Healthy Animals: Healthy Planet

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Everything is Connected

**ECOSYSTEM SERVICES**

- **Provisioning**
  - Food
  - Fresh water
  - Wood and fiber
  - Fuel
  - ...

- **Supporting**
  - Nutrient cycling
  - Soil formation
  - Primary production
  - ...

- **Regulating**
  - Climate regulation
  - Flood regulation
  - Disease regulation
  - Water purification
  - ...

- **Cultural**
  - Aesthetic
  - Spiritual
  - Educational
  - Recreational
  - ...

**LIFE ON EARTH - BIODIVERSITY**

**CONSTITUENTS OF WELL-BEING**

- **Security**
  - Personal safety
  - Secure resource access
  - Security from disasters

- **Basic material for good life**
  - Adequate livelihoods
  - Sufficient nutritious food
  - Shelter
  - Access to goods

- **Freedom of choice and action**
  - Opportunity to be able to achieve what an individual values doing and being

- **Health**
  - Strength
  - Feeling well
  - Access to clean air and water

- **Good social relations**
  - Social cohesion
  - Mutual respect
  - Ability to help others

*Source: Millennium Ecosystem Assessment*
Everything is changing
The rate of change is incomprehensible

**HUMAN NUMBERS THROUGH TIME**

<table>
<thead>
<tr>
<th>2,000 YEARS AGO...</th>
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<tbody>
<tr>
<td>A.D. 0</td>
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...at the dawn of the first millennium A.D., the world’s population was around 300 million people.
The rate of change is incomprehensible.

1,000 YEARS LATER...

A.D. 1000

...the population had risen by as little as 10 million. And well into the second millennium, it grew less than 0.1 percent each year. The numbers in Europe even fell in the 1300s—struck down by the Black Plague. But beginning in the late 18th century, the Industrial Revolution would raise living standards and spur growth.
The rate of change is incomprehensible

800 years later...

1800
ONE BILLION

...the population had climbed to the landmark level of one billion people. Almost 65 percent of all people lived in Asia, 21 percent in a prospering Europe, and less than 1 percent in North America.
The rate of change is incomprehensible

1927 TWO BILLION

127 YEARS LATER...

...the two-billionth baby was born. From 1920 to 1950, the population growth rate hovered around 1 percent a year. But beginning in the middle of the century, the advent of antibiotics and other public health advances profoundly altered life expectancy, increasing the number of children who would live to bear their own children.
The rate of change is incomprehensible.

1960
THREE BILLION

33 YEARS LATER...
...advances in medicine, agriculture, and sanitation had spread to many places in the developing world. By 1960, the global population reached three billion, and in the late 1960s the growth rate hit an all-time peak of 2.04 percent a year.
The rate of change is incomprehensible...
The rate of change is incomprehensible

13 YEARS LATER...

1987
FIVE BILLION

...the five-billionth baby was born.
The rate of change is incomprehensible

12 YEARS LATER...

1999
SIX BILLION

... around October 12, 1999, the six-billionth baby arrived. Today, Europe and Africa each hold about 12 percent of the world’s population. Nine percent live in Latin America, 5 percent in North America. And, just as in 1800, Asia is home to the majority of Earth’s inhabitants—roughly 61 percent, or more than 3.5 billion people.
The rate of change is incomprehensible

ROUNGLY 50 YEARS FROM NOW

Over the next half century, our numbers will increase again, likely to a staggering nine billion people. Nearly all of this growth will take place in developing countries, where the demand for food and water already outstrips supplies.
World Population Growth Through History

World Population Growth Through History

Sustainability 2050: The Challenge

UN Population Projections

Projected with current fertility rates
Sustainability 2050: The Challenge

UN Population Projections

Median Estimate
Sustainability 2050: The Challenge

UN Population Projections

When technology and culture collide technology prevails, culture changes

What we do in the next 10 years will shape Earth and Humanity for the next 100 years

What we do in the next 10 years will shape Earth and Humanity for the next 100 years
We are all in this together

Human Activities Dominate Earth

Croplands and pastures are the largest terrestrial biome, occupying over 40% of Earth’s land surface.
Meeting Food Needs by 2050

Freezing the Footprint of Food
How to triple food production on the same amount of land by 2050

Jason Clay

The role of research

- Genetics 50%
- Poor Management Practices 50%
- Technology 40%
- Underperforming Land 25%
- Property Rights 20%
- Waste 10%
- Overconsumption 5%
Measuring Sustainability:

**Metrics**: Quantifiable phenomena to measure an endpoint

**Index**: Aggregation of metrics to a single number, requires normative criteria for integration of metrics with different units

**Baseline**: Benchmark used to measure change over time

**Life Cycle Assessment (LCA)**: One method for measuring the inputs and outputs in a process in a step towards quantifying sustainability

Is there a standard method for LCAs?
- ISO 14040 and 14044 Standards
- PAS 2050 for greenhouse gasses
- No standard for Life Cycle Inventory
- No guidelines for most other metrics
Sustainability is Multi-metric

Asks the question: So What?

Multiple Metrics

Indexed

Rockström et al., Nature 2009
Stages of a life cycle assessment

Life Cycle Assessment Framework

Goal and Scope Definition

Inventory Analysis

Impact Assessment

Interpretation

Direct Applications:
- Product development and improvement
- Strategic planning
- Public policy making
- Marketing
- Other
Why LCA?

• The Economy
  – Efficiency

• Resource Conservation
  – Efficiency

• Consumers Care
  – Establish proactive position
Life Cycle Analysis to Understand and Manage Supply Chain Processes
LCA allows for impact assessment from cradle to grave
LCA allows for impact assessment from cradle to grave

Boundaries matter
Life Cycle Assessment Allocation

By Mass?

Kg CO$_2$e per kg

By Value?
Life Cycle Assessment: Reconciling Functional Units

\[ \text{CO}_2 \rightarrow 1 \text{ g CO}_2\text{-equiv. / g CO}_2 \]

\[ \text{CH}_4 \rightarrow 21 \text{ g CO}_2\text{-equiv. / g CH}_4 \]

\[ \text{N}_2\text{O} \rightarrow 310 \text{ g CO}_2\text{-equiv. / g NO}_2 \]

Greenhouse Gas Potentials
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 – guards against burden shifting
- Sustainability Metrics and Life Cycle Inventory data (LCI) should be transparent, validated, widely available, and inexpensive
- The same LCA data and models should be used by producers, retailers, policymakers, NGOs and consumers
Major Challenges in the Food System

• Consumers are far removed from producers.
• Complexity of the supply chain results in ineffective feedback systems and irrational decisions.
• Volatility of food prices create immediate human suffering and political instability, especially for the bottom billion.
• The future prosperity of humanity depends on increasing prosperity for the bottom billion.
The Food Marketing Chain

- Production
- Processing
- Distribution
- Direct Mktg
- Wholesale
- Retail
- Consumption

Safety
Security
Stability
Carbon Footprint of Fluid Milk in the US
Funded by the Dairy Research Institute

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Calculating a carbon footprint requires:

- A full system-level accounting of greenhouse gases emitted in association with a product or service
  - Energy consumption
  - Manure & nutrient management
- The system begins with extraction from nature and includes packaging disposal (cradle to grave)
- Life Cycle Assessment is a systems analysis tool commonly used as a framework for these calculations
LCA Methodology

- ISO 14044 compliant, with external review
- Goal: Determine GHG emissions associated with consumption of one gallon of milk to US consumer.
- Scope: Cradle to grave. Specifically including pre-combustion burdens for primary fuels and disposal of packaging.
Life Cycle Assessment Case Study: Carbon Equivalent GHG in Dairy Production, Processing, Distribution, Consumption
Overview of LCA of milk supply system
Life Cycle Inventory –
Data Drives the Work

Surveys:
1) Dairy Producer (~535; 9% response rate)
2) Farm to processor transportation data
   (~211,000 round trips – 2007 only)
3) Milk Processor (50 plants responded)

Published Literature:
1) Peer Reviewed Literature
   a) Enteric Methane, Nitrogen and Methane from manure management
   b) Life cycle inventory data for crop production (NASS, Budgets, USLCI)
2) Other Publications (e.g. IPCC, EPA)
3) Expert opinion (e.g., hay production budgets from Ag Extension)
Major Assumptions

- Infrastructure excluded
- Biogenic carbon
  - Sequestration not included; nor respiration
- Economic allocation as base case
  - Biological / causal model for milk : beef
  - Milk solids model for cream : fluid milk
- IPCC Tier 2 models for manure management
- Product loss: 12% retail + 20% consumer (ERS food availability study)
1 Gal Fluid Milk GHG emissions

35 Tg Total Supply Chain
Greenhouse Gas Emissions
95% confidence: 30 to 45Tg
17.6 lb CO$_2$e/gallon
95% confidence band: 15.3 to 20.7 lb CO$_2$e/gallon
Overall Takeaways

- **Do more with less**
  - Improving efficiency
  - Innovation – manure and nutrient management
  - Technology transfer

- **Operations with smaller carbon footprint have generally adopted better management practices and have higher feed conversion**

- **A ‘one size fits all’ solution does not exist**
  - Opportunities exist to improve across the spectrum

- **Strive for continuous improvement by adopting better management practices and utilizing decision support tools**
Water is different than GHG

Need to put water in context

Virtual Water
• Only calculates the total volume of water used to produce good/service regardless of type of water

Water Stress
• Is a function of the amount of water use and the amount of water available (water use/water availability)
• Predictor of direct economic costs
Two Major Categories of Water

**Green Water**
- Soil moisture from precipitation
- “Free”

**Blue Water**
- Water withdrawn from surface or groundwater for consumption
- Direct Economic Costs
Evaluating the Water Footprint in the Production of Liquid Milk

Dr. Matlock
Center for Agriculture and Rural Sustainability
Dairy Farm Water Use: Context & Potential for Impact

• **Goal**: Understanding the (geographical) hotspots for dairy operations with regard to water consumption

• To place the dairy sector in the larger context of water consumption and availability
Total Water Use In Liquid Milk Life Cycle Phases

US Dairy Supply Chain Water Use

Water Use (gallons per year)

Feed

On-Farm

Processing

Retail

Consumption
USGS Basins and Watersheds
Most impacts are from crops rather than direct use.
Direct Dairy Water Use

Watershed with highest direct use for dairy is Central Valley in California
Dairy Water Use to USGS Total Agricultural Water Use

Compared to total agricultural use, dairy direct use is very low. Therefore, where the feed is grown matters more than where the cattle are grown.
• Diary water use is largely water embodied in the crops used to feed cows
• Water quality impacts from the dairy industry is largely associated with feed production (fertilizer)
• Climate change impacts on dairy will be on water availability for feed
National Scan-level Carbon Footprint Study for Production of Swine

Greg Thoma
Jason Frank
Charles Maxwell
Cash East
Darin Nutter

Funded by the National Pork Board
Goal and Scope

Determine GHG\(^1\) emissions associated with delivery of one serving of pork to US consumer.

Cradle to grave. From crop production through consumption and package disposal

\(^1\)Greenhouse gases, expressed as CO\(_2\) equivalents
Energy consumed at every point in the value chain
Some Underlying Assumptions

• 9.5 piglets/litter and 3.5 litters per sow
• Finished live weight: 268 lb
  – Carcass = 0.75 live weight
  – Boneless = 0.65 carcass
• Typical corn, soy meal, distiller’s grain diets
  – With supplements accounted; 82% digestibility
• IPCC Tier 2 GHG emission factors for manure systems\(^2\)
  – 1kg of manure=2kg methane
• Biogenic Carbon
  – crop sequestration & animal respiration excluded

1 American Society of Agricultural Engineers, 2005 ASAE D384.2 MAR2005.
Some Underlying Assumptions

• 10% waste (spoiled or uneaten) by consumers
• Economic allocation
  – Feed byproducts
  – Rendering co-products
• Space allocation
  – Retail
  – In-home
Material and energy flows are integrated over a sow’s productive life. The farm gate total consumption of feed and energy required to grow all the litters produced by one sow is allocated to the total finished weight of her litters.
Results:
Carbon Footprint of Pork
The Big Picture

- 2.2 lb CO$_2$e per 4oz serving
  - (8.8 kg CO$_2$e/kg pork consumed)
  - with a 95% confidence interval from 1.95 to 2.55 lb CO$_2$e.

- The contribution of emission burden:
  - 10.3%: sow barn (including feed and manure handling);
  - 54.3%: nursery to finish (including feed and manure handling);
  - 7.4%: processing (6.4%) and packaging (1.1%);
  - 12%: retail (electricity and refrigerants);
  - 15.9%: the consumer (refrigeration and cooking).
Connecting Line Weight is Proportional to GHG Contribution

GHG contribution (cumulative kg CO2e contributed by this branch of the network)

Reference Flow (quantity of material or energy)

Process or Material Contributing to Footprint

1 kg
Overall
7.82

1 kg
In Home
2.08

2.05 kg
Finish Barn
3.4

16.3 MJ
Electricity,
3.49
1 kg
In Home
2.08
1 kg
Overall
7.82

16.3 MJ
Electricity
3.51
15.1 MJ
Electricity
3.4
3.49
1 kg
In Home
2.08
2.05 kg
Finish Barn
3.4
Cradle to grave footprint:
Base case: Deep pit

- 1.54 kg Processing
- 0.904 lfdays Retail
- 1.07 kg Corn Grain
- 0.922 kg Deep Pit

Electricity:
- 8.09 MJ
- 1.74
- 0.491 m3
- 1.18
- 0.519 m3
- 1.18

Natural Gas:
- 1.18
- 3.95 kg
- 0.825 kg
- 0.898
- 0.000187 kg
- 0.369

Soybean Meal:
- 0.49
- 1 kg

Cooking:
- 0.898

Deep Pit:
- 0.0927 kg Sow Barn
- 0.572

Finish Barn:
- 2.05 kg
- 0.553
- 0.0328 kg N Fertilizer
- 0.362

In Home:
- 1 kg
- 1.13

Retail:
- 1.2

Processing:
- 0.494

Sow Barn:
- 0.572

Overall:
- 7

This flow is a credit for avoided production of nitrogen fertilizer.
Live Swine Production

The model has 1 kg boneless pork as the comparative unit; thus 2.05 kg live animal weight must leave the farm gate.
Pork Processing

1 kg Processing

- Natural Gas: 0.0368 m³
- Electricity: 0.654 MJ
- Carbon dioxide: 0.0111 kg
- Diesel: 2.96E-6 m³
- Heavy fuel oil: 0.0848 MJ

Total: 0.0885
Consumption is also important
Detailed View of Relative Contribution to Footprint
Relative Contribution to Footprint

Percentage Contribution to GHG Emissions

- Packaging
- Consumption
- Retail
- Processing
- Live animal production
- Fuel
- Electricity
- Manure
- Feed
- Piglets

Life Cycle Total
Farm Gate Total
Uncertainty

- All variables have some variability
- Propagation of uncertainty performed by Monte Carlo simulation
Conclusions

• Estimated GHG emissions consistent with international studies
• Pork footprint is comparable to other protein sources.
• Manure management is a large opportunity
• Consumption contributes a significant fraction of the total footprint
• Fuels and Electricity are important, while not the largest contributors to the overall footprint, still present opportunities for increased efficiency
• Processing is relatively efficient per kg processed
• Transportation is less of a contributor than expected
Sustainability Initiatives
Agricultural Sustainability Metric Initiatives

Field to Market – The Keystone Alliance for Sustainable Agriculture
- Focused on commodity agriculture
- Metrics are outcomes based, technology neutral (undefined)
- Metrics are regional to national in scale

The Sustainability Consortium
- Focused on supply chain
- Metrics are outcomes based, technology neutral
- Metrics are local to global scale
Field to Market Alliance

- **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.
Field To Market 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
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”
Total annual energy use increased by 28 percent
Water use increased by 17 percent
Greenhouse gas emissions increased by 34 percent.
Soil loss decreased by 33 percent.

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

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

- Total annual soil loss decreased by 11 percent
- Climate impact increased by 15 percent
- Total energy use decreased by 29 percent
- Total water use increased by 39 percent.

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

Total annual soil loss and climate impact did not change.

Total energy use decreased by 45 percent.

Total water use decreased 26 percent.

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

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

- Total annual soil loss decreased by 54 percent.
- Climate impact increased 5 percent.
- Total energy use decreased by 18 percent.
- Total water use decreased 11 percent.

(Values are expressed as 5-year centered averages.)
The Sustainability Consortium was organized in 2009 by The University of Arkansas and Arizona State University in collaboration with the Walmart Foundation.

TSC is an independent organization of diverse global participants who work collaboratively to build a scientific foundation that drives innovation to improve consumer product sustainability through all stages of a product's life cycle.
What TSC Does

The Sustainability Consortium drives scientific research and the development of standards and IT tools, through a collaborative process, to enhance the ability to understand and address the environmental, social, and economic implications of products.
Level 1 Sustainability Measurement and Reporting System
Generating Actionable Knowledge

World of Knowledge
- Includes all available sources;
- LCA Models and Scientific Studies
- Industry, Gov’t, NGO Reports and Standards
- Expert Knowledge and Opinions
- Stakeholder Opinions

Category Dossier
- Potential issues and solutions associated with a product and its supply chain.
- Each statement is characterized by source and evidence (transparency and method type)
- Continuously improves

Category Sustainability Profile (CSP)
- Includes only the most relevant, credible and actionable information
- Maps the sustainability landscape associated to a single category
- Continuously improves and matures

SMRS Approach
Category Sustainability Profile

Many End Uses and Benefits of a CSP

Key Performance Indicators
- Organizational Performance Tracking
- Supplier Scorecards

Category Sustainability Profiles

Innovation Workshops
- Generate new solutions
- Collaboration between competitors
- Challenge innovators

Education and Awareness
- Educate and train employees
- Focus research and development
- Consumer awareness and education campaigns
Choosing Metrics, Setting Goals

Outcomes of Level 1 SMRS Activities

Category Dossier
[dos-ee-ey]
Description: Collection of evidence gathered from literature, models, subject matter interviews.
Purpose: Provides transparency and credibility.

Category Sustainability Profile
Description: Synthesis and of information found in Dossier.
Purpose: Education and awareness about the most relevant and actionable issues and opportunities.

Key Performance Indicators (KPI)
Description: Metrics used to record organizational progress on issues and opportunities described in a CSP.
Purpose: Performance tracking and communication of progress.

Benchmarking
Goal Setting
Linked
Support farmers and their communities
More than a billion people rely on agriculture for subsistence. By the end of 2015 in emerging markets, Walmart will help many small and mid-sized farmers gain access to markets by:

1. **selling $1 billion** in food sourced **from 1 million small and medium farmers**;

2. **providing training to 1 million farmers and farm workers** in such areas as crop selection and sustainable farming practices -- the company expects half of those trained to be women; and

3. **increasing the income** of the small and medium farmers it sources from **by 10 to 15 percent**.

In the U.S., Walmart will **double** its sale of locally sourced produce and increase its purchase of select U.S. crops.
Produce more food with fewer resources and less waste

Walmart has one of the world’s largest food supply chains and is committed to reducing and optimizing the resources required to produce that food and driving more transparency into its supply chain. The goals include:

1. accelerating the agricultural focus of the Sustainability Index, beginning with a Sustainable Produce Assessment for top producers in its Global Food Sourcing network in 2011;

2. investing more than $1 billion in its global fresh supply chain in the next five years; and,

3. reducing food waste in its emerging market stores and clubs by 15 percent and by 10 percent in stores and clubs in its other markets by the end of 2015.
Sustainably source key agriculture products
Walmart will focus on two of the major contributors to global deforestation, palm oil and beef production.

Require sustainably sourced palm oil for all Walmart private brand products globally by the end of 2015. Sourcing sustainable palm oil for our U.K. and U.S. private brand products alone will reduce greenhouse gas emissions by 5 million metric tons by the end of 2015.

Expand the already existing practice of Walmart Brazil of only sourcing beef that does not contribute to the deforestation of the Amazon rainforest to all of our companies worldwide by the end of 2015. It is estimated that 60 percent of deforestation in the Brazilian Amazon is related to cattle ranching expansion.
We shall never achieve harmony with land, any more than we shall achieve absolute justice or liberty for people. In these higher aspirations, the important thing is not to achieve but to strive.

- Aldo Leopold
Green water = soil moisture from precipitation

Evaporated

Integrated into product

Not returned to same watershed

Water withdrawn for consumption

Water withdrawn by humans

Water returned to same watershed

Blue water = surface water and groundwater withdrawn for consumption

Surface water

Groundwater