



Soil quality indicators in Life Cycle Assessment

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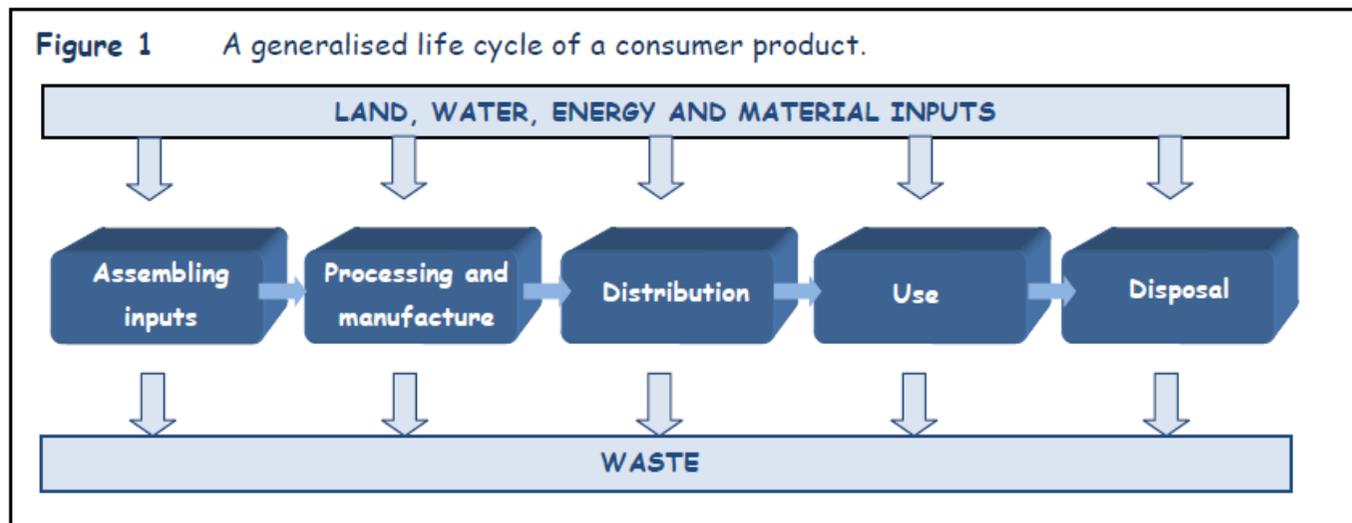


Setting the scene

- What is an LCA
- Why undertake LCAs
- Life cycle inventory activities to date in Australia

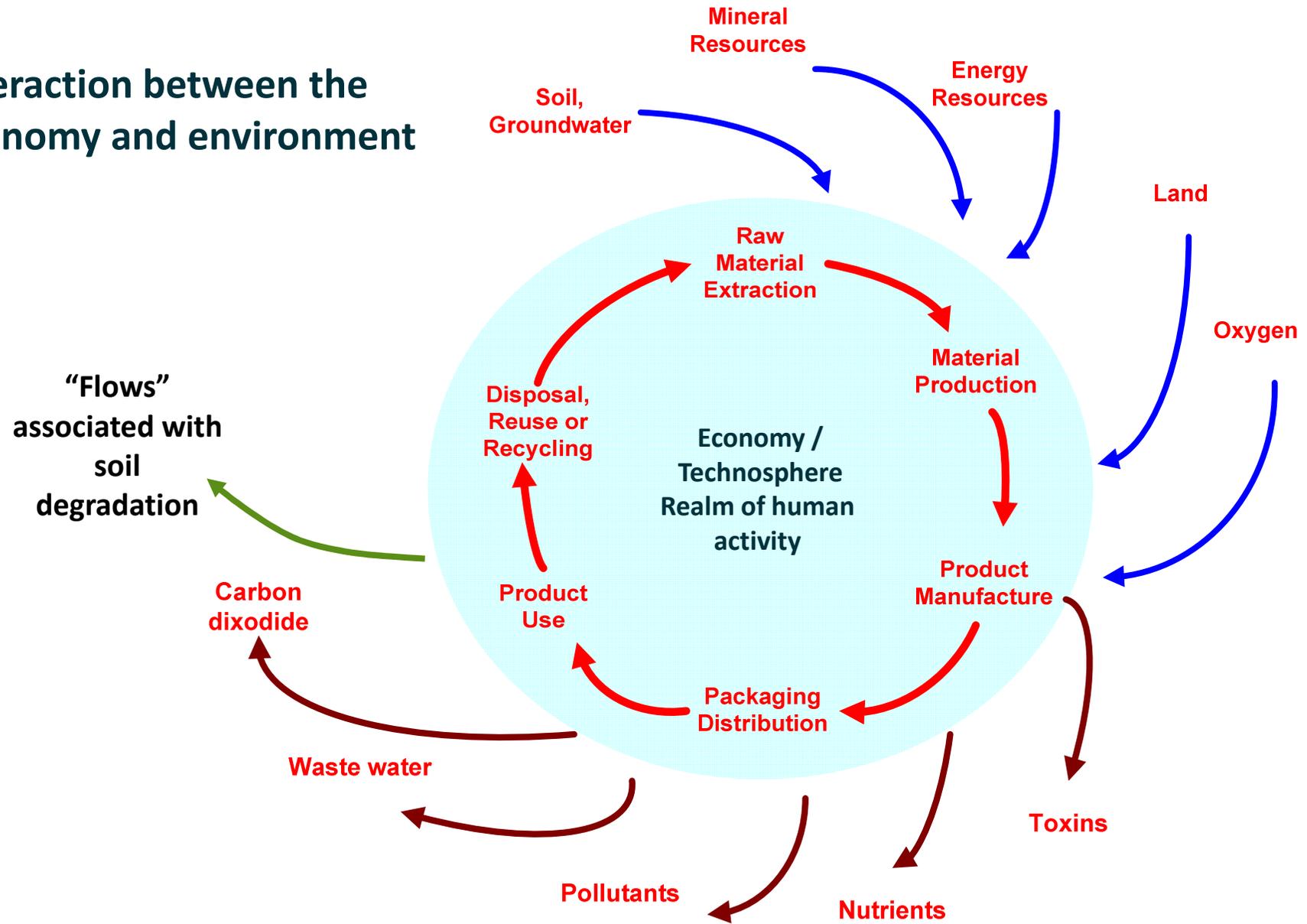
What is a Life Cycle Assessment?

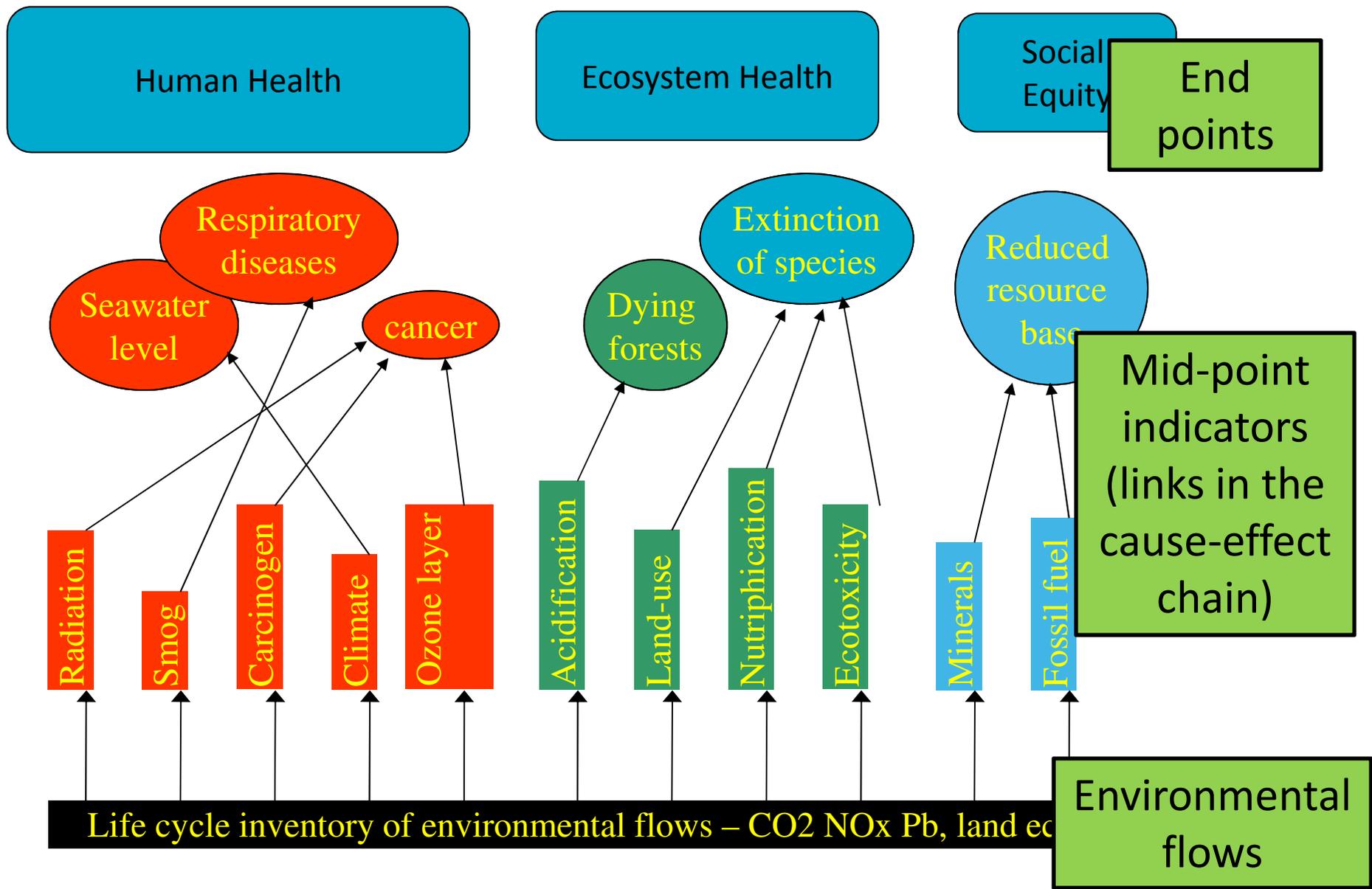
- LCA is the most commonly used tool to determine the environmental impact that a product or service has, by taking into account all of the impacts from resource extraction, production, use, through to end of life disposal.

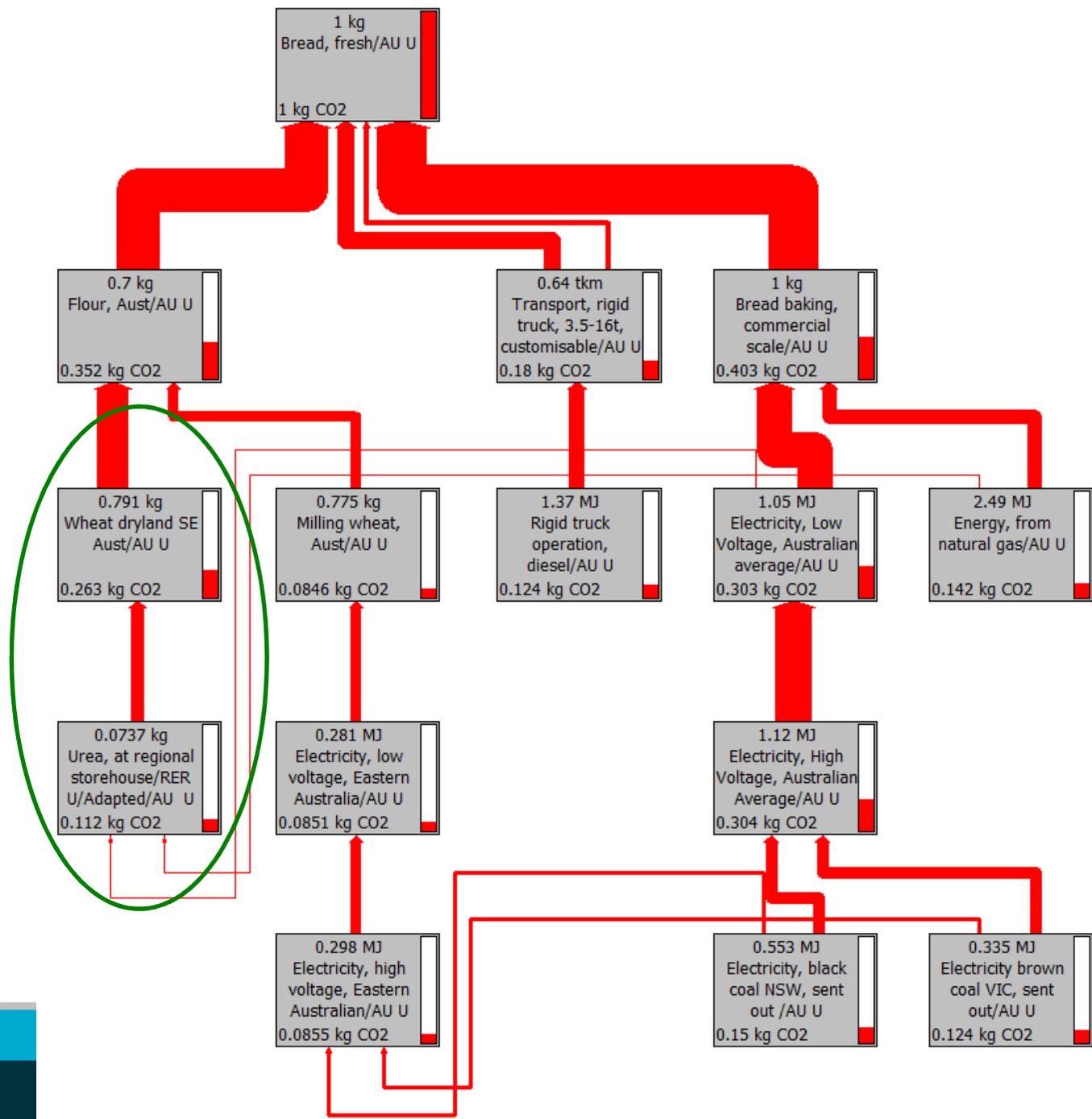


Source: Ryan, S 2012. Buying Choices for a More Sustainable Canberra, Report for the ACT Commissioner for Sustainability and the Environment

Interaction between the economy and environment







Reasons for environmental assessment (Life Cycle Assessment)

- Environmental product declarations to inform consumer choice
 - ❖ European Commission to adopt LCA as the approach to be used for environmental assessment of products for the 'Single Market for Green Products' (see http://ec.europa.eu/environment/eussd/smgp/product_footprint.htm).
- Delivery agreements where the supplier is required to demonstrate an on-going improvement program of environmental sustainability
 - ❖ EU, Japanese, Australian markets – especially supermarkets
- The likely advent of trade agreements premised on climate change mitigation efforts
 - ❖ Covered economies versus uncovered economies for carbon pricing

Reasons for environmental assessment (Life Cycle Assessment)

- Unilateral need to respond to global warming – triggered by realignment of insurance risk and costs to the economy
 - ❖ Covered economies versus uncovered economies for carbon pricing
- Negotiations for international agreements on greenhouse gas emissions reduction targets
 - ❖ Especially China and India for export production (carbon footprint of exports)
- Need to produce more food globally with a lower environmental impact
 - ❖ Global significance but more so for countries that produce large amounts of staple foods – e.g. Australia, China, India, Africa, south America, north America, Russia.....
- Need to have a consistent framework for assessing the environmental impact of different industry sectors and combined impact in different regions
 - ❖ Regional and national significance for evaluation of NRM investments, industry investment in sustainable production,

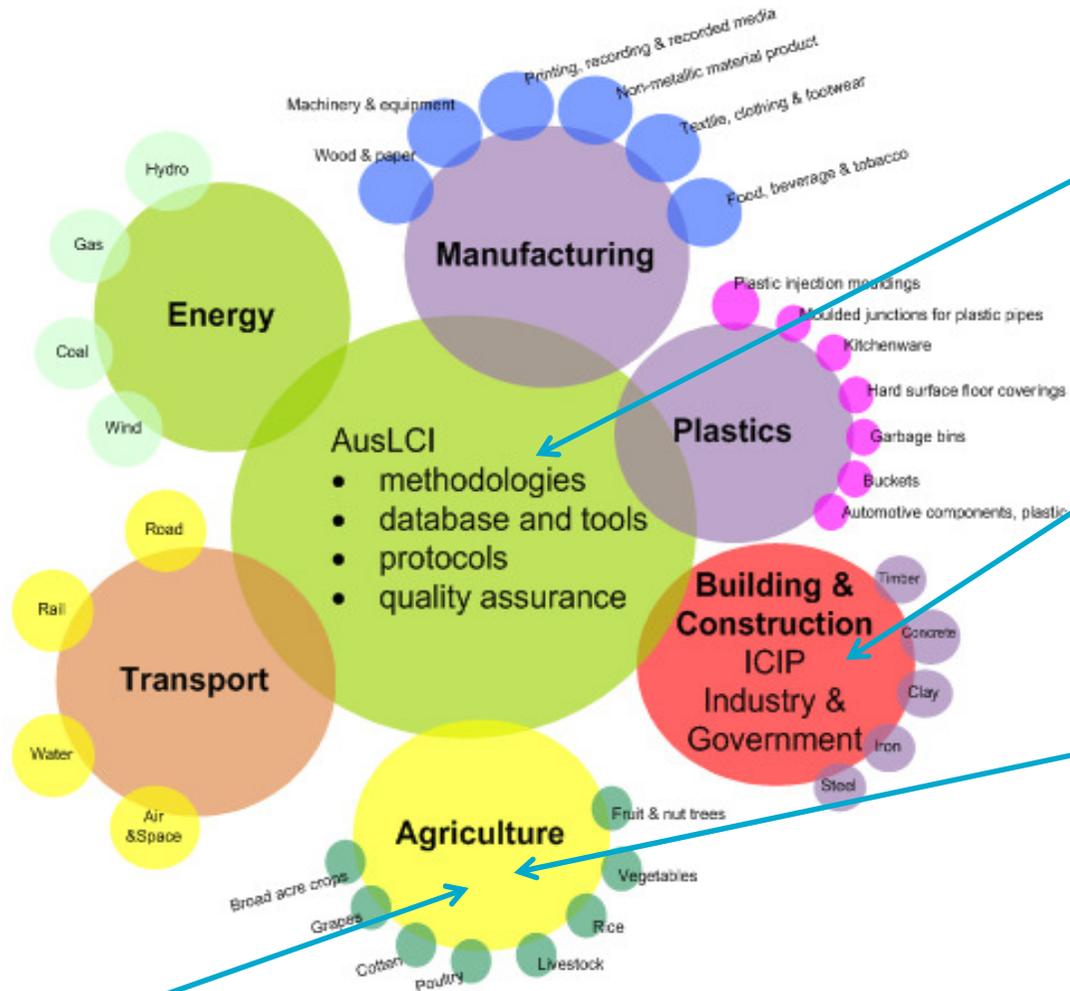
Role of Life Cycle Inventory

- Life Cycle Assessment is only as good as the underlying data or Life Cycle Inventory (LCI) that is used for the analysis.
- Country specific LCI for agricultural products is essential for Australian agriculture to undertake environmental impact studies.
- In the absence of country specific data, LCA practitioners will use the next best data available and this is often from Europe and the USA (with ecoinvent[®] being the most used LCI).

Advantages of a Public Inventory

- Act as a repository for LCI from the many LCA studies being undertaken, to reduce duplication of common inventory e.g. wheat
- Consistent approach applied to inventory across sectors e.g. consistent modelling of pesticide flows
- Guidelines and standards can be set for:
 - Transparency
 - Data quality
 - Review
 - Standard formats
- Inventory can be structured so that it can be efficiently updated e.g. change in N₂O emissions factor for N fertiliser use, improved flows model as GIS data is updated nationally.

LCI Activities in Australia



Series of guideline documents on data collection, reviewing, best practice guide now available on AusLCI website

Major project by BPIC now completed with gate-to-gate data published, needs further development to be integrated into full life cycle unit process LCI.

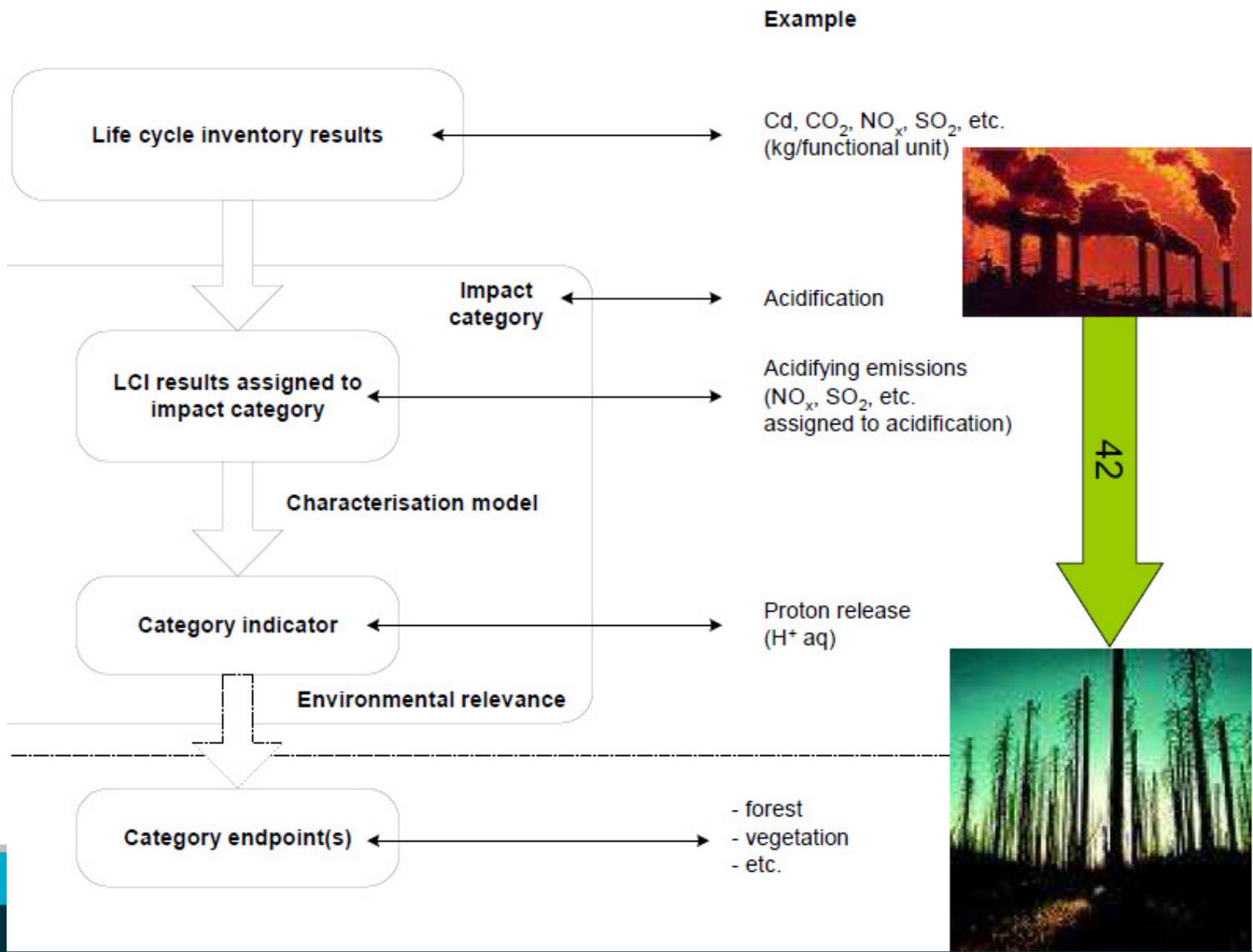
AusAgLCI – commenced in Dec 2011, will cover major products, public research agency providing data, funding support from industry, goal is unit processes from cradle-to-farm gate.

Extensions to AusAgLCI – Department of Agriculture Innovation Fund project for grazing and general cropping inventory (CSIRO and LCS; March 2014) and GRDC project for detailed cropping systems including rotations (NSW DPI, CSIRO and LCS; July 2014)

Over to Tim.....

- Elementary flow, cause and effect pathways, impact assessment in general
- Approaches taken for different land-based impact categories
- How should we think about soil indicators in the context of LCA

The principle of characterisation



Elementary flow

- material or energy entering the system being studied that has been drawn from the environment without previous human transformation, or material or energy leaving the system being studied that is released into the environment without subsequent human transformation
- Source ISO 14044

Examples of elementary flows

- Mineral ores
 - Lead ore, in ground
 - Lead, 5.0% in sulfide, Pb 3.0%, Zn, Ag, Cd, In, in ground
 - Lead, Pb 0.014%, Au 9.7E-4%, Ag 9.7E-4%, Zn 0.63%, Cu 0.38%, in ore, in ground
- Fuels
 - Coal, brown in kg
 - Coal, brown, 10.0 MJ per kg, in ground in kg
 - Coal, brown, 14.1 MJ per kg, in ground in kg
 - Energy from brown coal in MJ
- Land occupation and transformation
 - Occupation, arable, conventional tillage in m².years
 - Transformation, from arable, non-irrigated, extensive in m²

Examples of elementary flows

- Soil –Raw material input
 - Carbon, in organic matter, in soil
 - Clay and soil, extracted for use
 - Clay and soil, related unused extraction
 - Soil, unspecified, in ground
- Emission to air
 - Particulates
 - Particulates Matter >10um
 - Particulate Matter 10.0 um
 - Particulate Matter 2.5 um

Examples of elementary flows

- Water emissions
 - Soil loss by erosion into water
 - Organic substances, unspecified
 - Solved substances
 - Solved substances, inorganic
 - Suspended substances, unspecified
 - Salts, unspecified
 - Acidity, unspecified
- Soil emissions
 - Salts, unspecified
 - Acidity, unspecified

Examples of elementary flows

- Biomass

Documentation Input/output Parameters System description			
Products			
Transformation, from forest, extensive	land	28.3	m2
Transformation, to forest, intensive	land	28.3	m2
Occupation, forest, intensive	land	4240	m2a
Wood, hard, standing	biotic	1.12000	m3
Energy, gross calorific value, in biomass	biotic	14300	MJ
Carbon dioxide, in air	in air	1320	kg
<small>Carbon dioxide, in air in air 1320 kg logarithmic 1.0 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 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2168</small>			

How many elementary flows are there

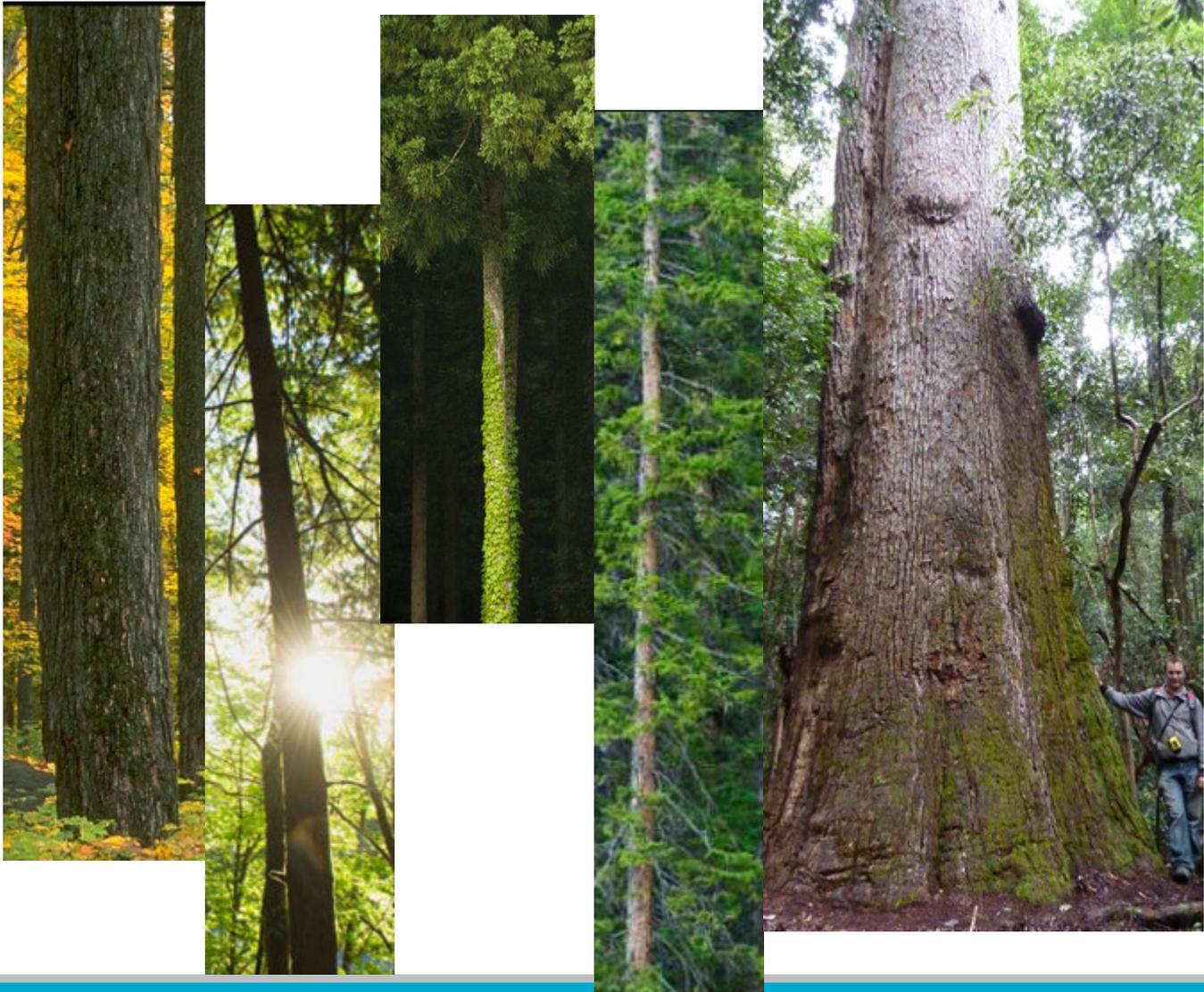
- In SimaPro
 - Raw materials 1800
 - Air emissions 4700
 - Water emissions 3700
 - Soil emissions 3400
- Also emission sub-compartments for air water and soil emissions

Air	Water	Soil
non-urban air or from high stacks	ground-	agricultural
low population density, long-term	ground-, long-term	forestry
lower stratosphere + upper troposphere	ocean	industrial
urban air close to ground	surface water	unspecified
indoor	unspecified	
unspecified		

How to position the elementary flow.

- Elementary flow definitions should enable meaningful aggregation in the impact assessment model.
- Timber production
 - Flow of standing hardwood, in mass units, - or
 - Land occupation in area time and land transformation in area?
- Which is better to aggregate and predict effects on biodiversity?

Adding up the trees



= ?

Area of land use change



= ?



New types of elementary flows

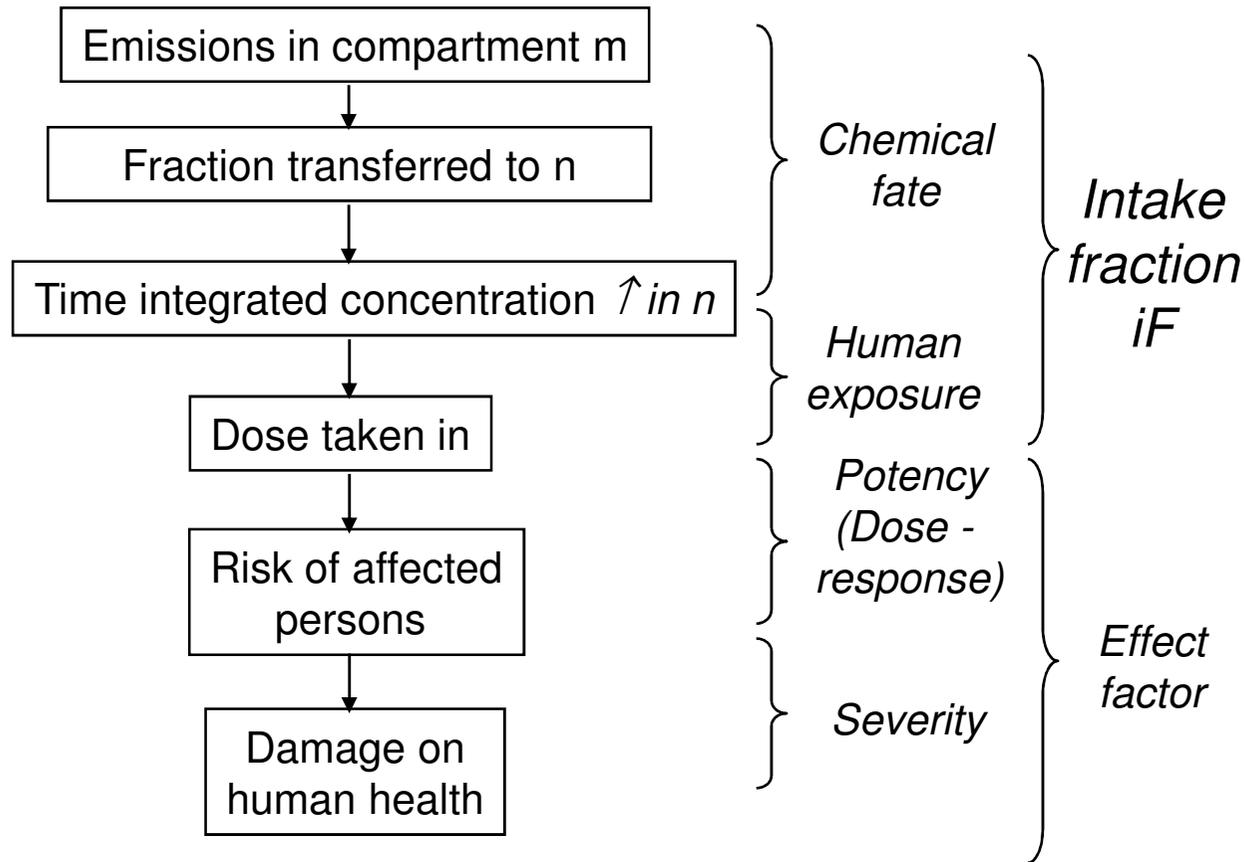
- Social Hot Spot database – risk levels used for attributes
 - Risk of Child Labor in sector, Female , VHR
 - Risk of Child Labor in sector, Female , HR
 - Risk of Child Labor in sector, Female , MR
 - Risk of Child Labor in sector, Female , LR
 - Risk of Child Labor in sector, Female , URL
 - Risk of Child Labor in sector, Female = ne

Compartment	Subcompar	Substance	CAS number	Factor	Unit /
Social		Risk of Child Labor in sector, Total , HR		5	CL mrh eq / work hours
Social		Risk of Child Labor in sector, Total , LR		0.01	CL mrh eq / work hours
Social		Risk of Child Labor in sector, Total , MR		1	CL mrh eq / work hours
Social		Risk of Child Labor in sector, Total , VHR		10	CL mrh eq / work hours

New types of elementary flows

- Water footprint flows – adding geography to elementary flows
 - Water, lake, AE
 - Water, lake, AF
 - Water, lake, AL
 - Water, lake, AM
 - Water, lake, AO
 - Water, lake, AR
 - Water, lake, AT
 - Water, lake, AU
 - Water, lake, AZ
 - Water, lake, BA
 - Water, lake, BD
 - Water, lake, BE
 - Water, lake, BF

The environmental mechanism – example of human toxicity

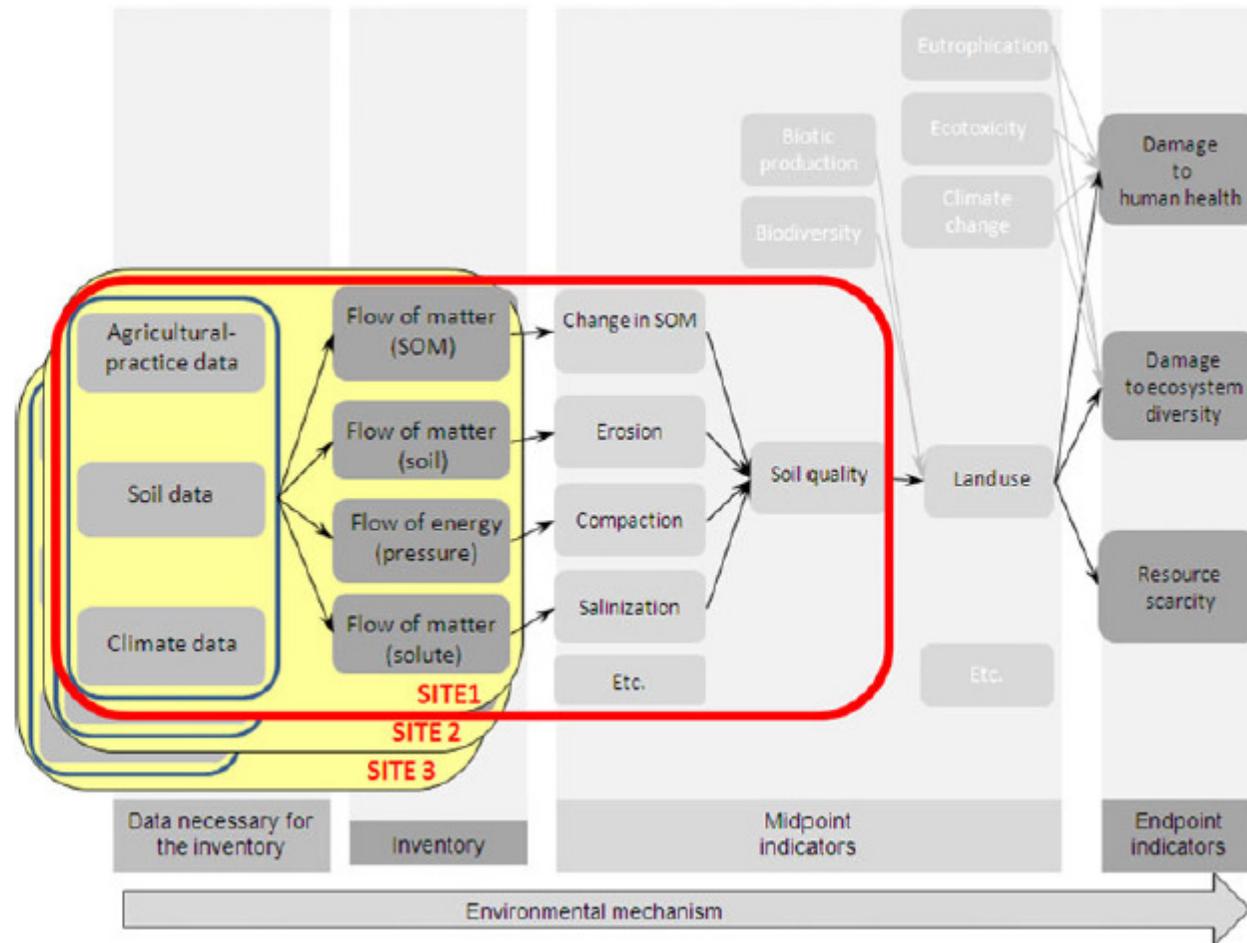


Current approaches to land use

- Biodiversity metrics based:
 - Direct occupation of land – displacing biodiversity and stopping it re-establishing on that land
 - Increased segregation of remaining natural land.
- Japanese LIME model included NPP as an endpoint in LCA.
- Ecological footprint- based on exclusive use of land based on NPP.
- ILCD – carbon deficit from land use change.
- World impact+ method – focus on regionalisation of impact assessment – included soil ecological functions – erosion resistance, water supply, water filtration.

The scope of our work for the next two days

Fig. 1 Conceptual steps for assessing impacts on soil quality (outlined) (adapted from Garrigues et al. 2012). Not all potential links between midpoint indicators are shown



Source: Garrigues et al. 2013. Development of a soil compaction indicator in life cycle assessment. International J Life Cycle Assessment 18:1316.

Back to Sandra

- Current flows in AusAgLCI to cover impact categories
- Inventory produced to date
- Some LCI results
- Expectations from the workshop

Impact categories

- **Global warming:**

- Flows are based on IPCC (2006) and National Inventory Report (DCCEE 2011) methodologies.
- Emissions directly associated with production (e.g. direct and indirect GHG emissions from fertiliser use, burning of stubble, crop residues) are included as inventory flows but not potential carbon sinks and sources (soil, litter and vegetation carbon changes); it will be the domain of the LCA practitioner to add these where appropriate.

- **Water use:**

- Elemental flows required to support a range of impact assessment approaches are included. Green water is included if there is a land transformation that changes the availability of water downstream for other users.

- **Land use:**

- The land cover classifications used by ecoinvent® are used as the basic flow in the inventory.
- To inform the discussion on land use and the competing demands for land, an approach that classifies both area and the capacity of land to produce food is required.

Impact categories - continued

- ***Eutrophication:***

- Nitrogen flows are estimated using Australian NIR methodology and phosphorus flows are estimated by the method used by ecoinvent[®].
- Both methods are responsive to fertiliser inputs, and use regional data (at the intersection of GIS layers for agro ecological region and land use) to determine if leaching and run-off is occurring, and to estimate net export of soil (relevant for P transport to waterways).

- ***Ecotoxicity:***

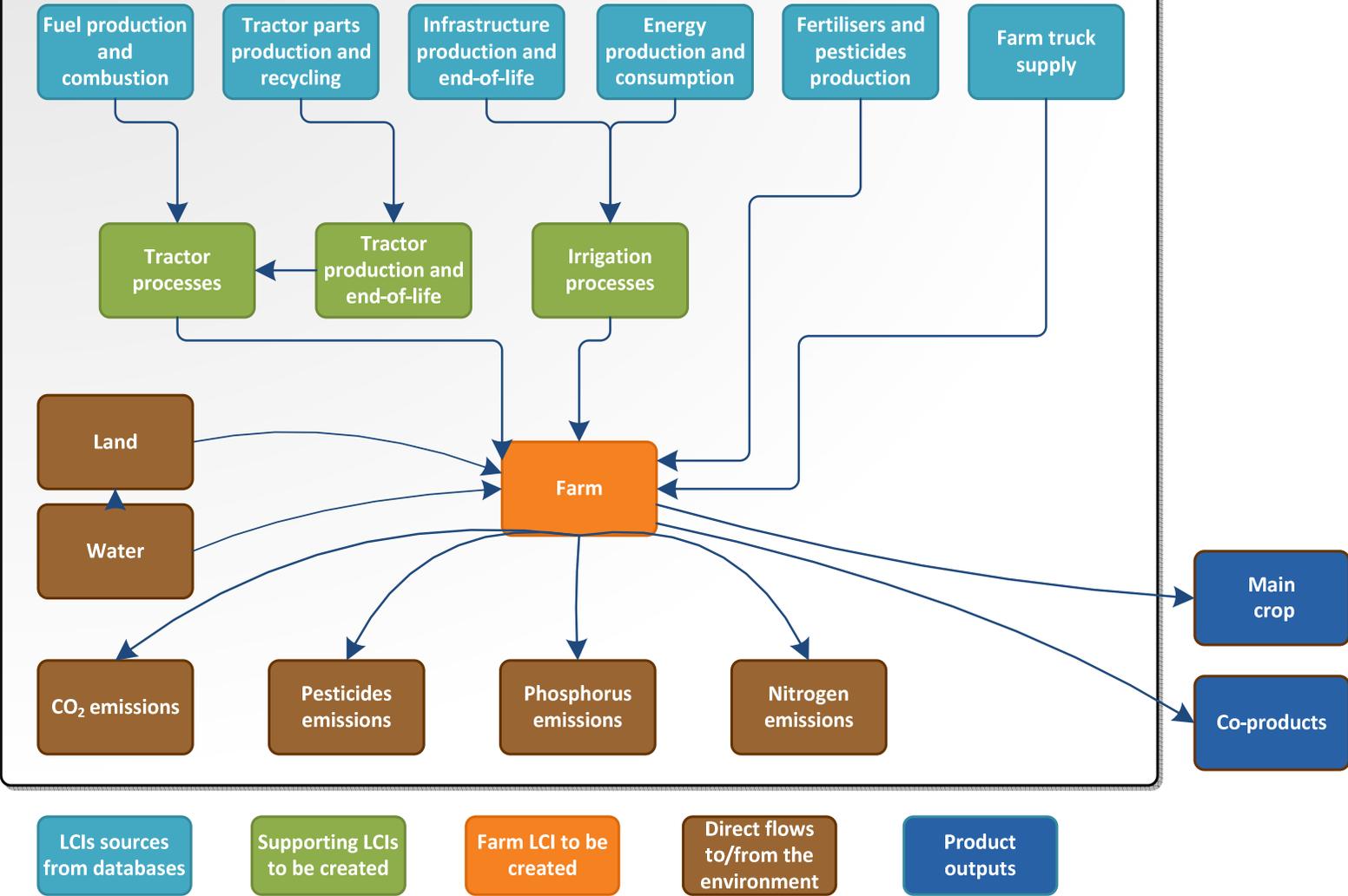
- Flows of specific active ingredients to soil, water and air are estimated from PestLCI, adapted to Australian conditions.
- Parameters modified for Australian conditions are climate related (temperature, precipitation, evaporation, solar radiation), soil characteristics (depth, proportion sand, silt and clay, pH, organic content, bulk density), and field data (slope).
- Profiles for use in PestLCI have been constructed from GIS layers at the intersection of agricultural land use and agro ecological region.
- A number of pesticides used in Australia have been added to the model, using readily available data on key parameters (molecular weight, solubility, vapour pressure, half life in soil).

What has been produced to date

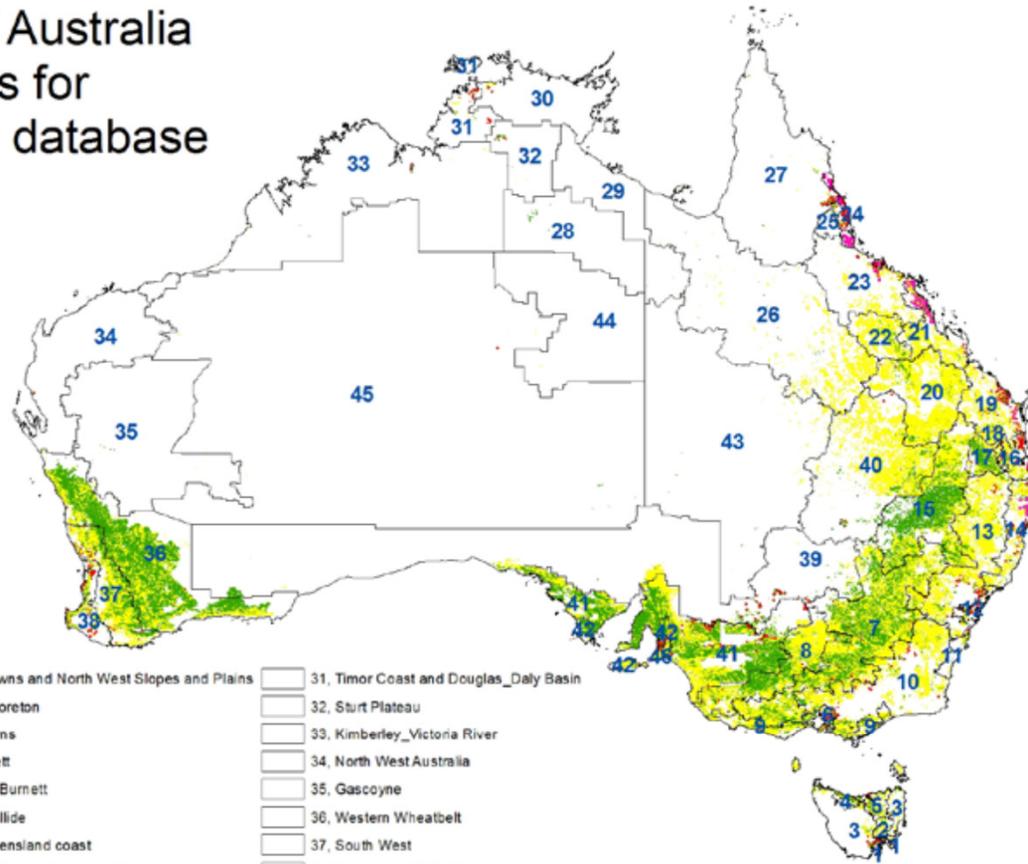
Sector	Processing	Material	Total
Cotton	14	4	18
Horticulture	17	16	33
Livestock*	2	12	14
Grains	19	16	35
Sugar	13	7	20
Irrigation			23
Other			4
Total			147

* Supporting inventory

FARM BOUNDARIES



Agroecological regions of Australia and the Land Use Classes for products in the AusAgLCI database



Legend

Agroecol_regions region_no, Region_nam

- 1, Hobart
- 2, Jordan_Coal_Tasman
- 3, Tasmanian_Forests
- 4, Burnie
- 5, North Central
- 6, Melbourne Region
- 7, Central and South West Slopes and Plains
- 8, South Riverina and Wimmera
- 9, Far South and East Victorian Coast
- 10, Southern Highlands - Tablelands and Gippsland
- 11, South Coast and Illawarra
- 12, Sydney Basin
- 13, Central - North Tablelands and Granite belt
- 14, Northern Rivers and Mid-north Coast

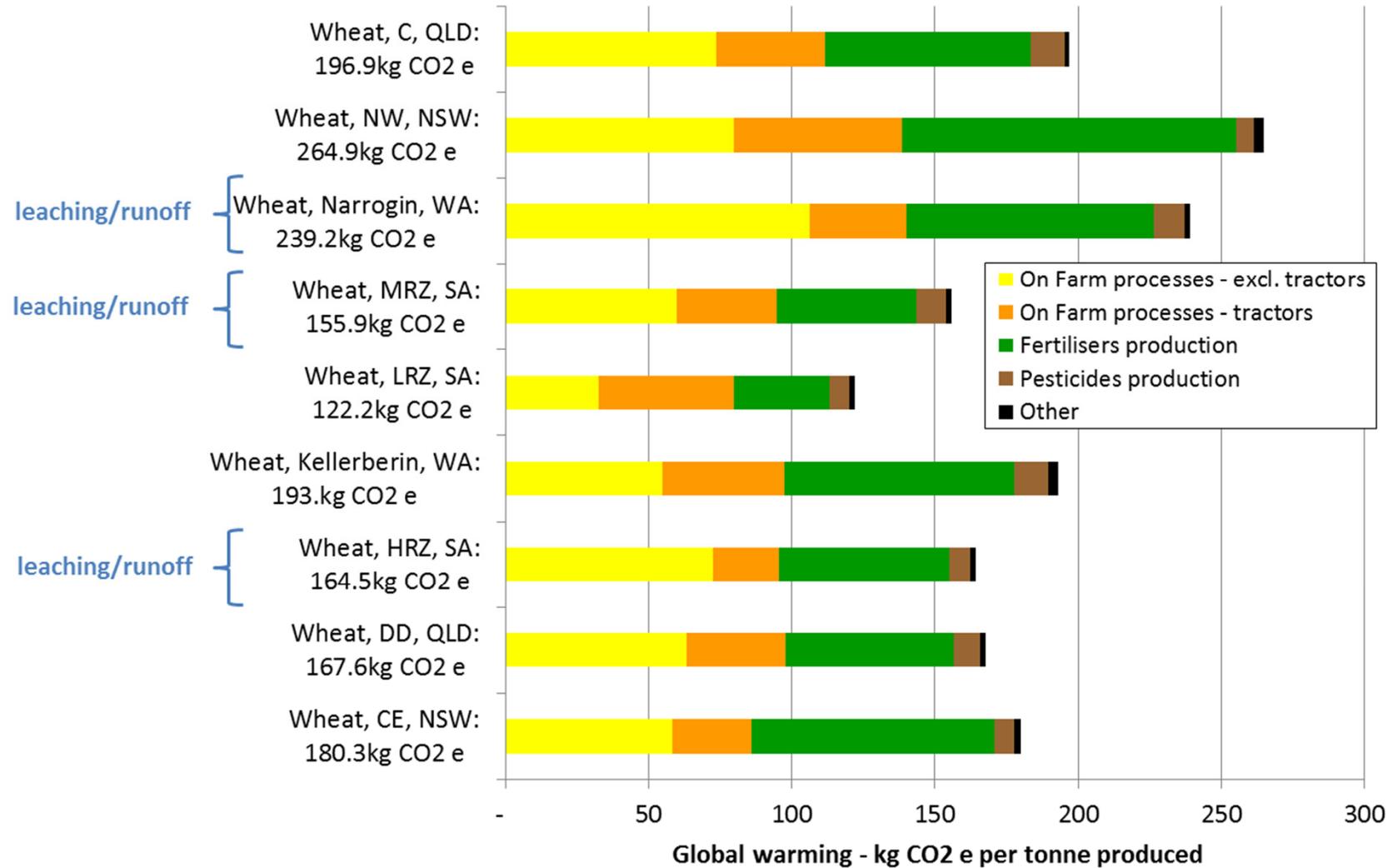
- 15, Western Downs and North West Slopes and Plains
- 16, Brisbane_Moreton
- 17, Darling Downs
- 18, South Burnett
- 19, Wide Bay_Burnett
- 20, Dawson_Callide
- 21, Central Queensland coast
- 22, Central Highlands Queensland
- 23, Burdekin
- 24, Wet Tropic Coast
- 25, Northern Queensland Tablelands
- 26, Central West and Gulf
- 27, Cape York
- 28, Barkly Tablelands
- 29, Marakai_Arnhem Land
- 30, Esley_Gulf Land

- 31, Timor Coast and Douglas_Daly Basin
- 32, Sturt Plateau
- 33, Kimberley_Victoria River
- 34, North West Australia
- 35, Gascoyne
- 36, Western Wheatbelt
- 37, South West
- 38, Lower South West
- 39, Goldfields_Nullabor_Flinders and Daring
- 40, Maranoa_Warrego
- 41, Mallee_Murray and central North South Australia
- 42, Southern Coastal South Australia
- 43, Channel Country
- 44, Central Australian Ranges
- 45, Tanami - Petermann - Simpson and Western Deserts
- 46, Adelaide Region

Land Use Classes

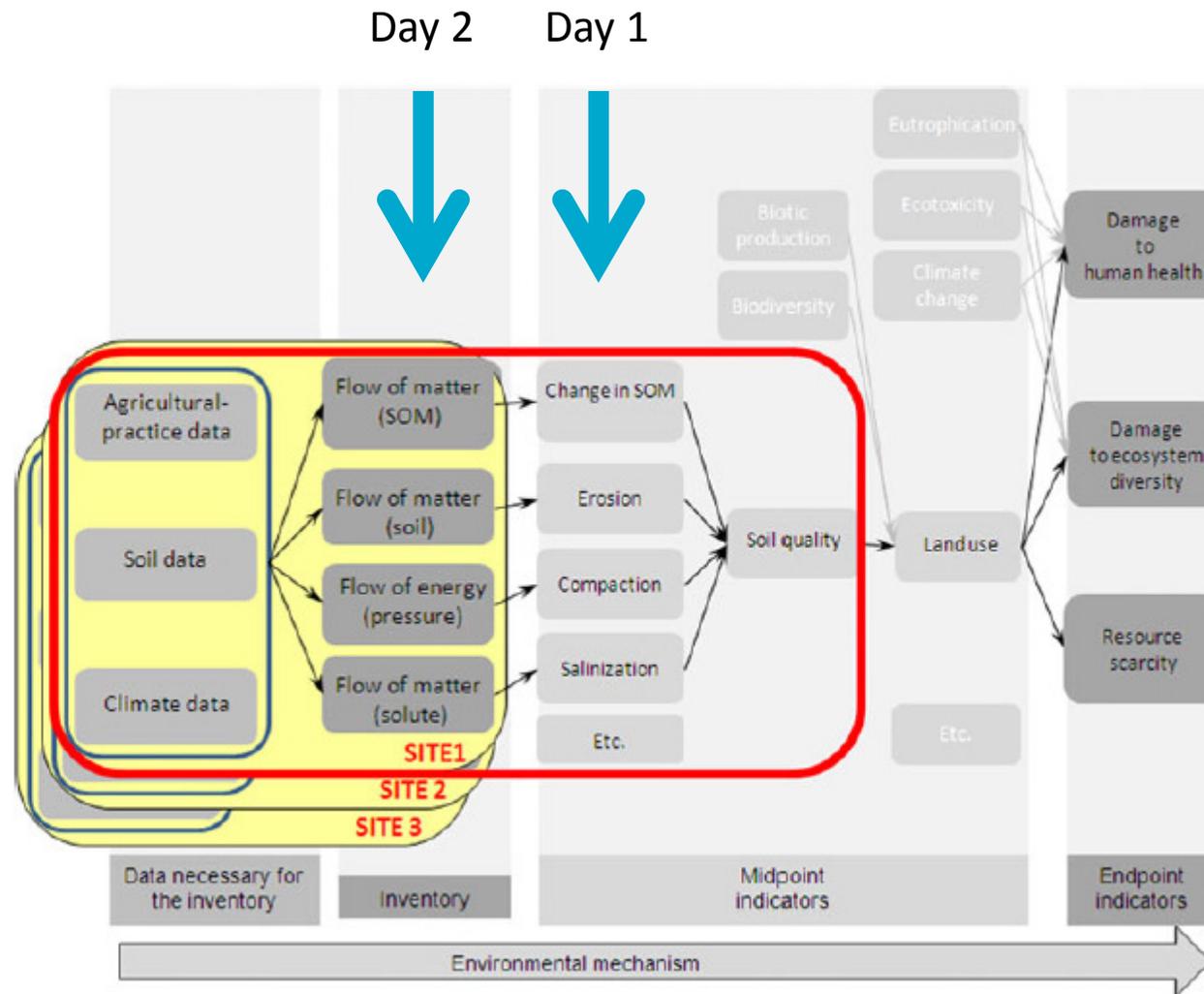
- Pastures
- Cropping
- Seasonal Hort
- Perennial Hort
- Sugar
- Cotton

Preliminary Wheat GHG Results



The scope of our work for the next two days

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Source: Garrigues et al. 2013. Development of a soil compaction indicator in life cycle assessment. International J Life Cycle Assessment 18:1316.

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