CO_2 CH_4

How Big is the Fruit Growing Footprint ?

CO_2 N_2O

Washington State University

World Class. Face to Face.

Yakima Valley

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WSU-Center for Sustaining Agriculture and Natural Resources

Center for Sustaining Agriculture & Natural Resources

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Outline

- Definitions
- Food miles, transport energy
- System energy, GHGs
- Life Cycle Assessment
- Closing thoughts

LifeCycles, Victoria, BC

Sustainability

"Meet the needs of today without reducing ability of future generations to meet their needs"

Try to balance:

- *Economic*
- *Environment*
- *Social*

Better to say "more sustainable"

Easier to define what is not sustainable

And now energy – what will sustainability mean in a post-petrol world?

Can agriculture be sustainable if the rest of society is not?

Sustainable Agriculture

"A long-term goal"

Economically Viable

Environmentally Sound

A direction to move in

Not a fixed set of farming practices

"A question, not an answer"

Socially Acceptable

Sustainability is Relative

Pest management successes – IPM, biocontrol, reduced risk products

Apple - *Cydia pomonella* control – change over time

Conventional then

Lead arsenate

DDT

Azinphos-methyl

Pheromone mating disruption

Codling moth granulosis virus

??

Conventional now

Sustainability Issues

- Environmental -

Pesticides

Soil erosion

Water quality, quantity

Energy

Atmosphere (e.g. methyl bromide, GHGs)

Biodiversity, habitat

Loss of farmland, urbanization


Degraded water quality

What is a footprint ?

A measure of the impact of a system, practice, or product on one or more environmental factors; need a reference point

- **Food miles – ignores production energy, different transport forms**
- **Energy use – renewable or not; primary or embedded; input/output ratios**
- **Other non-renewables – mined minerals; fate?**

Footprint cont'd

Emissions – GHG, odor, acid rain, toxins (pesticides)

- EIQ (NY) Apple: Conv. 938, IPM 167, Organic 1799
- EIR (WA) Apple: Conv+MD 2893, IFP 2211, Organic 466
- Protected Harvest - Toxicity Units per acre

Carbon footprint – specifically CO_2 and/or other gases in CO_2e

Life Cycle Assessment (LCA) – air, water, energy, biodiversity, … social

Footprint cont'd

Ecological footprint – the amount of resource area needed to support a given lifestyle

- 2003 ave. global biol. capacity 1.8 ha/person;
- US footprint 9.6, Switzerland 5.1, China 1.6

Many qualitative programs – set a threshold of practices

- **Food Alliance** – pest management, soil & water, safe and fair working conditions, biodiversity

Footprint only measures negatives; need to include positives.

Apple

Small inherent footprint

Plant seed; water (rain or irrigate); pick fruit; eat; throw away core

As we add management, we add footprint:

- **tractors to plant trees;**
- **irrigation piping and pumps;**
- **bins, CA storage, packing lines, boxes;**
- **trucks for transport;**
- **waste disposal**

Compare to car: everything has a footprint - Metal, glass, plastic, paint, fuel, paved road

Transport Energy

	Energy[1] (Gal/ton-mile)		Emissions[2] (g CO_2e/MT-km)	
Hwy truck	0.0228		270	
Rail	0.0023	0.1x	21	0.08x
Water	0.0037	0.16x	130	0.5x
Air	0.1584	7x	1,101	4x

[1] DOE EERE, 2004

[2] Environment Canada, 2002; ave. 1990-2000

Transport Energy

Suburban - 4000 lb,16 mpg town; 4 mi RT to store; purchase 5 lb apple in 50 lb groceries

0.031 gal/ton-mile 0.0050 gal/lb fruit

Semi-truck – 48,000 lb net freight; 6 mpg

0.004 gal/ton-mile

To NYC market	Fuel	Gal/lb fruit
NY 200 mile	34 gal	0.0007
MI 1000 mile	167 gal	0.0035
WA 2800 mile	467 gal	0.0097
by rail	155 gal	0.0035

New Zealand Response to Food Miles

Compared apple, onion, dairy, and lamb produced in NZ or EU alt.; sold in UK

Used LCA approach to calculate energy use and CO_2 emissions

NZ apples use 1/3 energy of UK apples for production; less CO_2 emissions for NZ apples purchased in UK

Caroline Saunders et al., 2006, Lincoln University, NZ

NZ vs UK Apple Study

	Energy (MJ/MT apple)		Emissions (kg CO_2/MT fruit)	
	NZ	UK	NZ	UK
Farm	950	2,961	60.1	186.0
Direct energy	573	2,337	29.8	152.1
Indirect (N,P,pesticides,…)	300	624	24.7	33.8
N fertilizer	104	362	4.8	18.1
Equipment, buildings	78	?	5.6	?
Post-harvest	2,030	2,069	124.9	85.8
Cold storage UK 6 mo	-	2,069	-	85.8
Ocean ship (17.8K km)	2,030	-	124.9	-
Total	2,980	5,030	185.0	271.8

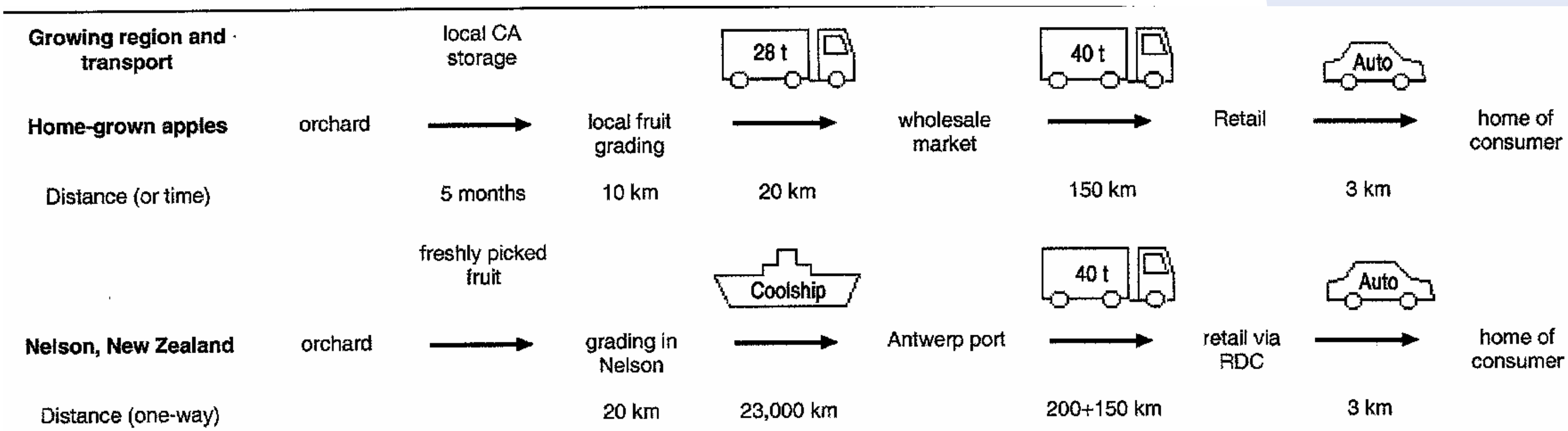
1 gal diesel = 147 MJ *(Saunders et al., 2006)*

NZ vs German Apples

<u>**Braeburn apple**</u>

NZ – 90 MT/ha, no storage, ocean transport

DE – 40 MT/ha, 5 month CA storage, local transport



27% more energy required for imported fruit

(Blanke & Burdick, 2005)

NZ vs German Apples

	Primary energy (MJ/MT fruit)			
	NZ		Germany	
Fruit production	**2,100**	28	**2,800**	48
Local transport	**139**	2	**69**	1
Initial cooling	**86**	1	**86**	1
Ocean trans. or Storage	**2,836**	38	**810**	14
Packaging	**650**	9	**650**	11
Truck to wholesale	**276**	3	**93**	2
Truck to retail	**262**	3	**235**	4
Consumer (4 km)	**1,150**	15	**1,150**	20
Total	**7,499**	**%**	**5,893**	**%**

(Blanke & Burdick, 2005)

Why the Difference ?

	Energy (MJ / MT apple)			
	Saunders		*Blanke*	
	NZ	UK	NZ	GER
Farm	950	2964	2100	2800
Postharvest		2069		810
Transport	2030		2836	
	2980		2199*	3610
Distance (km) from NZ to		17,840*		23,000
Schlich et al. 2003				14,000

Full Cost of Food System - UK

	per person/yr	
Cost of food basket	$2,014	
Total externalities	$ 160	8%

	% of externalities
Ag production	19
Domestic transport	29
Sea, air transport	<0.01
Shopping	16
Waste disposal	<0.01

(Pretty et al., 2005)

What About WA to NY ?

	Energy (MJ/MT apple)	
	WA	NY
Farm	950	2,961
Direct energy	573	2,337
Indirect (N,P, pesticides, …)	300	624
N fertilizer	104	362
Equipment, buildings	78	?
Post-harvest	5,147	2,297
Cold storage 6 mo	2,069	2,069
Semi-truck (WA 2750 mi)	3,078	228
Total, by truck	6,097	5,258
Total, by rail (1041 MJ/MT)	4,060	5,258

Life Cycle Assessment

Apple production system comparison

– Rita Schenck, IERE, 2001

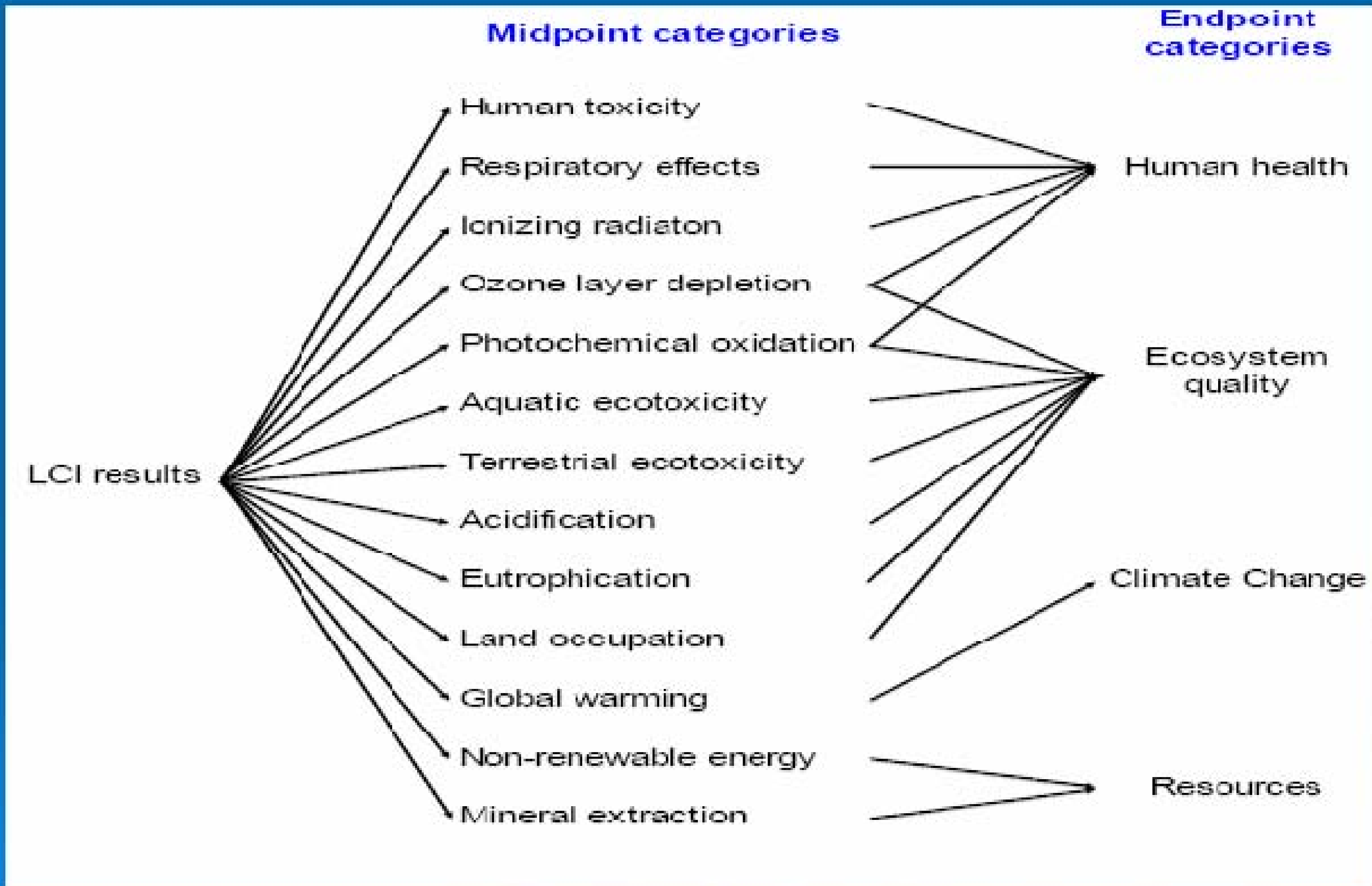
- Depletions: fossil fuel, water, mineral
- Land use / biodiversity
- Air - GHG, acidification, smog, airborne toxicity, ozone depletion
- Water - Aquatic toxicity, eutrophication

Extensive literature, many groups, some international harmonization

American Center for Life Cycle Assessment
http://www.lcacenter.org/

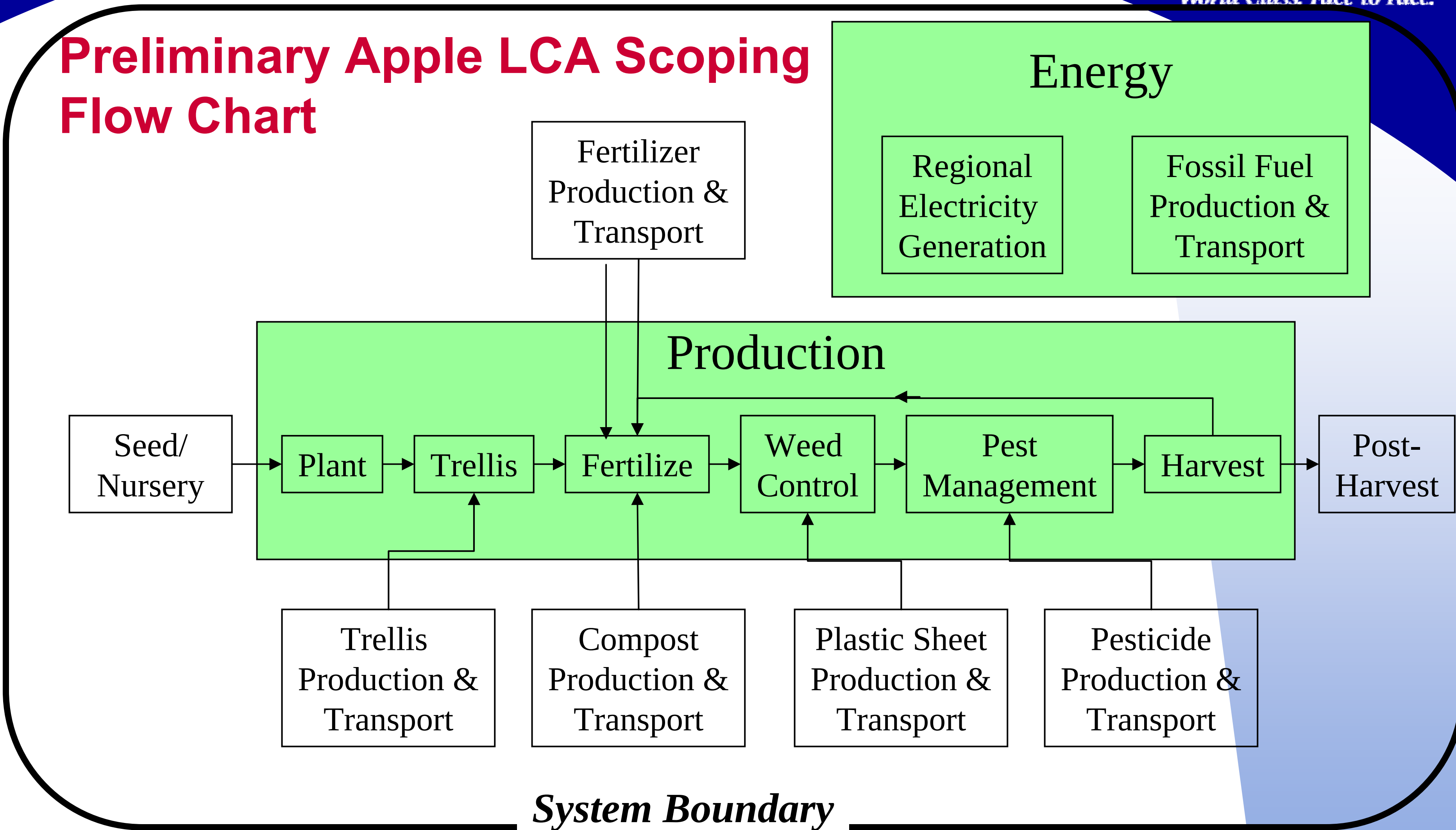
Institute for Environmental Research and Education
http://www.iere.org/sustain/LifeCycle.htm

LCA Categories



(Yrigoyen & Castells, 2006)

Preliminary Apple LCA Scoping Flow Chart



Energy is an input to almost all processes; for simplicity, its arrows are not included in this diagram

(IERE, 2001, unpublished)

Social Indicators

Corporate policy

Equality of opportunities

Freedom of association

Access to potable water

Social security

Intellectual property

Satisfaction

Product quality

Respect for privacy

<u>Social LCA</u>

Qualified working time
- paid work time

Health & safety
- lethal, non-lethal accidents

Humaneness
- no child labor

(Makishi et al., 2006)

Let's Do A WA Tree Fruit LCA

Customers requesting (requiring) this information

Do our own defensible study

Focus areas:

- Production – lower energy like NZ ?
- Storage – hydropower advantage for energy source
- Transport – how big a piece is it? Options?
- Water – sustainability issues

Closing Thoughts

There is no "right" way

Every method has assumptions

May be more useful in relative terms – change over time, comparison studies

Need a reference point

Big challenges – energy, water, pesticides

Need to account for positives, not just negatives

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