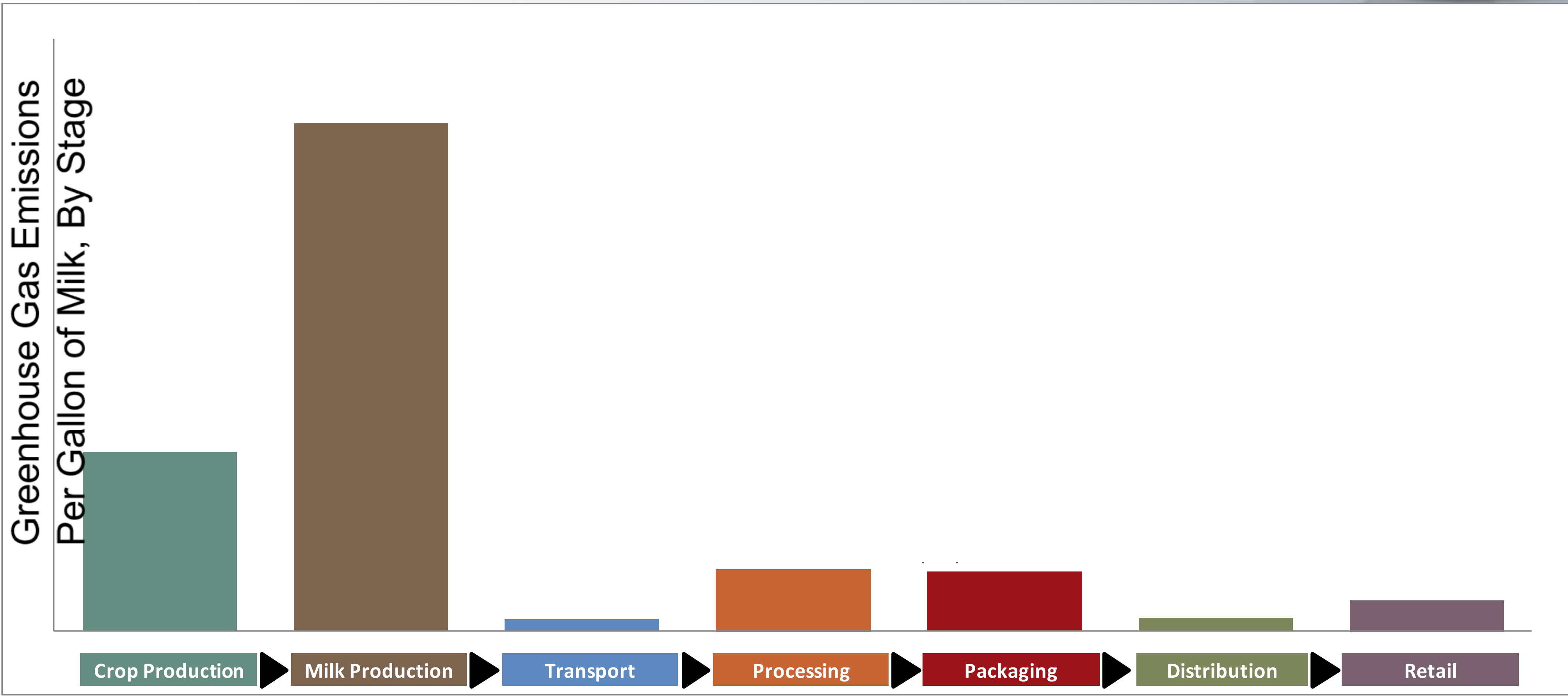
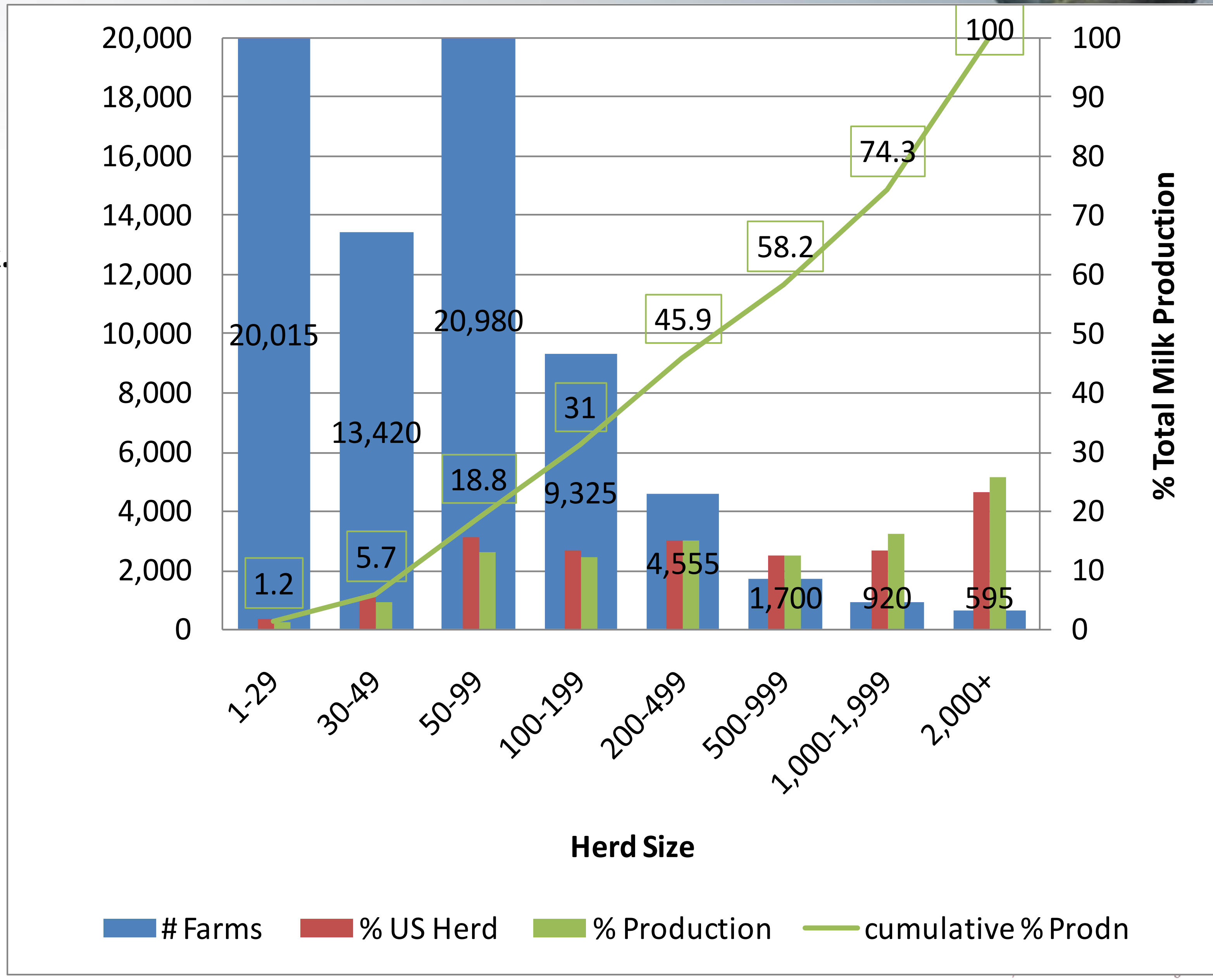
Scan level carbon footprint for Liquid Milk



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

US Dairy Demographics

Approximately 10% of largest farms produce 50% of milk. 50% 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, N_2O, 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,
   - “Fat-Protein Corrected” Milk – Functional Unit

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Cotton LCA:

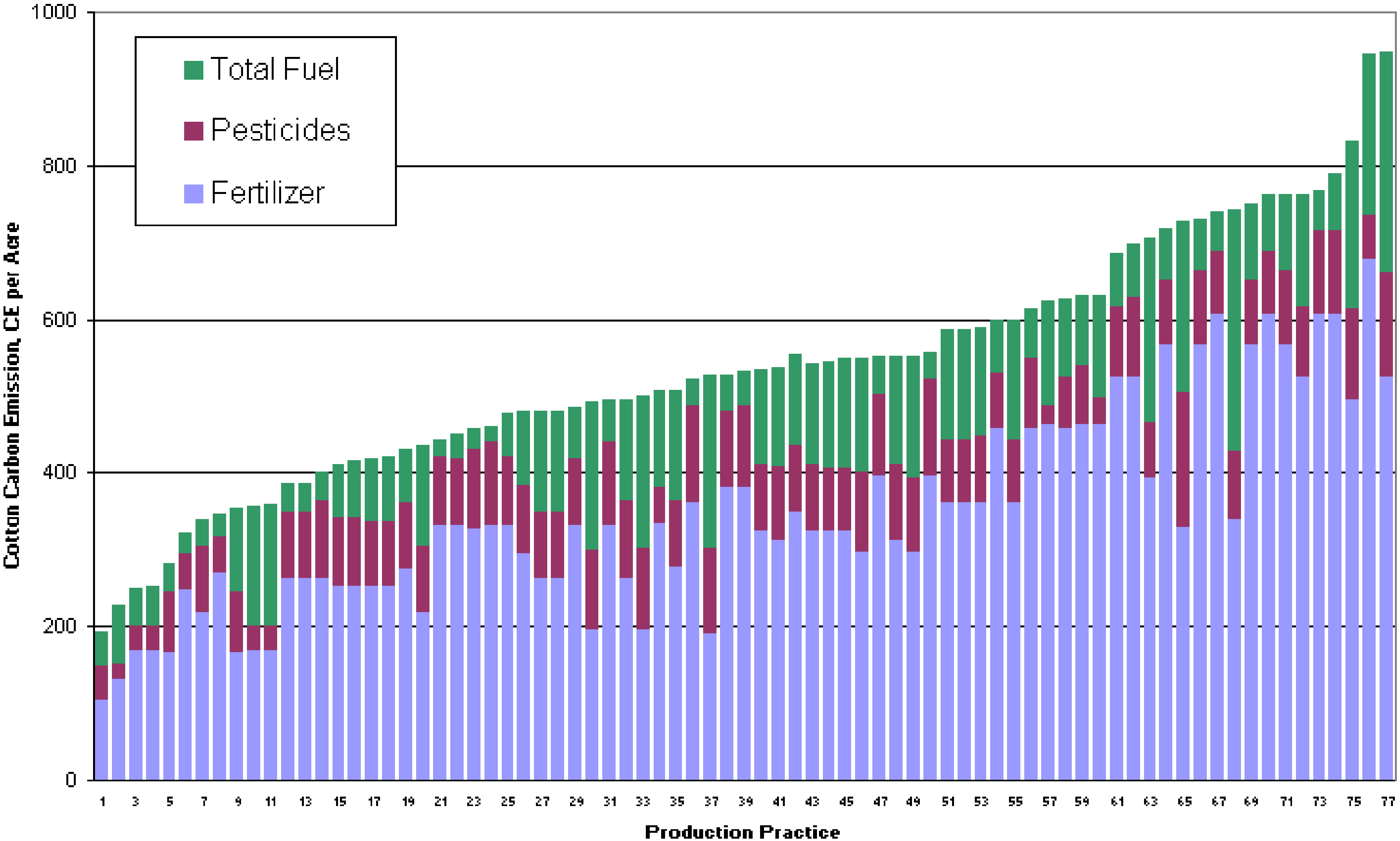
Goal & Scope

- Greenhouse Gas Emissions
- US, State and County Averages for 1 lb Upland Cotton Lint From Tilling to Boll Buggy
- Not Including Infrastructure

LCI: State Extension Production Budgets

Impact Assessment: Used GHG/GWP as Impact Category

Carbon Emission By Production Practice



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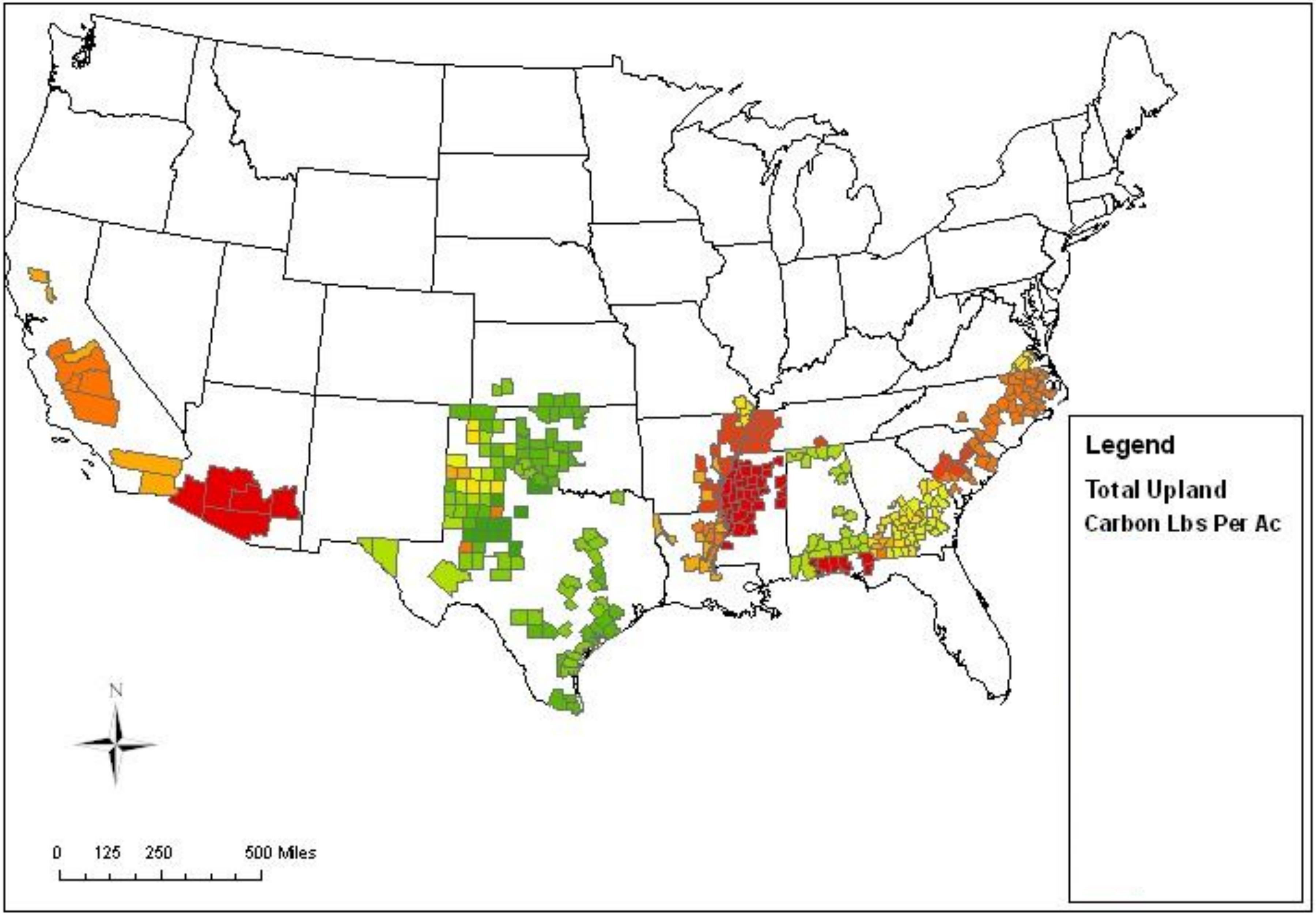
GHG Per Acre



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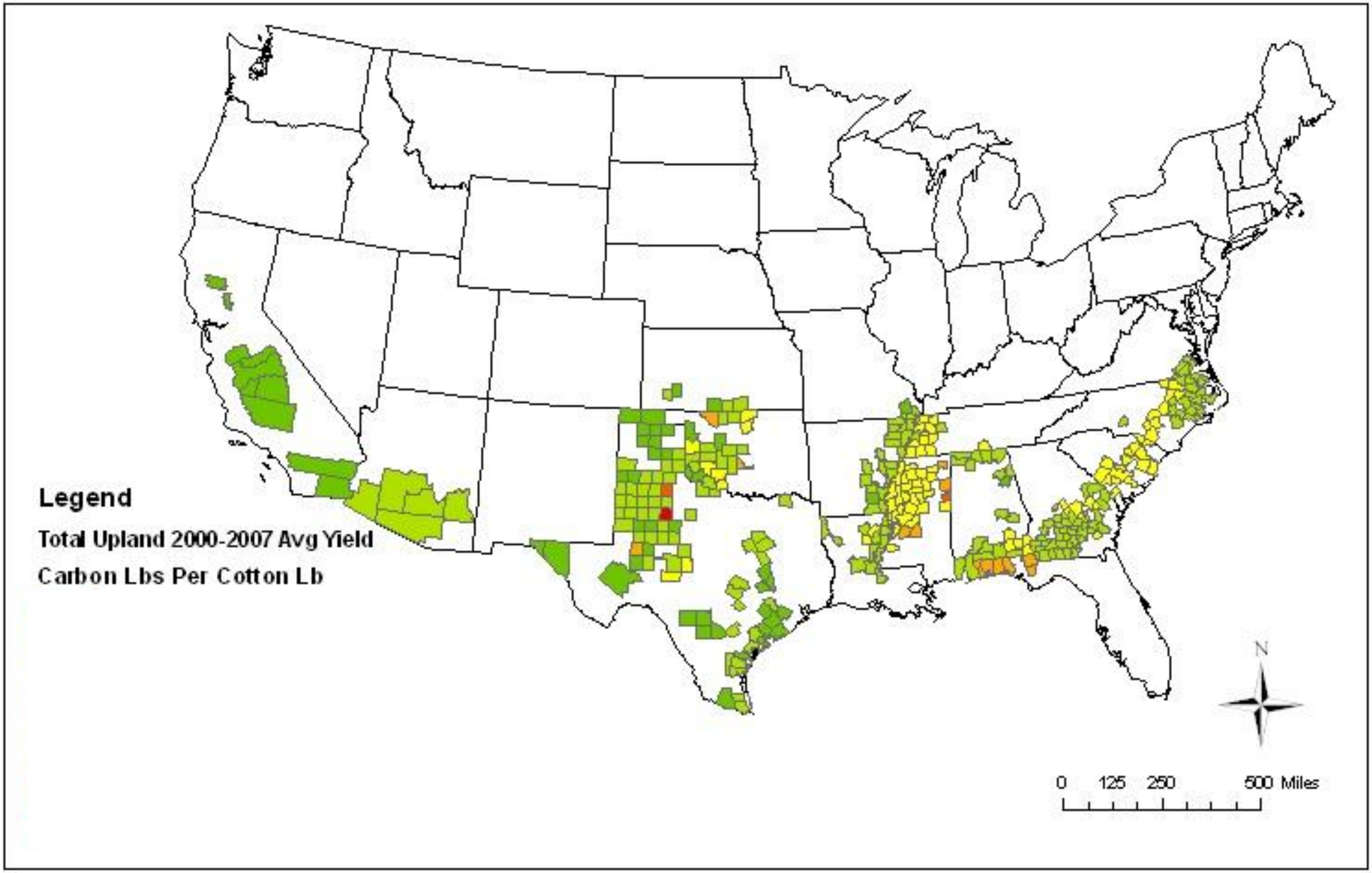
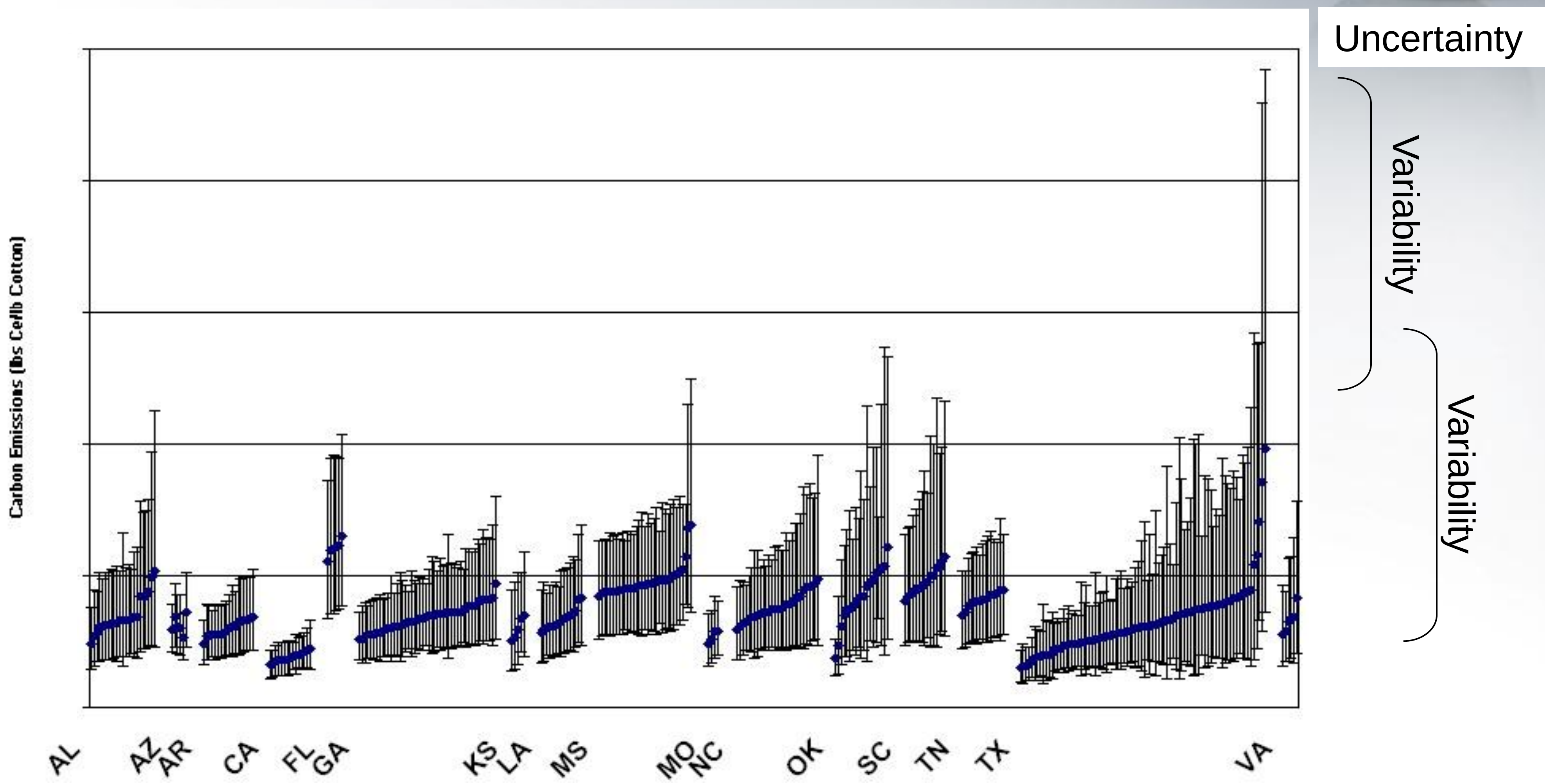
of Agriculture

Carbon Per Pound Cotton

Based on 2000-2007 Avg Yield



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

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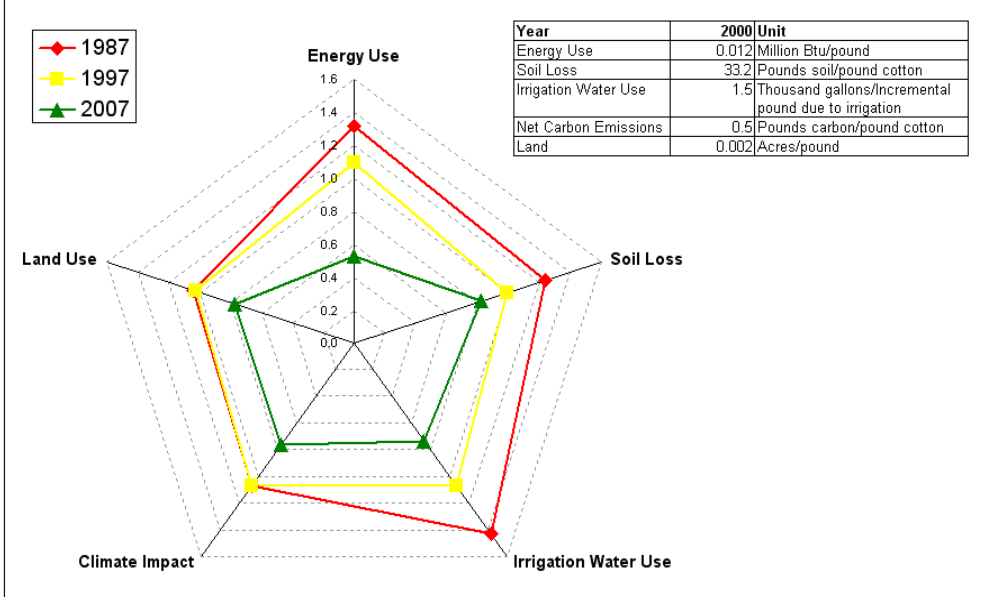
Environmental Indicator Report
Cotton: Summary of Results

Field to Market
Keystone Alliance for Sustainable Agriculture

Over the study period (1987-2007),

- **Productivity** (yield per acre) increased 31 percent, with most improvement occurring in the second half of the study period.
- **Land use** has fluctuated over time, with an overall increase of 19 percent. Land use per pound produced has decreased 25 percent.
- **Soil loss** per acre decreased 11 percent while soil loss per pound decreased 34 percent.
- **Irrigation water use** per acre decreased 32 percent, while water use per incremental pound of cotton produced (above that expected without irrigation) decreased by 49 percent.
- **Energy use** per acre decreased 47 percent while energy use per pound decreased 66 percent.
- **Greenhouse gas emissions** per acre decreased nine percent while emissions per pound fluctuated, with more recent improvements resulting in a 33 percent average decrease over the study period.

Cotton Efficiency Indicators (Per Unit of Output, Index 2000 = 1)



(Values are expressed as 5-year centered averages.)

• Total annual trends over the time period indicate soil loss and climate impact in 2007 are similar to the impact in 1987, with average trends over the study period remaining relatively flat. Total energy use decreased 45 percent and total water use decreased 26 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																

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