A formulation of ecological value added

By Taryn Reddy and Rob Thomson,
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About the speakers

- **Taryn Reddy**
- Lecturer
- PhD student

- **University of the Witwatersrand**
- Largest fossil collections in the Southern hemisphere.

About the speakers

- **Rob Thomson**
- Professor emeritus
- Co-vice-chair, Resources and Environment Working Group, International Actuarial Association

- **University of the Witwatersrand**

What’s behind the title?

- Triple Bottom Line group of IAA’s Resources and Environment Working Group
- PhD
- ‘triple bottom line’
- No agreed-upon methodology
- Start with ecology
- Our objective
- Challenge to you

Agenda

- The problem
- Current measures
- Criteria for measurement
- Our formulation

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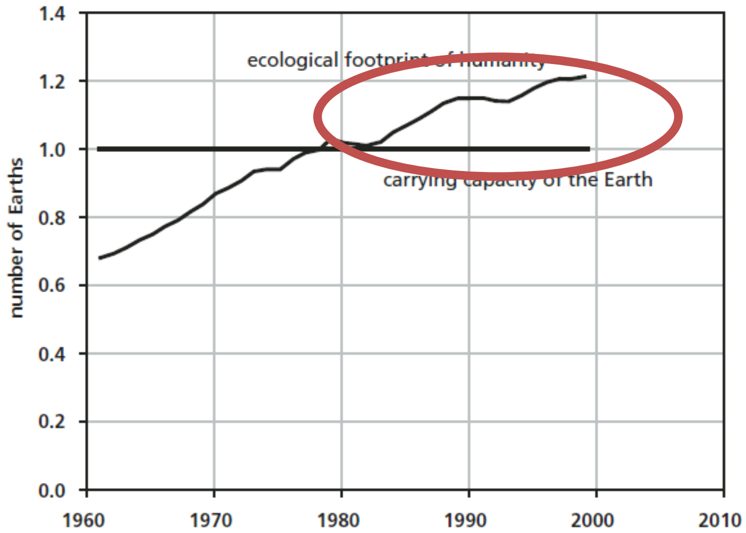
Let’s look at the situation nearly two decades ago



Ecological Footprint versus Carrying Capacity

This graph shows the number of Earths required to provide the resources used by humanity and to absorb their emissions for each year since 1960. This human demand is compared with the available supply: our one planet Earth. Human demand exceeds nature’s supply from the 1980s onward, over-shooting it by some 20 percent in 1999. (Source: M. Wackernagel et al.)

Is human activity sustainable?

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Fraught with problems

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TOTAL ENVIRONMENTAL PROTECTION EXPENDITURES AND INVESTMENTS BY TYPE

a. Report total environmental protection expenditures by:
- Waste disposal, emissions treatment, and remediation costs
- Prevention and environmental management costs

- Lack of comparability across entities
- Does not measure outcomes
- Focus on the past
- Reductionist
- Not meaningful in each domain

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Criteria for measurement

- Born from the shortcomings of current measures
- Ultimate effects
- Meaningful in each domain
- Allow for comparability
- Additive across time and space
- Attributable
- Aggregable
- Implementable
- Simple yet not reductionist

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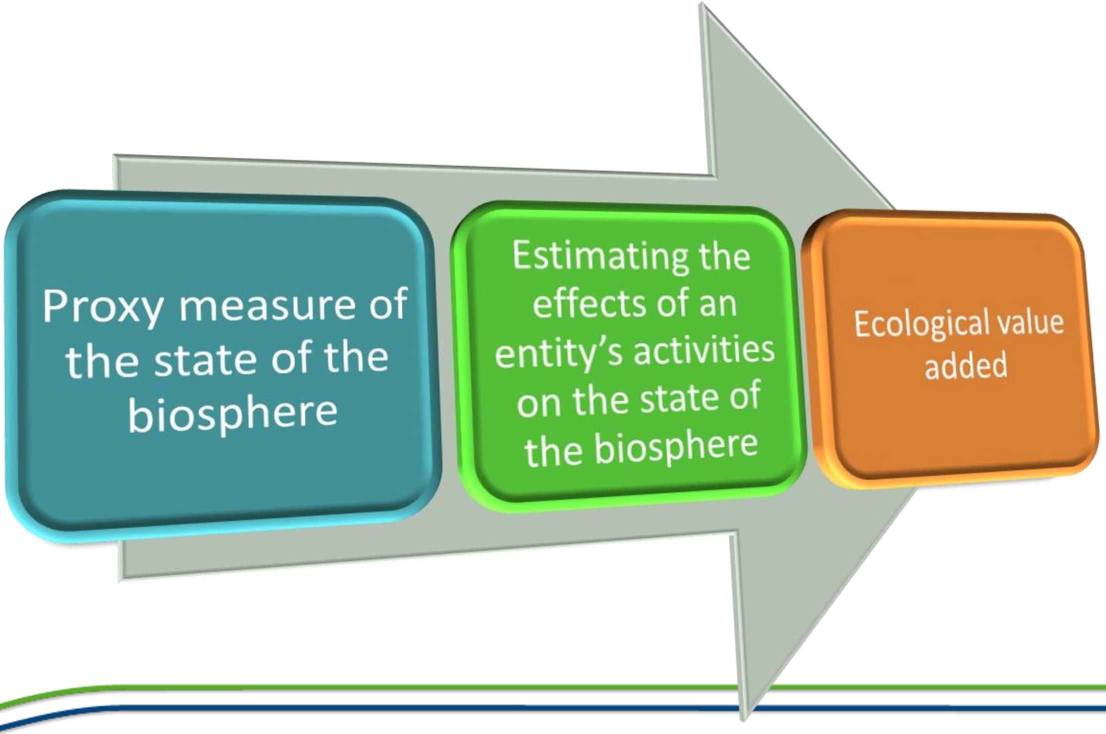
Our formulation



Consider the Earth-proxy measure of the state of the biosphere

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‘Eco’: measure the state of grid-cell g at time *t* as:

$$e_{gt} = d_{gt} m_{gt}^{\alpha_B}$$

Ecological state of the biosphere as:

$$E_{Gt} = \sum_{g \in G} e_{gt}$$

A method of estimating the effects of an entity's activities on the state of the biosphere

Consider an entity

- Measure at year-end t' for emissions during year t
- Lagged effects
- Immediate effects

Global effects

Local effects

Direct effects

Global effects at year-end *t′* of activities during year *t*

- Indicators-greenhouse gases and land-use change, most already being measured.
- General Circulation Models:
  - Concentration of each greenhouse gas on each receptor grid-cell.
  - Simulate the climate on each receptor grid-cell.
- Sample-based models:
  - Effect on each receptor grid-cell at year end *t′* of all entities’ emissions during year *t*.

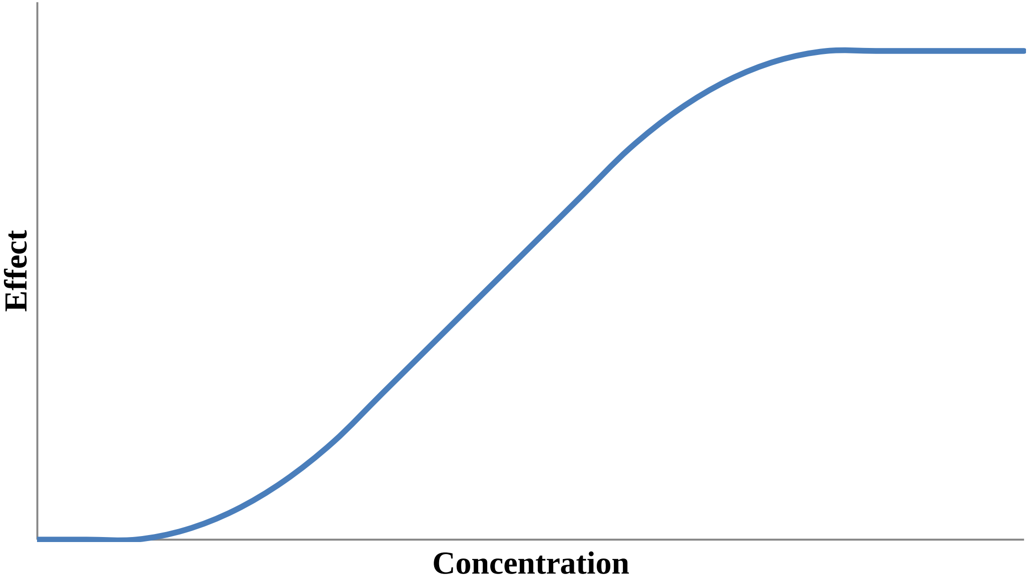
Global effects at year-end t' of activities during year t

- Marginal effects
- Attribute the effects to indicators using proportion to marginal effects.
- Each entity's contribution to the effects of each indicator, determined by proportion to its indicator value.
- Each entity's contribution to the effects of all indicators during year t on all receptor grid-cells at time t', sum across indicators and grid cells.

Local effects at year-end *t′* of activities during year *t*

- Air-pollutant emission type indicators
  - Atmospheric dispersion model
    - Use emissions to determine the concentration of each indicator on/over the air above each receptor grid-cell
- Soil-pollutant emission type indicators
  - Formula describes how the pollutants concentration changes over time
- Water-pollutant emission type indicators
  - Hydrological transport model
    - Use emissions to determine the concentration of each indicator in the water in each receptor grid-cell
- Feedback

Local effects at year-end *t′* during year *t*
Damage functions



Local effects at year-end t' of activities during year t

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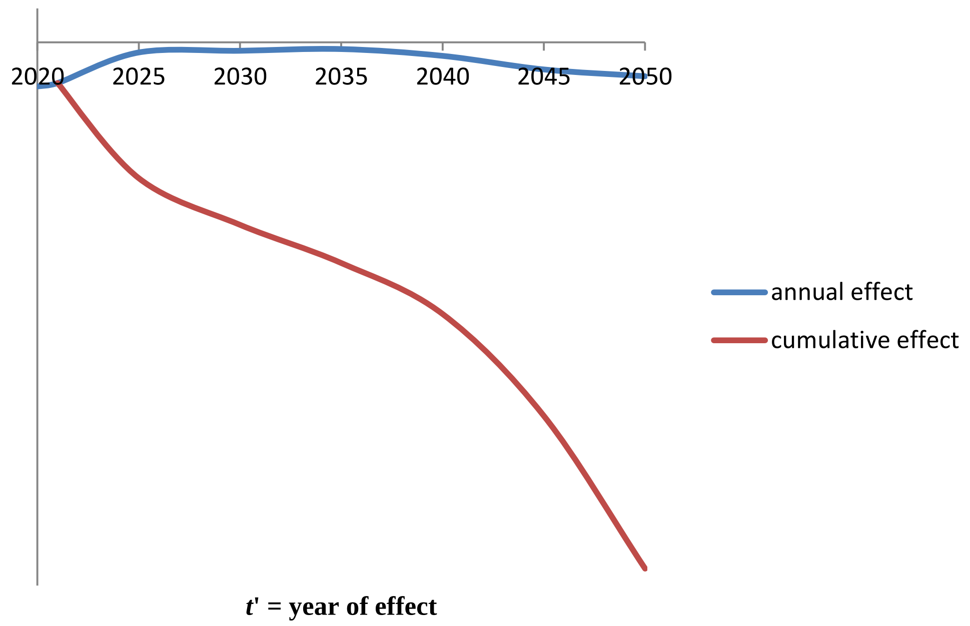
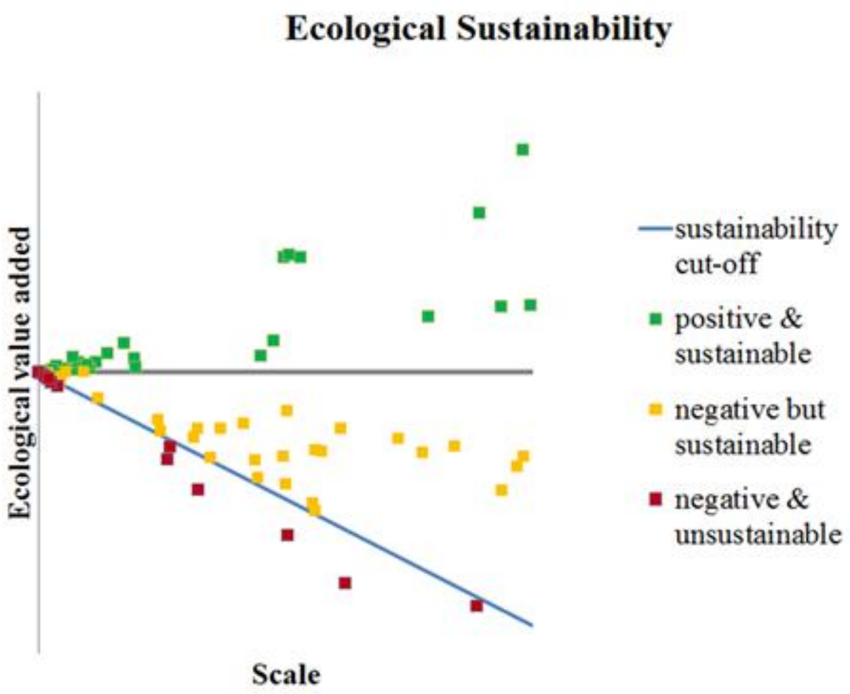
Ecological value added



Ecological sustainability



Thank you very much for your attention!

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