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TROPICAL ECOSYSTEMS hub

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Natural and Economic Systems
Truly dynamic and interlinked

First project

Socioeconomic Systems and Reef Resilience

JAMES COOK UNIVERSITY AUSTRALIA

Australian National University

Australian Government Great Barrier Reef Marine Park Authority

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- The influence of socioeconomic variables (e.g. price, cattle numbers) on water quality/sediment

  (also provides an indication of whether market based policies are likely to be useful for NRM)

- The relative 'value' of the goods and services provided by the Great Barrier Reef World Heritage Area (GBRWHA) to residents of and visitors to the GBR Catchment area

  (also provides indication of likely environment/economy trade-offs)

Preliminary results only (may change as data are updated and more sophisticated analysis is undertaken)

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WHAT DOES THE ECONOMY DO TO THE ENVIRONMENT?

Focused on the Burdekin, using historical/time series data to estimate an equation that links

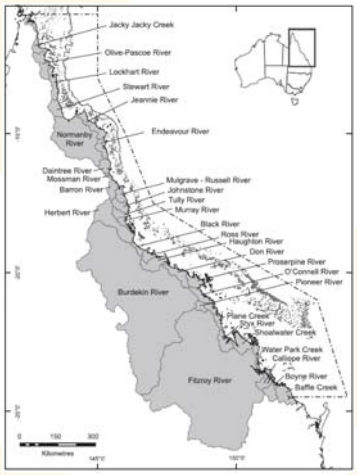
- **Sediment loads**

  Coral samples collected and used to

  hind-cast estimates of annual sediment load

to:

- **Prices** (e.g. beef, gold, wages and interest rates)
- **Land use** (specifically: cattle numbers)
- **Climate** (e.g. rainfall, temperature, extreme events)



Key challenge: to devise a system for overcoming data deficiencies

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CONCEPTUAL FRAMEWORK

- ❑ Hybrid reasoning approach
- ❑ We then use those priors to build our conceptual model.
- ❑ Not able to obtain data on all relevant variables, so we used several proxies, and had to omit some variables altogether.
- ❑ Sediment loads would be a function of:
  - **climate – charteroised by temperature (mean max temp for each year)**
  - **rainfall – proxied by Jarvis' measure of areal rainfall**
  - **rainfall intensity – using a dummy variable set equal to one during years in which there was an extreme event**
  - **catchment wetness – proxied by including lagged rainfall measures; and**
  - **landuse – proxied by cattle numbers.**

Preliminary results only (may change as data are updated and more sophisticated analysis is undertaken)

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CONCEPTUAL FRAMEWORK

We hypothesise that **landuse** is likely to alter when there are changes in the **profitability of different industries** – so another set of variables is also added the model :

- beef prices,
- gold prices,
- coal prices,
- interest rates,
- wage rates; and
- climate (characterised by rainfall, temperature , extreme events)

(using annual 'water years', from late 1930's to 2011)

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THE MODEL

pre-dam period:

Sediment *= f { Cattle numbers , rainfall , temperature , Extreme events , Wages , Beef prices , Gold prices}*

Cattle numbers *= f { rainfall , temperature , Extreme events , Wages , Beef prices , Gold prices }*

full-period :

Sediment = f { Cattle numbers , rainfall , temperature , Extreme events , Wages , Beef prices , Gold prices , Dummy dam years , Dummy post-dam years }

Cattle numbers = f { rainfall , temperature , Extreme events , Wages , Beef prices , Gold prices , Dummy dam years, Dummy post-dam years }

The used Vector Autoregressive (VAR) methodology to capture simultaneous relationships

Preliminary results only (may change as data are updated and more sophisticated analysis is undertaken)

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Estimated Vector Autoregressive (VAR) model for pre-dam (Burdekin Falls Dam) period

(1938- 1983)	Cattle Numbers	Sediment
Constant	1.71 (0.09)	-5.6 (0.04)
Cattle Numbers (lag 1)	0.08 (0.39)	3.9 (0.04)
Sediment (lag 1)	-0.006 (0.36)	0.16 (0.03)
Rainfall (3 key stations)	-2.35E-05 (0.36)	0.03 (0.000)
Extreme Events	-0.09 (0.000)	0.89 (0.09)
Temperature	-0.08 (0.1)	0.92 (0.09)
Beef Prices	0.0003 (0.07)	0.03 (0.36)
Gold Prices	-5.44E-06 (0.11)	0.0009 (0.03)
Wages	0.0009 (0.16)	0.012 (0.47)
R-squared	0.42	063
Adj. R-squared	0.28	0.51
Sum sq. resids	0.24	467.14
S.E. equation	0.088	6.98
F-statistic	1.62	3.36
Log likelihood	47.40	-132.12
Akaike AIC	-1.88	7.1
Schwarz SC	-1.56	7.44
Mean dependent	0.02	9.33
S.D. dependent	0.09	8.57

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Estimated Vector Autoregressive (VAR) model for the full-period

(1938-2011)	Cattle Numbers	Sediment
C	5.39 (0.07)	-7.06 (0.13)
Cattle Numbers (lag 1)	0.90 (0.000)	0.32 (0.04)
Sediment (lag 1)	-0.000 (0.46)	0.04 (0.31)
Rainfall (3 key stations)	-0.04 (0.12)	14.9 (0.000)
Extreme events	0.015 (0.27)	3.03 (0.03)
Temperature	-1.11 (0.06)	15.11 (0.40)
Beef Prices	0.15 (0.03)	2.87 (0.29)
Gold Prices	0.08 (0.16)	-0.6 (0.02)
Wages	0.44 (0.03)	0.39 (0.43)
Post-dam * rainfall	0.08 (0.05)	-6.7 (0.03)
Post-dam years	-0.55 (0.05)	4.5 (0.06)
R-squared	0.87	0.50
Adj. R-squared	0.85	0.42
Sum sq. resids	0.59	953.5
S.E. equation	0.09	5.65
F-statistic	42.99	6.30
Log likelihood	70.72	-220.98
Akaike AIC	-1.65	6.44
Schwarz SC	-1.31	6.79
Mean dependent	0.14	7.13
S.D. dependent	0.25	7.48

Preliminary results only (may change as data are updated and more sophisticated analysis is undertaken)

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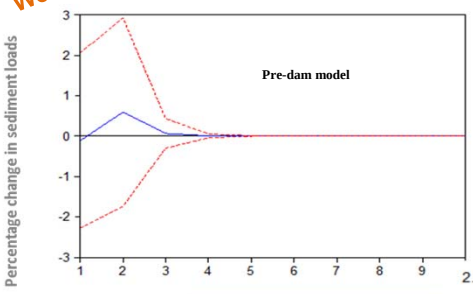
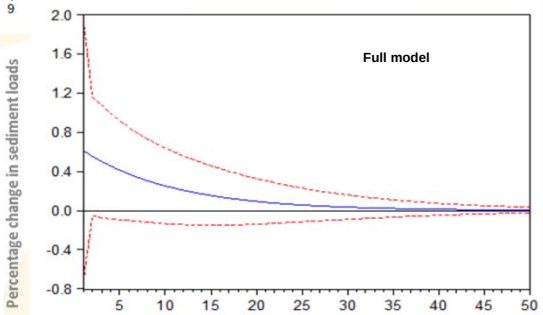
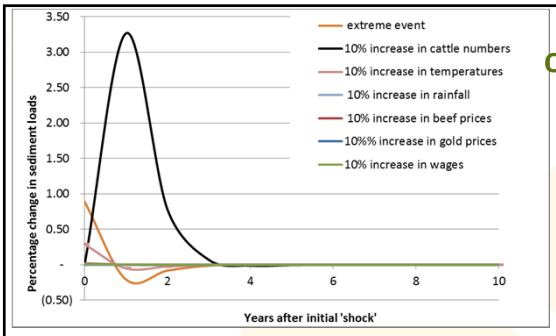
Work under review

WHAT HAPPENS TO SEDIMENT LOADS WHEN CATTLE NUMBERS INCREASE BY ONE STANDARD DEVIATION ?



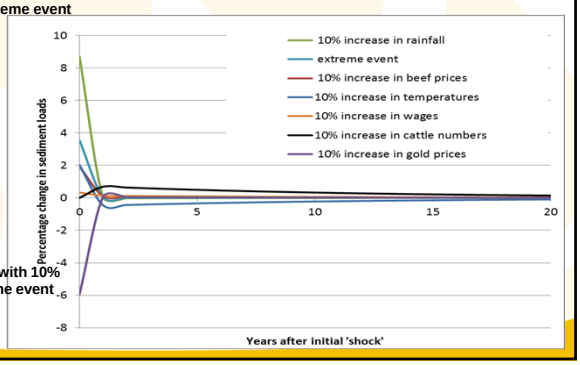


AND WHAT HAPPENS WHEN OTHER THINGS CHANGE? (FULL PERIOD MODEL)



Pre-dam model: % change in sediment loads associated with 10% change in rainfall, temperature and/or with an extreme event

Work under review



Full model: % change in sediment loads associated with 10% change in rainfall, temperature and/or with an extreme event

Preliminary results only (may change as data are updated and more sophisticated analysis is undertaken)

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PUBLICATIONS

- Jarvis, D., Stoeckl, N., Chaiechi, T. (2013) **"Applying econometric techniques to hydrological problems in a large basin: quantifying the rainfall-discharge relationship in the Burdekin, Queensland, Australia"** *Journal of Hydrology* – Vol 496, 24 July, pp 107-212
- Chaiechi, T., Stoeckl, N., Jarvis, D., Lewis, S.E., Brodie, J. **"Comparing the impact of changes in both socioeconomic and biophysical systems on sediment loads in the Burdekin catchment adjacent to the Great Barrier Reef**." in Review.

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KEY MESSAGES...

- The Burdekin dam acts as a type of sediment trap
- Changes in the economy affect the environment
  - Even the world price of beef and gold
- Prices may be having a more significant impact nowadays than 50 years ago
- E.g. could use similar techniques to look at other water quality problems (toxins in the water, nutrients, etc.) in almost any region (data permitting).

Preliminary results only (may change as data are updated and more sophisticated analysis is undertaken)

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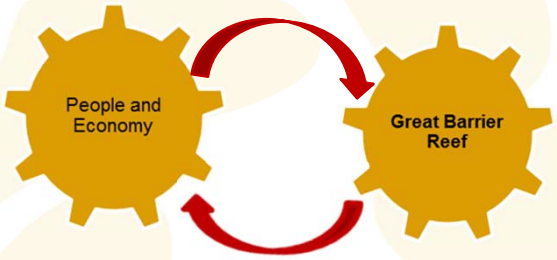
NATURAL AND ECONOMIC SYSTEMS TRULY DYNAMIC AND INTERLINKED

Changes in the economy affect the environment. These changes feed back and affect people and economy

Changes in the economy can have positive impacts on the environment (e.g. link between higher cattle prices and sediment)

Building true resilience



The environment is important to people: Improvements in the environment thus has a real impact on the economy (e.g. decreases in turbidity could increase tourist satisfaction Perhaps also resident satisfaction (and willingness to accept lower wages?)

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NORTHERN AUSTRALIA hub

Second Project
Improving the Efficiency of Biodiversity Investment

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Peter O'Reagain

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14

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BACKGROUND

- Limited budgets => need to consider both costs and benefits of conservation efforts.
- This project focuses on COSTS.
- COSTS depend on CONTEXT. For example,

  - it may be cheaper for graziers to fence streams than for cane farmers (since graziers are likely to own the 'right' type of equipment and have the 'right' expertise);

  - it may be cheaper for large property owners to control weeds than for small property owners to do so (since the small properties might be 'infected' by neighbouring properties more often) .

15

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KEY POLICY QUESTION

Can we improve (on-farm) biodiversity investments by identifying situations were there are 'synergies' between biodiversity and other (market) outcomes?

Key research challenge

Finding evidence of 'synergies'

16

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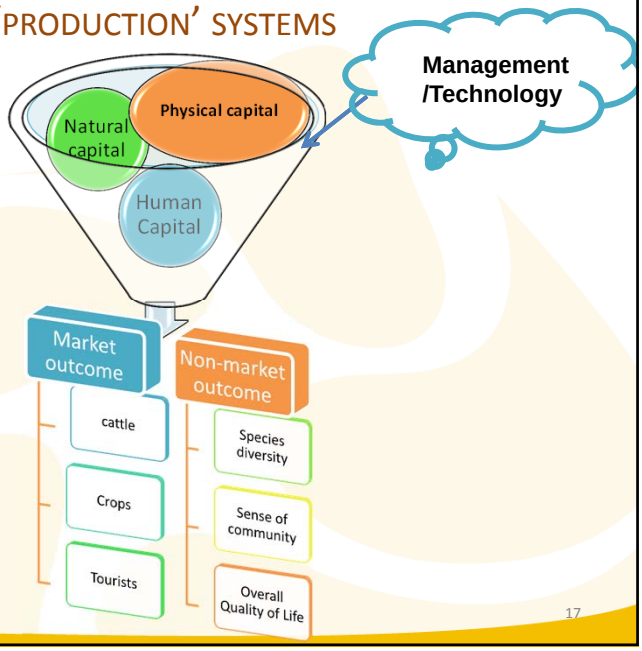
CONCEPTUALISATION: MULTIPLE INPUT - MULTIPLE OUTPUT 'PRODUCTION' SYSTEMS

Most businesses use a variety of different 'inputs' to generate a variety of different 'outcomes' (outputs). So a single 'input' (or activity) does not map to a single output



17

SYNERGIES AND TRADE-OFFS IN COMPLEX 'PRODUCTION' SYSTEMS

Consider fencing which might benefit both cattle and biodiversity because it

- ❑ Helps keep cattle on the areas of land you want them to graze
- ❑ Prevents cattle from getting into rivers and
  - ❑ Causing erosion, Polluting the stream
  - ❑ Trampling riparian vegetation
- ❑ May also prevent feral animals from entering rivers and other areas

⇒ there is a synergy and the true cost of this biodiversity 'action' =

(cost of erecting fences) minus (benefit to cattle operations)

But fences make it more difficult for croppers at harvest time (getting in the way)

⇒ there is a trade-off and the true cost of this biodiversity 'action' =

(cost of erecting fences) plus (extra harvesting costs)

18

Preliminary results only (may change as data are updated and more sophisticated analysis is undertaken)

OUR APPROACH (FOCUSING ON QUANTITIES/PRODUCTIVITY)

Data about inputs, outputs, land management practices, attitudes (etc.) collected in survey of land managers

Data sourced elsewhere (e.g. BOM)

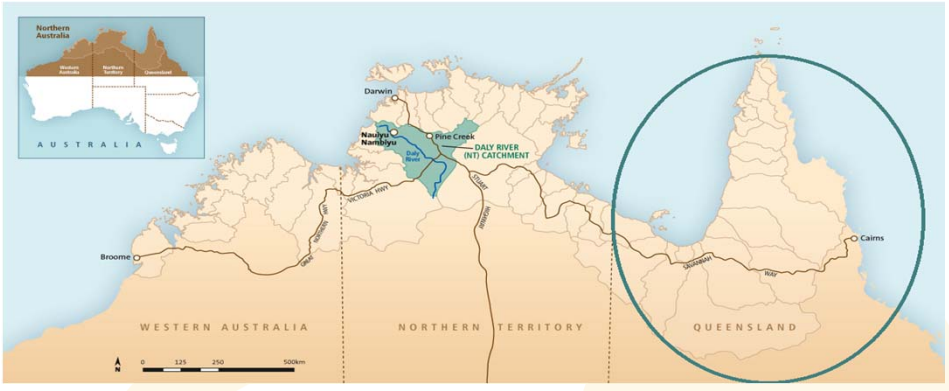
A produces more 'outputs' with the same number of 'inputs' as ***B***

=> ***A*** is more 'efficient' than ***B*** .

If 'efficiency' is linked to diversification (all else constant) => existence of synergies

Will use (non parametric) *Data Envelopment Analysis* to identify 'efficient'/'inefficient' properties, then regression analysis to look at characteristics of these properties

GEOGRAPHIC SCOPE



Adapted from map developed by Sue Jackson and her team in CSIRO

20

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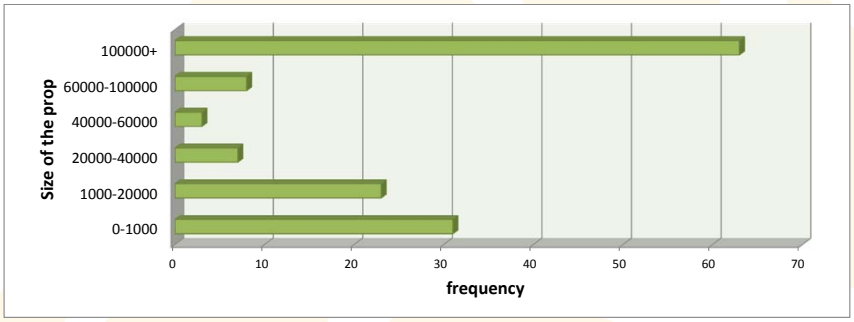
SOME PRELIMINARY RESULTS: INPUTS

	Area(hectare)
Mean	400486
Standard Error	361637
Median	11100
Mode	27000
Minimum	5
Maximum	49210000
Count	136



21

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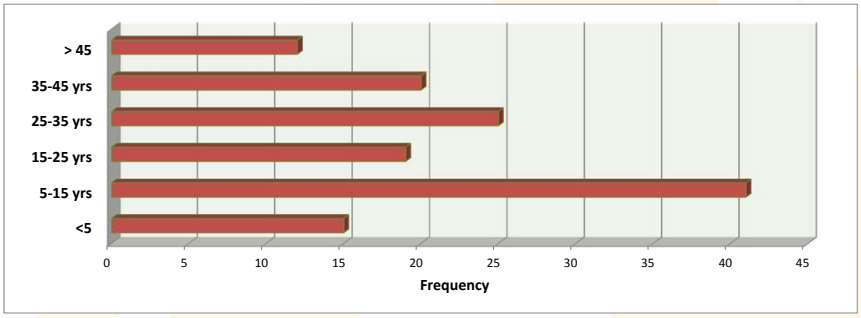
Years of managerial experience

Q: how many years have you owned / managed this land?



Sum of 132 properties

Preliminary results only (may change as data are updated and more sophisticated analysis is undertaken)

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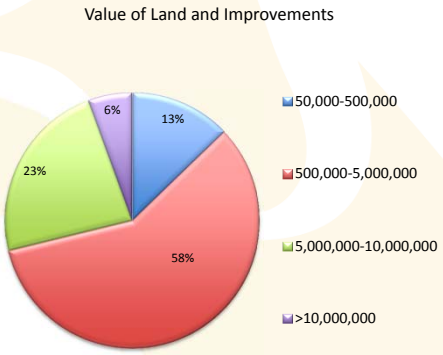
Land and Improvement Values

Land and Improvements Value	
Mean	$3,400,000
Median	$2,500,000
Mode	$1,500,000
Standard Deviation	$3,077,929
Minimum	$50,000
Maximum	$11,250,000
Count	125



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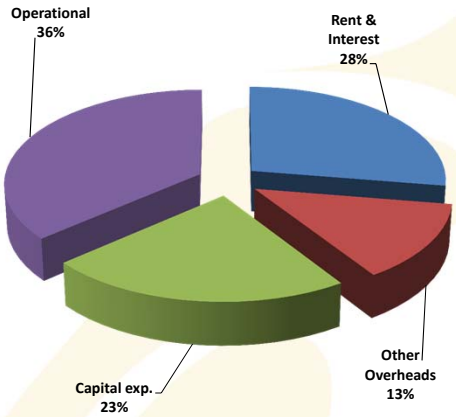
SOME OTHER INPUTS - EXPLICIT COSTS



Total costs (excluding labour)	
Mean	$470,000
Median	$253,500
Standard Deviation	$731,022
Minimum	$5,000
Maximum	$5,340,000
Count	113

24

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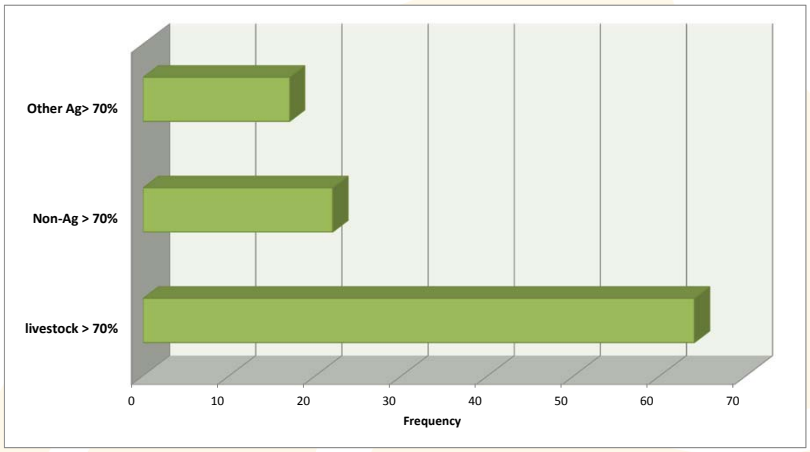
Outputs :

Specialisation Vs Diversification



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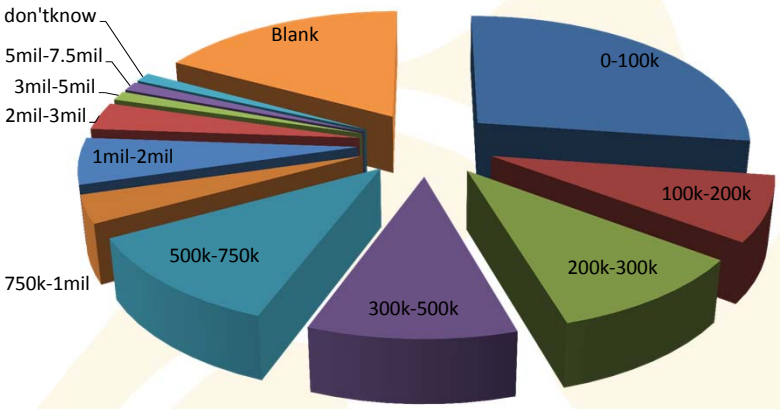
REVENUE GROUPS



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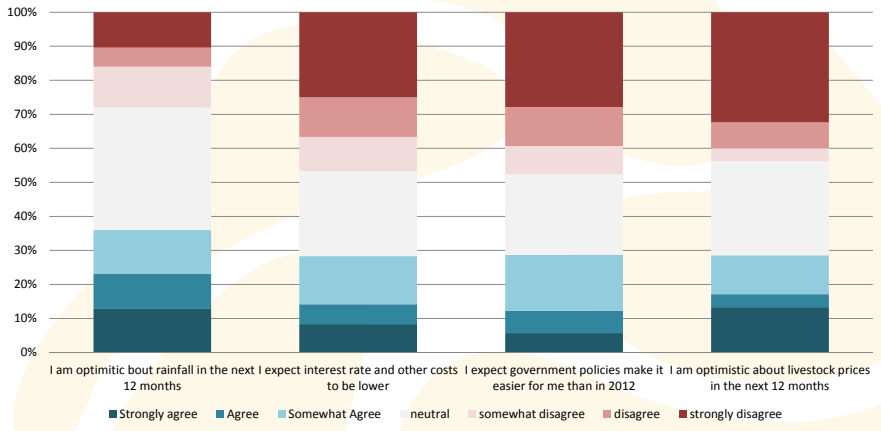
EXPECTATIONS

Expectations: Please indicate how much you agree or disagree with each of the following statements …



27

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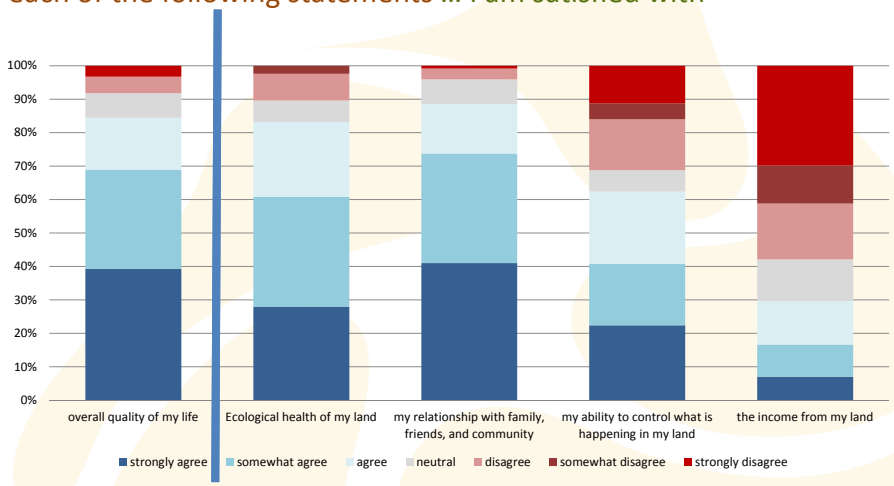
SATISFACTION WITH QUALITY OF LIFE AND KEY ASPECTS

Satisfaction: Please indicate how much you agree or disagree with each of the following statements … I am satisfied with



28

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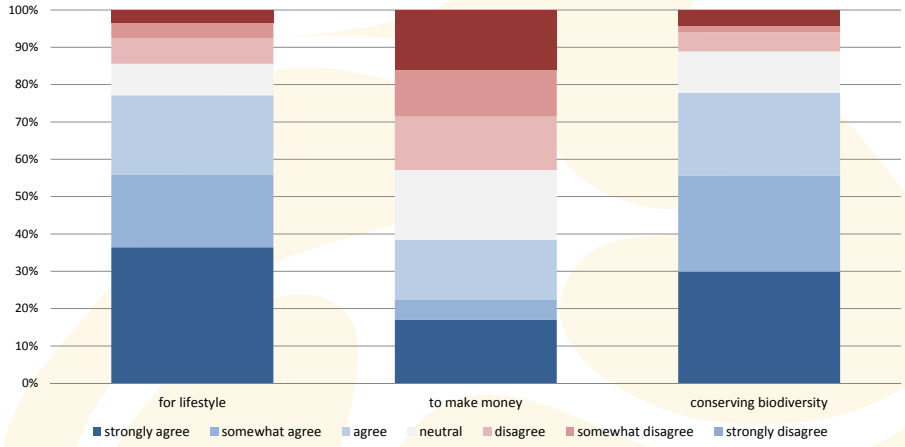
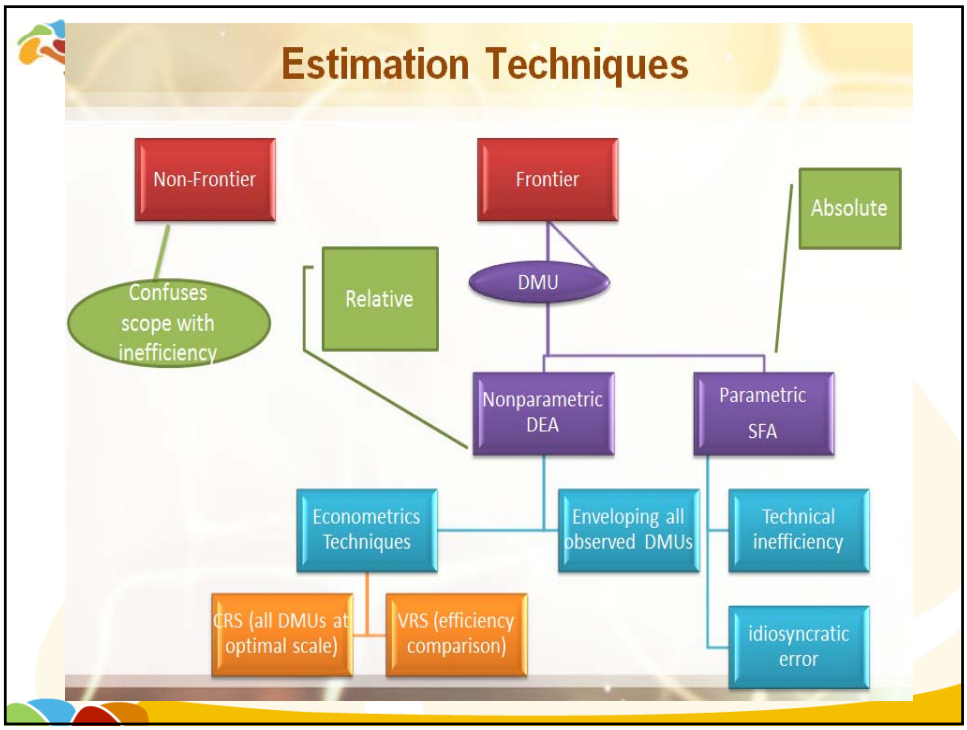
IS OUR MULTI-OUTPUT APPROACH APPROPRIATE?

Please indicate how much you agree or disagree with each of the following statements … My main reason for living here is





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VARIABLES

Inputs	Outputs (combinations)
Total cost	Production
Machinery Value	Ecological Health
Area	Relationships
Rainfall	Control
	Income
	Absence of Weed
	Absence of Pest
	Migratory Species

DEA ANALYSIS

Prop	(2) Prod+AOP	(2) Prod+Income	(2) Prod+ Migratory	(3) Prod+ Cont+ AOP	(3) Prod+Cont+income	(3) Prod+Cont+ migratory	(3) Prod+Relat+AOP	(3) Prod+Relat+income	(3) prod + relat+ Migratory	(3) Prod+Cont+Ecolo	(3) prod+eco lo+Relat
DMU1	1.00	1.17	1.00	1.00	1.13	1.00	1.00	1.04	1.00	1.00	1.00
DMU2											
DMU3	1.00	7.00	1.41	1.00	2.33	1.41	1.00	1.00	1.00	1.40	1.00
DMU4											
DMU5											
DMU6	1.00	1.58	1.78	1.00	1.38	1.38	1.00	1.00	1.00	1.38	1.00
DMU7											
DMU8		1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00
DMU9		1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00
DMU10											
DMU11	1.00	6.57	2.67	1.00	6.16	2.67	1.00	1.17	1.17	1.00	1.00
DMU12	1.00	1.80	1.34	1.00	1.76	1.34	1.00	1.00	1.00	1.00	1.00
DMU13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
DMU14			2.44			1.40			1.00	1.00	1.00
DMU15	1.00		1.00	1.00		1.00	1.00		1.00	1.00	1.00
DMU16	1.00	1.58	1.49	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
DMU17	1.00	1.30	2.87	1.00	1.30	2.87	1.00	1.17	1.17	1.17	1.17
DMU18		1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00
DMU19											
DMU20	1.00	3.80	2.64	1.00	3.45	2.64	1.00	1.40	1.40	1.40	1.40
DMU21	1.00	2.21	1.89	1.00	2.06	1.89	1.00	1.69	1.69	2.06	1.69
DMU22	1.00	7.00	2.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
DMU23											
DMU24											
DMU25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
DMU26											
DMU27	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
DMU28		1.00	1.34		1.00	1.17		1.00	1.00	1.13	1.00
DMU29											
DMU30	1.00	1.91	2.47	1.00	1.60	1.65	1.00	1.13	1.17	1.75	1.17

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POST- DEA ANALYSIS

DEA identifies properties which are 'efficient' when converting
- Capital, Labour + other inputs, Land and , Rainfall into various outputs.

We regressed efficiency against a range of other variables including
- Motivating factors (my main reason for living here is to …)
- Expectations about future prices
- Perceptions about the adequacy of various external capitals
  - (e.g. infrastructure, telecommunications, government policies etc)
- Soil type
- Vegetation type
- Presence of weeds and pests
- Presence and number of iconic, endangered, endemic and migratory species
- Number of listed heritage sites (wetlands and national heritage)

Initially used binary logistic (stepwise to identify key determinants with small data set).

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POST- DEA PRELIMINARY RESULTS

Characteristics of properties that are 'efficient' when converting Capital, Labour + other inputs, Land and , Rainfall into ……

Types of outputs	Characteristics of 'efficient' properties
Market only	Few weeds; absence of poor quality soil (tennesoil)
Environmental only	
Absence of pests	dependent upon agriculture for income, fewer species, non-Kandosol
Numerous migratory species	Fewer Grasslands, non-Rudosol, positive expectations about the future
Market and environmental only	
Market and Absence of pests	dependent upon agriculture for income, non-Kandosol, Few occurrences of native plants and animals
Market and numerous migratory species	dependent upon agriculture for income; fewer grasslands and fewer shrub-land; less Tenosol (absence of poor quality soil), fewer Reserves

Pest animals	Cane toad, cat, pig, various types of deer, one hump camel, rabbit, fox
Australian iconic species	Kookaburra, emu, little penguin, rainbow lorikeet, various frogs, various kangaroo, koala

Preliminary results only (may change as data are updated and more sophisticated analysis is undertaken)

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WHERE TO NEXT ?

We already have :

- ❑ Used GIS to combine socioeconomic and biophysical data
- ❑ Identified 'efficient' and 'inefficient' properties
- ❑ Undertaken some preliminary analysis to identify the characteristics of 'efficient' properties

Next we will:

- Finalise analysis and use insights to draw inferences about the presence or absence of synergies' across multiple outputs
- Share insights with others
- Also have graduate students looking at
  - Determinants of 'satisfaction' (using life satisfaction approach)
    - What matters most, money, environment, relationships?
  - Impact of extreme events on productivity

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WHEN FINISHED, WE WILL HAVE BETTER INFORMATION ABOUT THE …

Characteristics of 'efficient'/'inefficient' properties

- Which are 'best' at promoting biodiversity?
- Which are 'best' at promoting other market or non-market outcomes?

Synergies between various outputs

- Which 'outputs' go best with biodiversity?

36

Preliminary results only (may change as data are updated and more sophisticated analysis is undertaken)

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