Beyond Waste

Carbon and Nutrients in Soils

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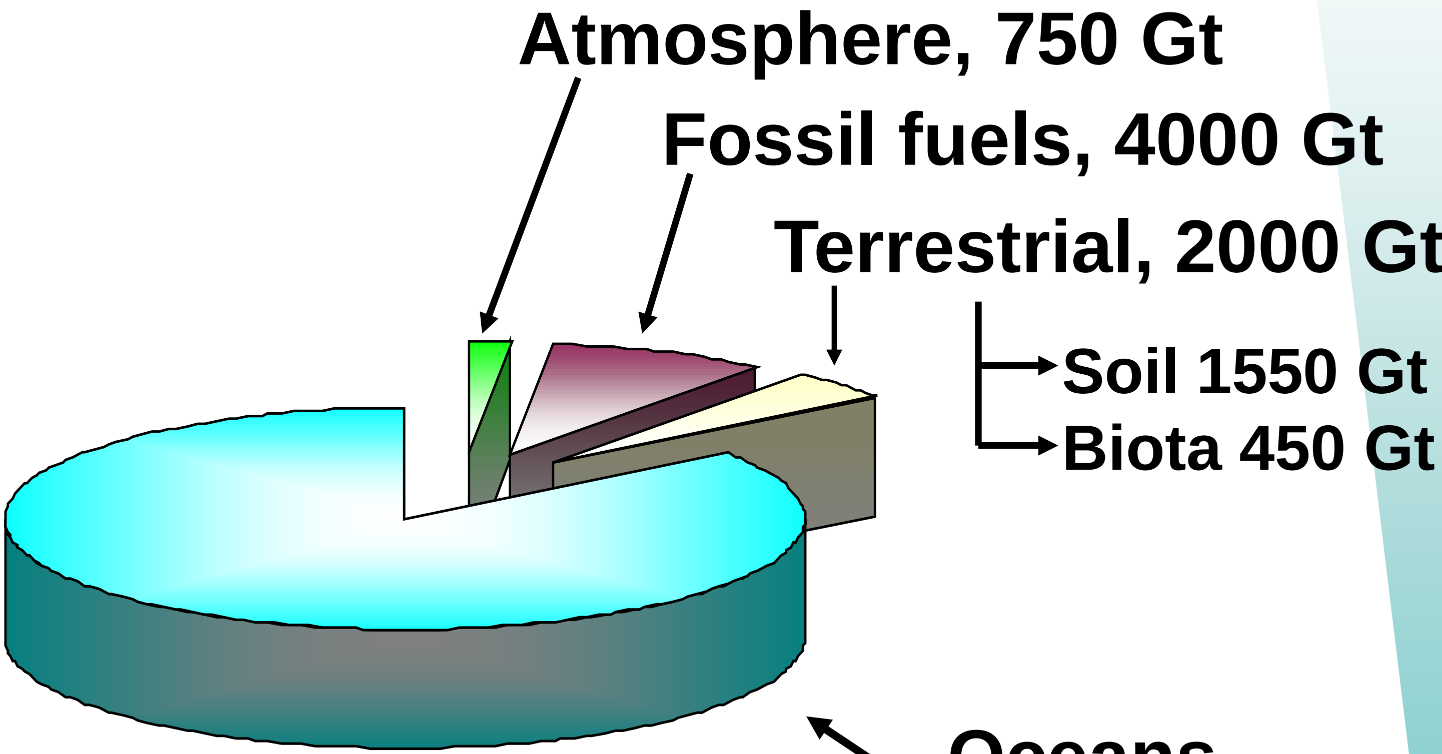
Global Carbon Pools



Lal et al. (1995)

Global Carbon Budget

	1970-1999	1990-1999	2000-2006
Sources (billion tons / yr)			
Fossil Fuel	5.6	6.5	7.6
Land Use Change	1.5	1.6	1.5
Subtotal	7.0	8.0	9.1
Sinks			
Atmosphere	3.1	3.2	4.1
Ocean	2.0	2.2	2.2
Land	2.0	2.7	2.8
Distribution of Emissions (%)			
Atmosphere	44	39	45
Ocean	28	27	24
Land	28	34	30

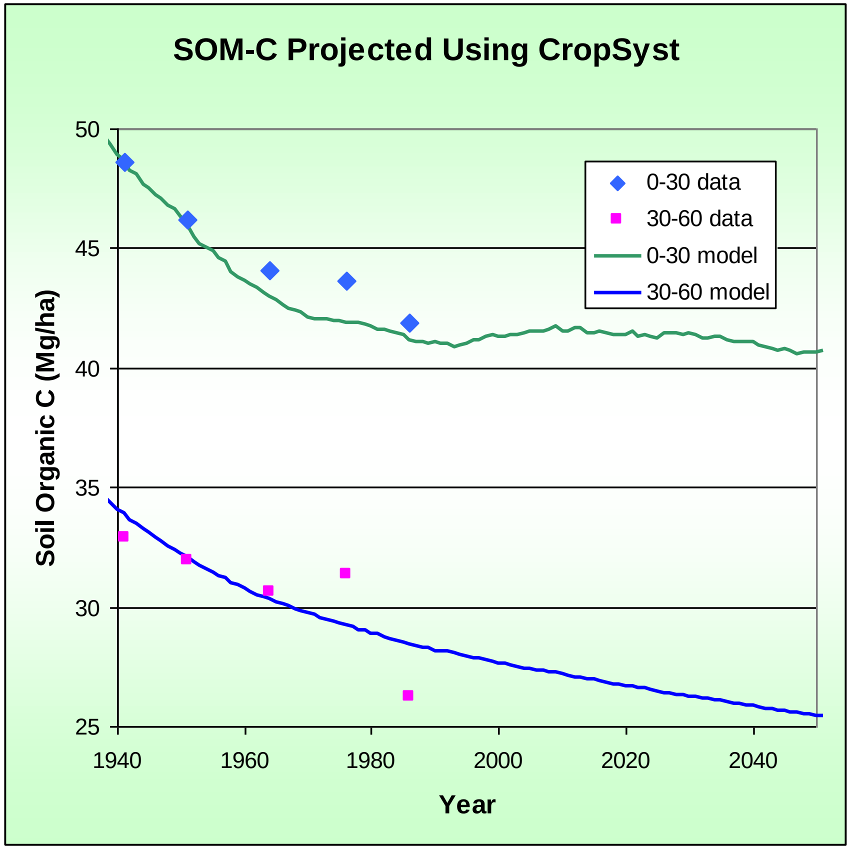
Canadell, et.al. 2007. PNAS

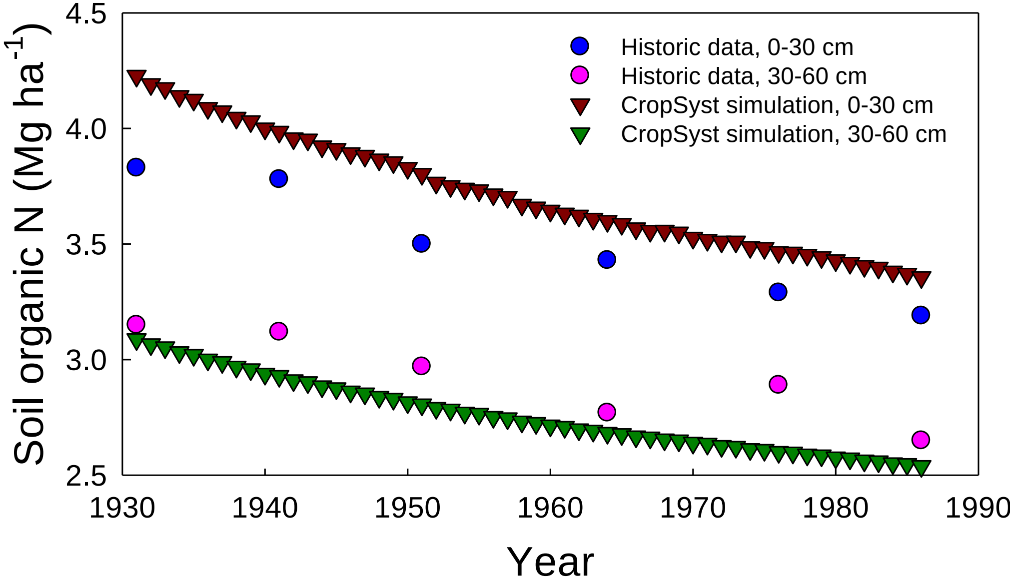
Washington State Emissions and Sinks

	1990	2000	2005
Emissions			
Electricity	16.9	23.3	18.9
Residential, Comm., Ind.	18.6	20.3	19.4
Transportation	37.5	45.9	44.5
Fossil fuel industry	0.5	0.7	0.9
Industrial processes	7.0	6.6	3.3
Waste Management	1.5	2.2	2.4
Agriculture	6.4	6.4	5.4
Subtotal	88.4	105.4	94.8
Sinks			
Forestry / Land Use	-28.6	-28.6	-28.6
Agricultural Soils	-1.4	-1.4	-1.4
Subtotal	-30	-30	-30
Net Emissions (MMT CO_2e)	58.4	75.4	64.8

http://www.ecy.wa.gov/climatechange/docs/WA_GHGInventoryReferenceCaseProjections_1990-2020.pdf

Current ag soils trends

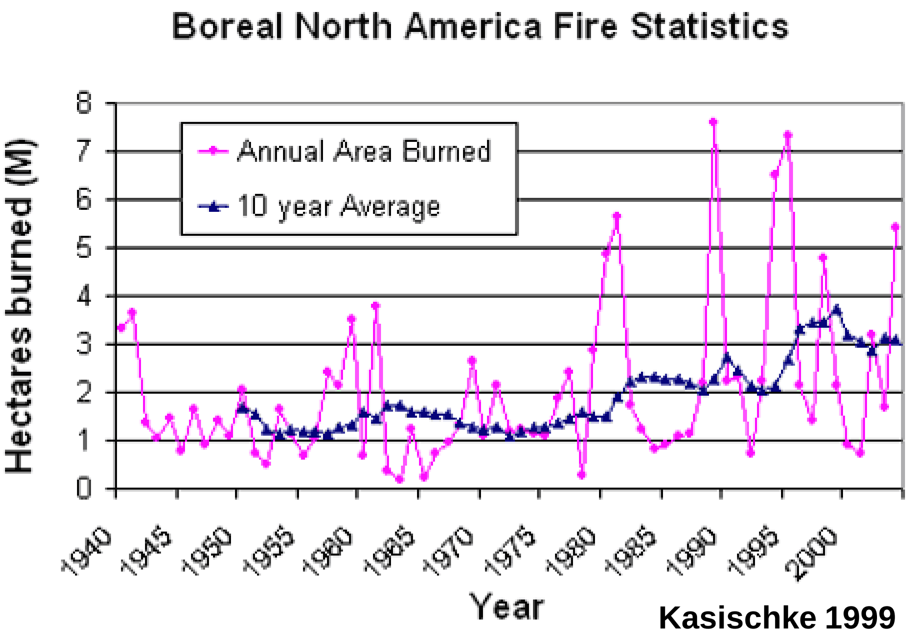




Long-term soil carbon trends (measured & modeled) for Pendleton, Oregon. Winter Wheat – Fallow, conventional tillage

A Changing Forest Carbon Trend?

Donnelly Flats Fire, near Delta Junction, Alaska. June 13-20th 1999. Photo courtesy of Tom Lucas, *Delta News Web*.



Kasischke 1999

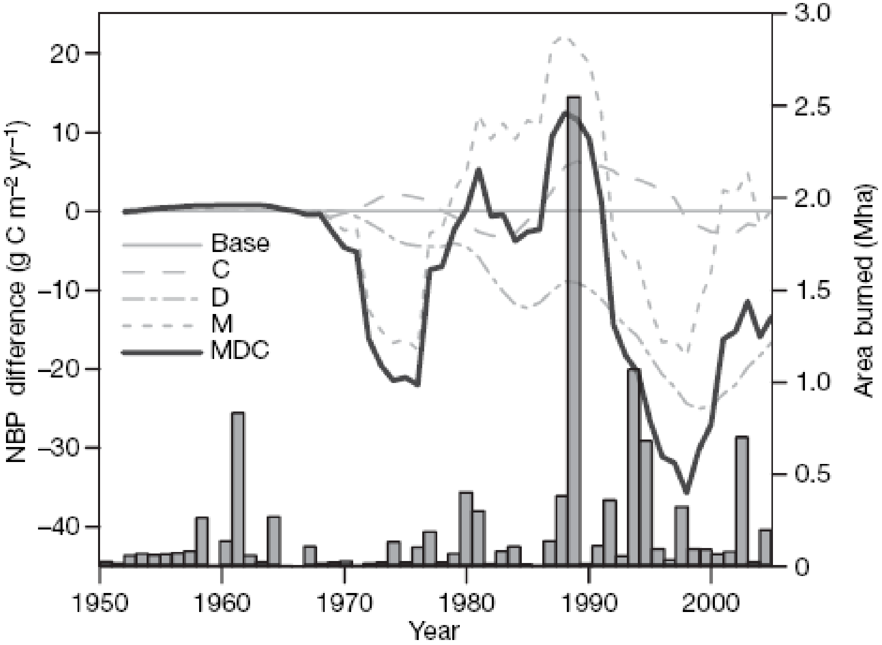


Figure 1 | Difference in net biome production (NBP) between simulation scenarios, over length of simulation. A negative value indicates a relative carbon source to the atmosphere. Scenario labels indicate main effects applied to base case (mid-century conditions): climate (meteorology, 'M'), CO_2 ('C'), disturbance ('D') and their combination ('MDC'). Data are smoothed using a 5-yr running mean. Bar graph, on right-hand axis, shows annual area burned in the study area.

Bond-Lamberty, et.al. 2007

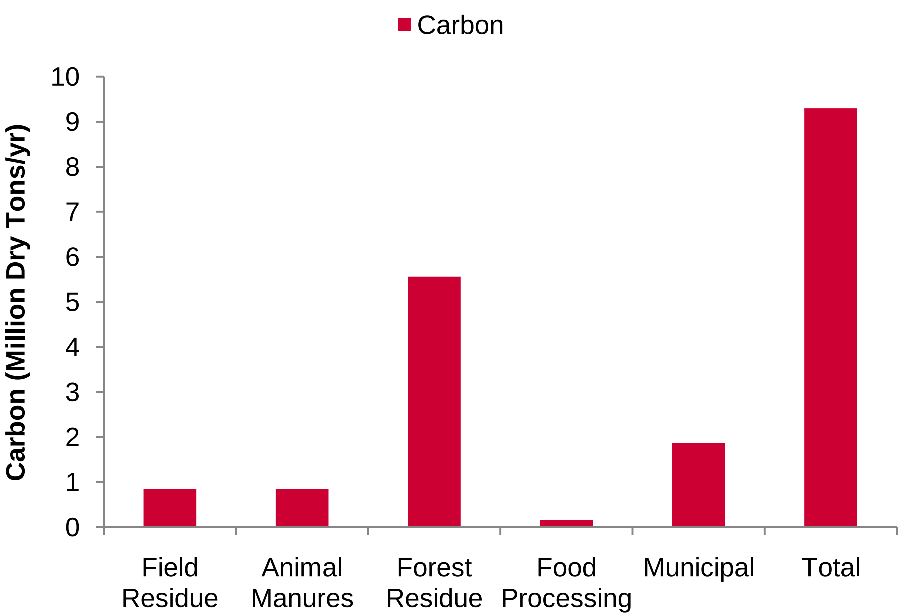
Biomass Inventory C & N:

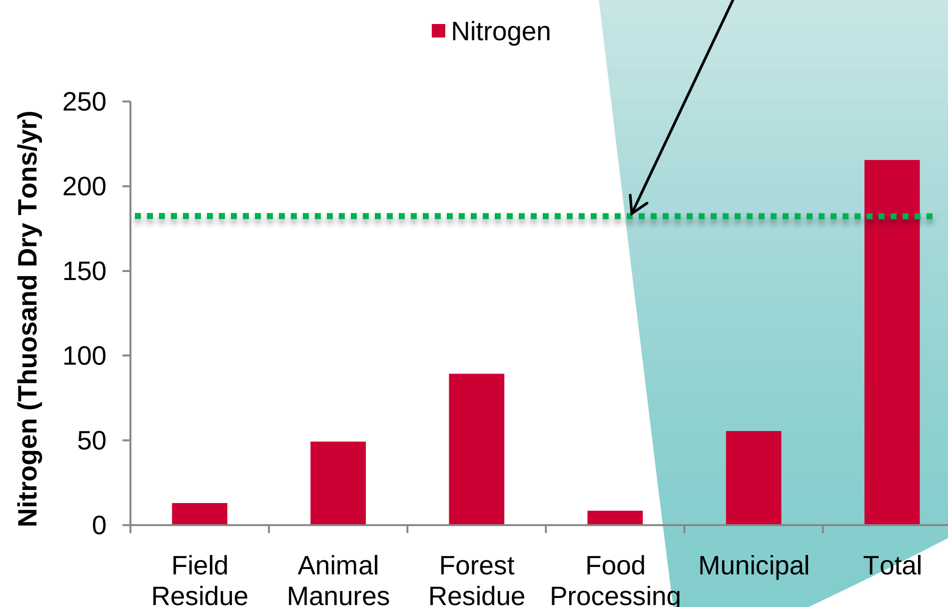
Over-simplified math to illustrate a point

At least 19.5 Million Dry Tons Biomass in Washington (2009)

Removing 20% of total C annually ~10% of Washington's Net CO_2

176,000 MT of synthetic N fertilizer inputs in 2001





Closing the Loop on Organics:

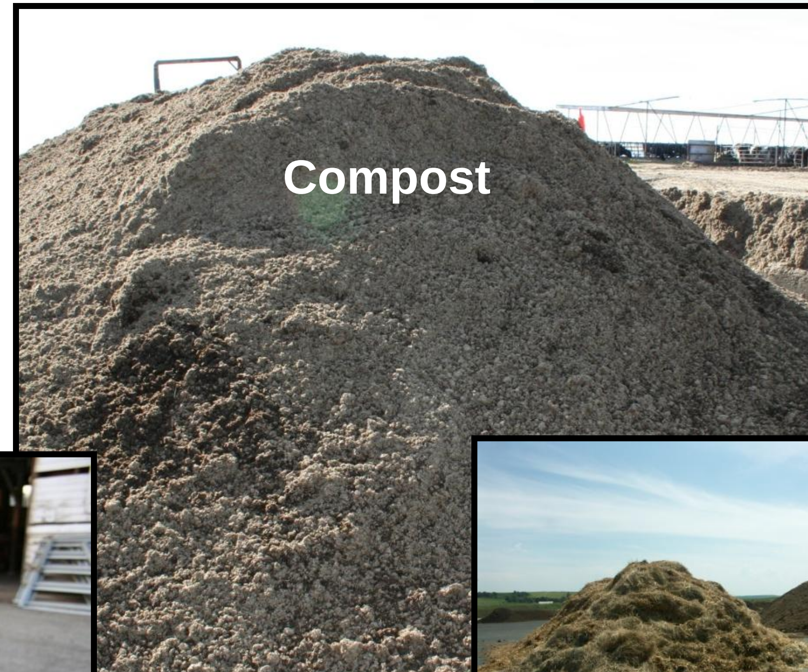
Current Generation Soil Amendment Products

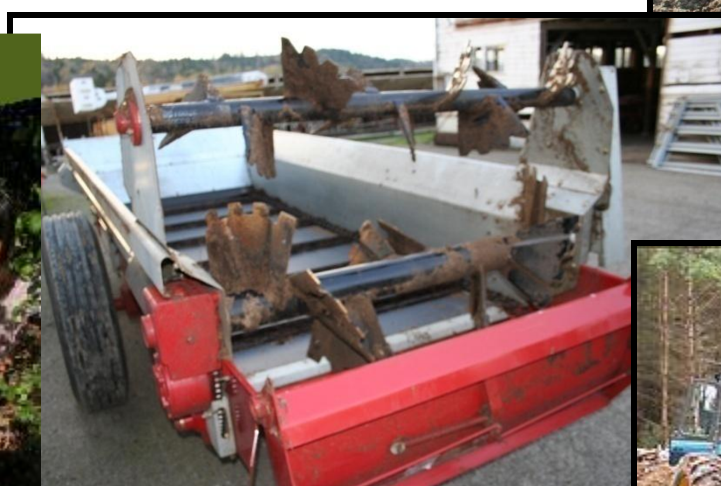
Composts, biosolids, manures, etc.: Recovered C, N, other nutrients, microbial activity, etc.

Costs of Production

- **Winter Wheat ~$300 – 400 / acre**
- **Winter Canola ~$200 – 250 / acre**

N fertilizer up to 40% of cost





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Closing the Loop on Organics: Next Generation Bioproducts

Critical Characteristics for Next Generation Organic Soil Amendments

- Consistency and reliability
- Predictability
- Precision

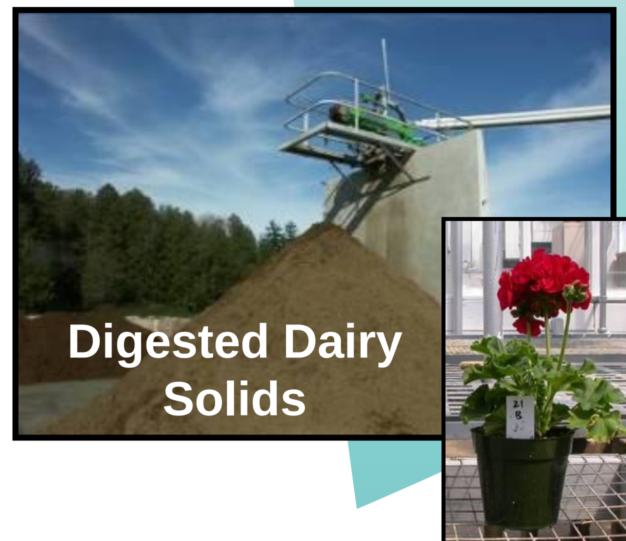
Cost / Value of Production

- Potatoes - ~$3,000+ / acre
- Spinach Seed - $3,000 / acre
- Sweet Cherries- ~$9,500 / acre
- Greenhouse / Nursery -- $600k – $800k / acre

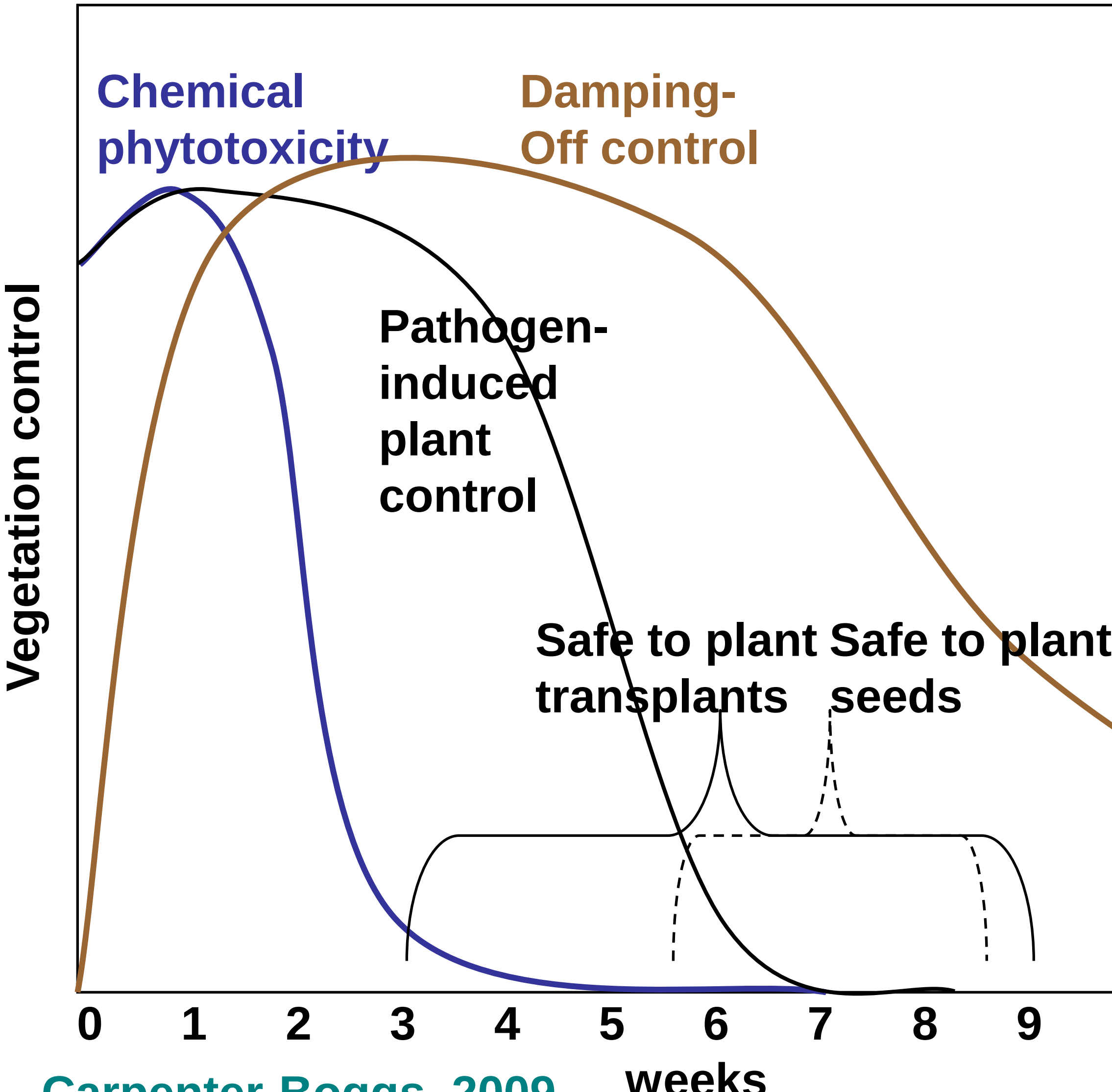

Brassica Seed Meal


Biochar


Fertilizer Recovery


Digested Dairy Solids

Next Gen Bioproduct Example: BSM for pathogen suppression / fertility



L. Carpenter-Boggs, 2009

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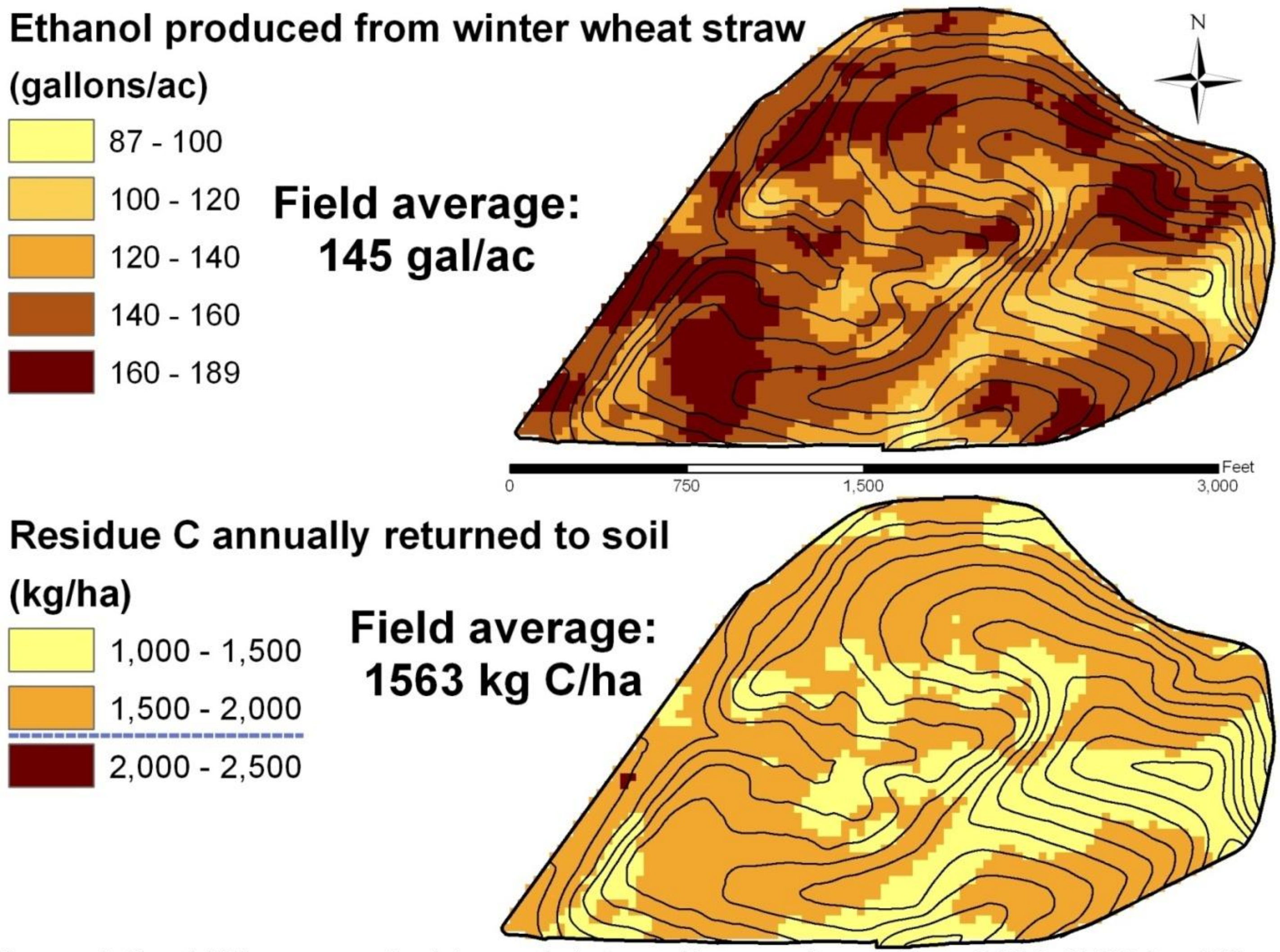
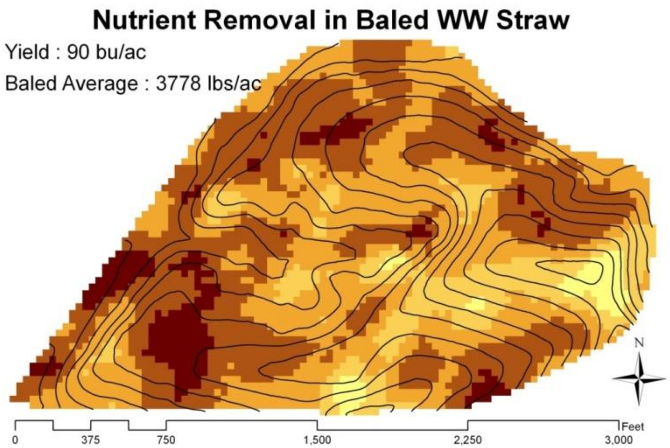
A final sustainability concern: trade-offs



Annual C additions needed to maintain soil organic matter: 2000-2500 kg C/ha

Trade-offs from residue removal for energy



WW N (lbs/ac)	WW P2O5 (lbs/ac)	WW K2O (lbs/ac)	WW S (lbs/ac)
8.53 - 10.54	3.39 - 4.18	19.87 - 24.53	1.83 - 2.26
10.54 - 12.54	4.18 - 4.98	24.53 - 29.20	2.26 - 2.69
12.54 - 14.55	4.98 - 5.77	29.20 - 33.87	2.69 - 3.12
14.55 - 16.55	5.77 - 6.57	33.87 - 38.53	3.12 - 3.55
16.55 - 18.56	6.57 - 7.36	38.53 - 43.20	3.55 - 3.98

	WW N ($/ac)	WW P2O5 ($/ac)	WW K2O ($/ac)	WW S ($/ac)
	4.69 - 5.80	2.03 - 2.51	4.97 - 6.13	0.95 - 1.17
	5.80 - 6.90	2.51 - 2.99	6.13 - 7.30	1.17 - 1.40
	6.90 - 8.00	3.99 - 3.46	7.30 - 8.47	1.40 - 1.62
	8.00 - 9.10	3.46 - 3.94	8.47 - 9.63	1.62 - 1.84
	9.10 - 10.21	3.94 - 4.42	9.63 - 10.80	1.84 - 2.07
Average	$7.85/ac	$3.40/ac	$8.31/ac	$1.59/ac

Nutrients in 1 Ton of WW straw = >$13 (NPV summer 07)

WSU Cook Agronomy Farm, Pullman, WA

Conclusions

- Comprehensive climate change mitigation efforts need to address terrestrial carbon pool (soils, vegetation, organic wastes)
- Organic wastes represent sources of carbon, nitrogen, other nutrients and benefits as well as fuel and GHG reduction
- Research to develop next generation technologies / products will maximize benefits of using organic materials
- There will still be sustainability trade-offs that need to be understood

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Center for Sustaining Agriculture & Natural Resources

Global Carbon Budget

	1980's	1990's	2000-2005
Net sources			
Fossil fuel CO2 emissions	5.4	6.4	7.2
Land use change flux	1.4	1.6	NA
Net sinks			
Ocean-atmosphere flux	-1.8	-2.2	-2.2
Residual Land Sink	-0.3	-1.0	NA
(Net land-atmosphere flux)	-0.3	-1.0	-0.9
Atmospheric Increase (Gt / yr)	3.3	3.2	4.1

Adapted and simplified from 4th IPCC Report: the Physical Science Basis. 2007