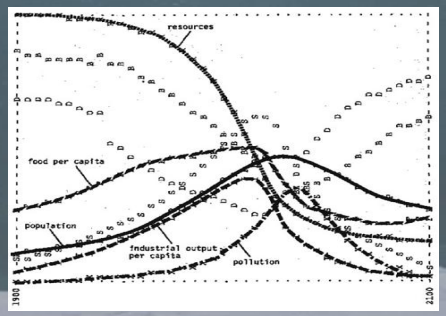
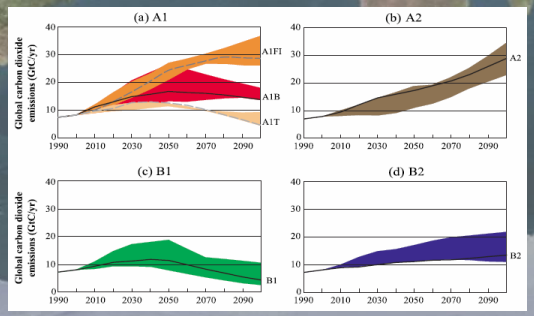
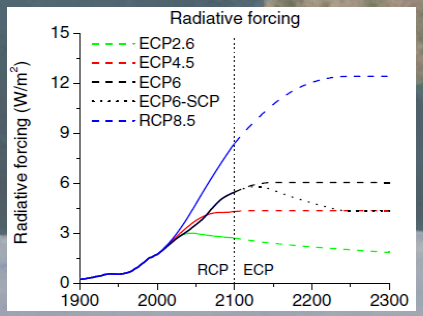
Landcare Research
Manaaki Whenua

Business-*Un*-Usual

Global Change over the Next 100 Years and Implications for New Zealand





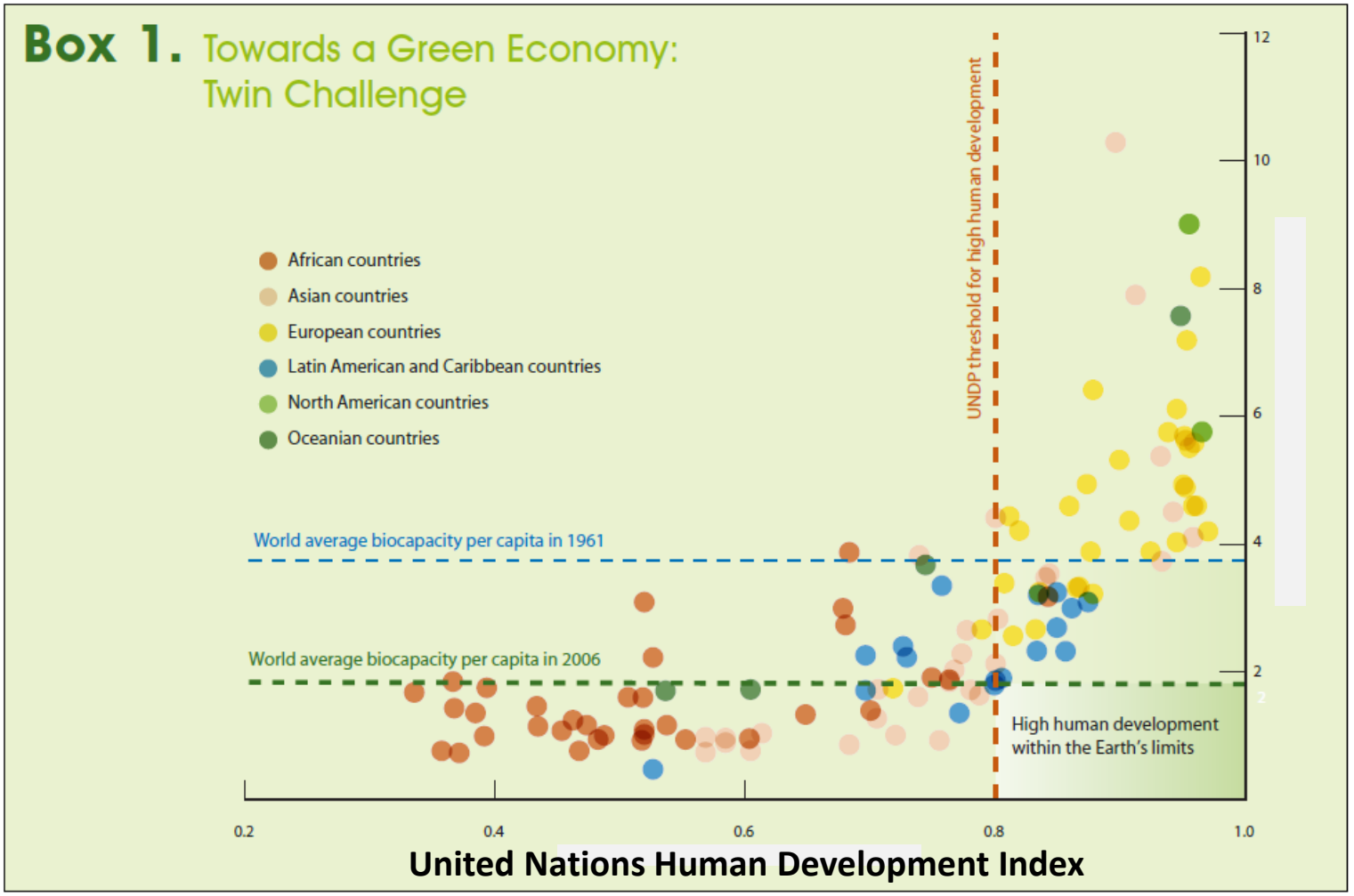


Dr. Daniel Rutledge
Landcare Research, Hamilton

Landcare Research Link Seminar
Wellington, 17 April 2012

21st Century Global Challenge:

How to "lift up" developing nations while maintaining developed nations.



Source: *The Ecological Wealth of Nations: Earth's Biocapacity as a New Framework for International Cooperation. Global Footprint Network (2010), p. 13; Human Development Index data from Human Development Report 2009 – Overcoming Barriers: Human Mobility and Development.* UNDP (2009).

Relevant Research

- MAF SLMACC Project:
  Triggers and Thresholds of Land-use Change in Relation to Climate Change and Other Key Trends
  ("Triggers Report" hereafter)

- MSI Ecosystem Services Project:
  Exploring long-term national scenarios of landscape changes and ecosystem services

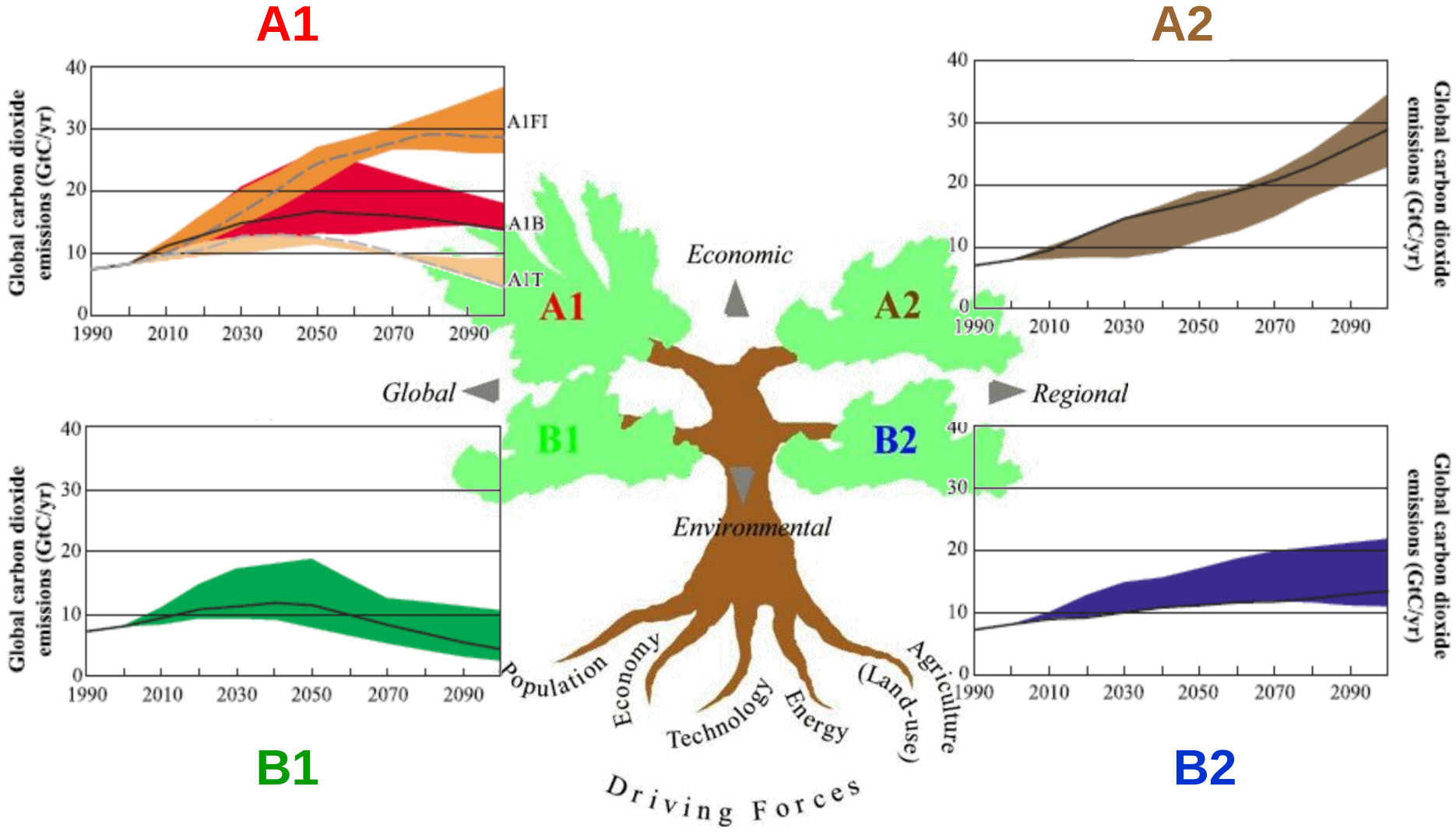
- Personal research

Key Trends Examined

- Agricultural Production
- Biodiversity
- Climate Change
- Economic Development
- Ecosystem Services
- Energy Resources
- Globalisation
- Land Use Change
- Mineral Resources
- Population & Migration
- Societal Preferences for Food & Fibre
- Water Security

Climate Change: Global Context

IPCC 4th Assessment Report Special Emissions Scenarios

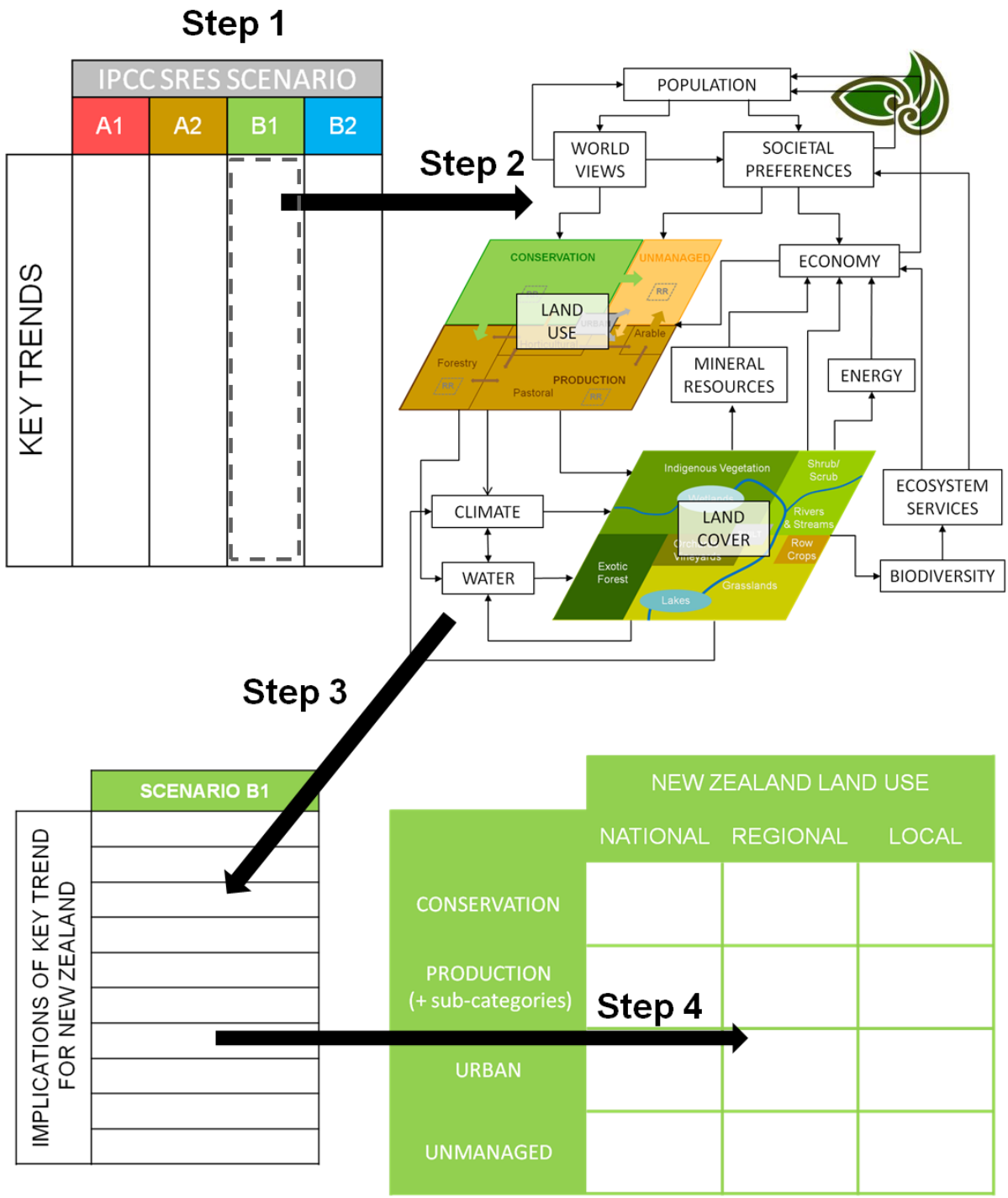


IPCC AR4 SRES Summary

Key Trend	Summary	IPCC SRES SCENARIO					
		A1F1	A1B	A1T	A2	B1	B2
Climate	Average Temperature Change 1990-2099 (°C)	+4.0	+2.8	+2.4	+3.4	+1.8	+2.4
	Cumulative CO_2 Emissions 1990-2100						
	Total (10^9 Tonnes)	2189	1499	1068	1862	983	1164
	Fossil Fuels (10^9 Tonnes)	128	1437	1038	1773	989	1160
	Land Use (10^9 Tonnes)	61	62	31	89	-6	4
Economic Development	2100 Global GDP (1990 = 21)						
	Total (10^{12} 1990 $USD)	525	529	550	243	328	235
	Per Capita (10^3 1990 $USD)	73.9	74.5	77.5	16.2	46.2	22.6
Energy	Primary Energy Use in 2100 (1990 = 351)						
	Global Total (10^{18} Joules/year)	2073	2226	2021	1717	514	1357
	Global Per Capita (10^{12} Joules/year)	292	313	284	114	72	130
Globalisation	Global (A1/B1) versus Regional (A2/B2)	Global			Regional	Global	Regional
Population & Migration	World Population in 2100 (10^9 people) (1990 = 5.3)	7.0			15.1	7.0	10.4
Technology	High vs. Low Rate of Progress	High			High	Low	Low

Triggers Report - Approach

Qualitative
Systematic
Downscaling
Framework

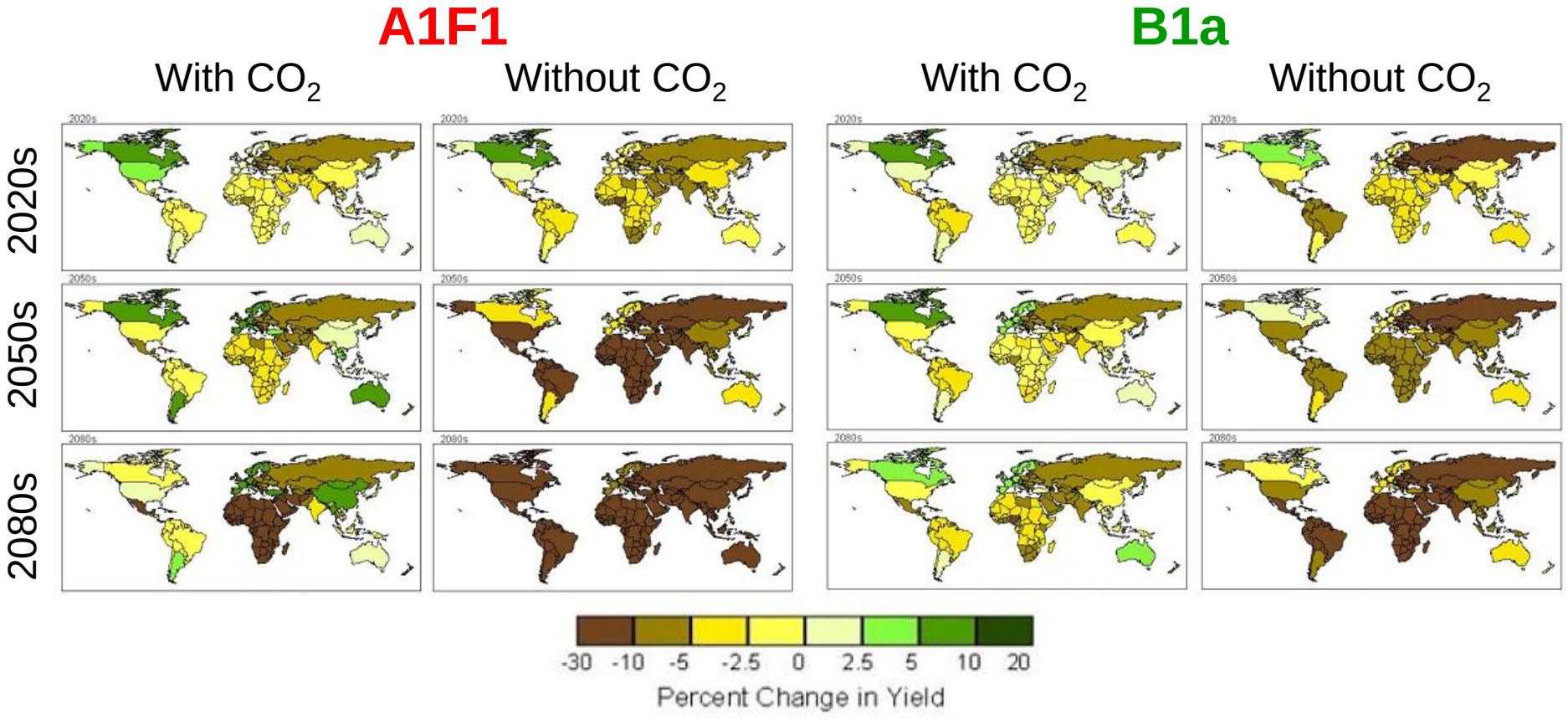


Agriculture

- Shifting patterns of production due to climate change
- Effects likely scale with magnitude of change but subject to complex effects (non-linearity)
- Regional “winners & losers”

Factor	Trend	Effect(s)
Temperature	↑	+ for growth to a certain threshold, - thereafter
CO_2	↑	+ for plant growth
Precipitation	✣	Variable – shifting patterns
Extreme Events	↑	Increasing frequency & intensity
Weeds & Pests	↑	Increasing risk of invasion & spread, costs of control

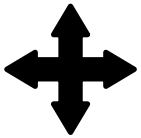
Agriculture: Estimated changes in cereal yields



Parry et al . 2004. Effects of climate change on global food production under SRES emissions and socio-economic scenarios. *Global Environnemental Change* 14: 53-67. Figures 2 and 6

Biodiversity

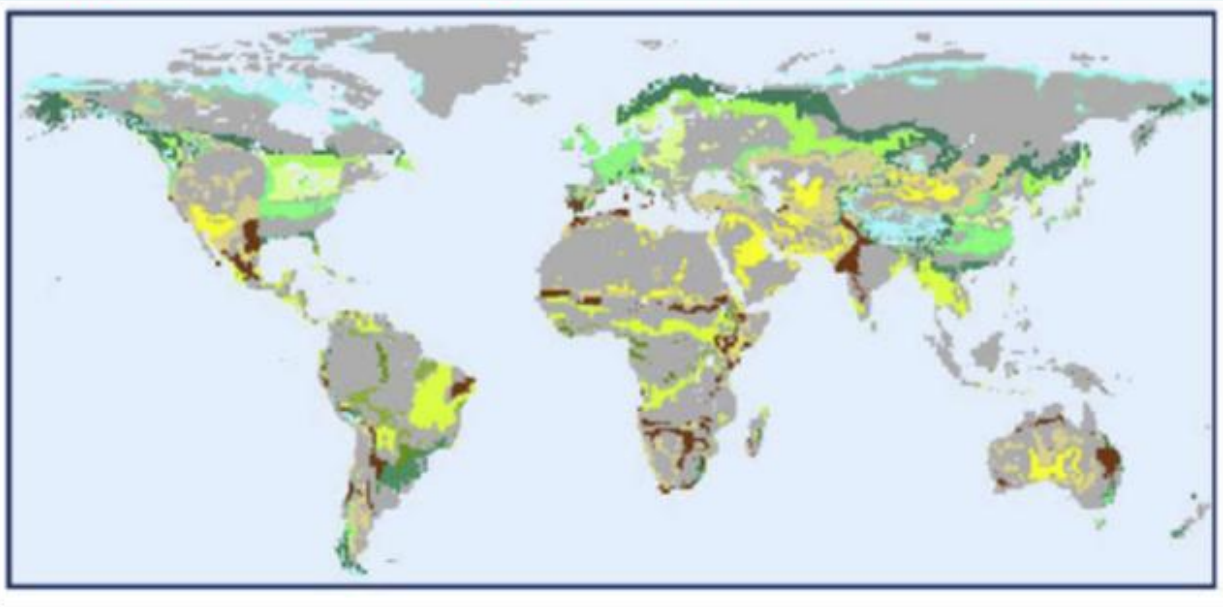
- Diverse effects of climate change based on complex nature of ecosystems & ecological communities and their responses
- Winners & losers
- Overall climate change will exacerbate trends in biodiversity decline

Factor	Trend	Effects
Biodiversity		Increased species extinctions
Habitats		Shifts to higher latitudes and elevations
Disturbance		Intensity & frequency
Coastal wetlands		By 20% globally
Extinction risk		For many species

Biodiversity

Range shifts to higher latitudes & elevations

Projected ecosystem shifts for 3 °C increase (HADCM-GCM)



Leemans & Eckhout. 2004. Another reason for concern: regional and global impacts on ecosystems for different levels of climate change. *Global Env. Change* 14: 219. Fig. 1.

Economic Development

- Broad range of projections to 2050 & 2100
  - SRES
    - Overall growth
    - Global GDP in 2100: $243 - $500 trillion USD
  - IMF & World Bank typically offer only short-term projections (e.g., 2020)
  - Differing assumptions & focus lead to different results

GDP Rank	IMF 2010	Hawksworth & Tiwari (2011) 2050	Ward (2011) 2050
1	USA	China	China
2	China	India	USA
3	Japan	USA	India
4	Germany	Brazil	Japan
5	France	Japan	Germany
6	UK	Russia	UK
7	Brazil	Mexico	Brazil
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9	Canada	Germany	France
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11	Russia	France	Italy
12	Spain	Turkey	Turkey
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  - Wildcards

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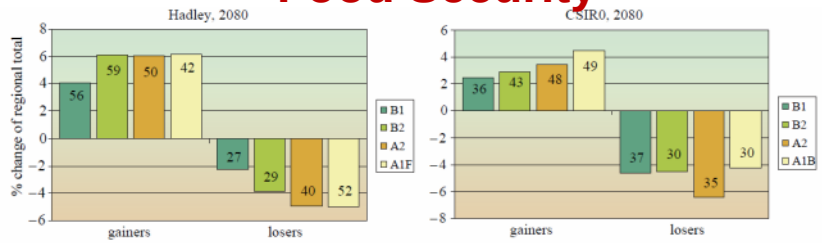
Ecosystem Services

- Millennium Ecosystem Assessment review of 24 ecosystem services
- Future trends difficult to gauge given lack of robust knowledge, data & models

PROVISIONING SERVICES			REGULATING SERVICES	
Food	Crops	▲	Air Quality Regulation	▼
	Livestock	▲	Climate Regulation	▼
	Capture Fisheries	▼	Global	▲
	Aquaculture	▲	Regional and Local	▼
	Wild Foods	▼	Water Regulation	+/−
Fiber	Timber	+/−	Erosion Regulation	▼
	Cotton, Hemp, Silk	+/−	Water Purification and Waste Treatment	▼
	Wood Fuel	▼	Disease regulation	+/−
Genetic Resources		▼	Pest Regulation	▼
Biochemicals, Pharmaceuticals, Natural Medicines		▼	Pollination	▼
Freshwater		▼		
CULTURAL SERVICES				
Spiritual and Religious Values		▼	Recreation and Ecotourism	+/−
Aesthetic Values		▼		

Ecosystem Services

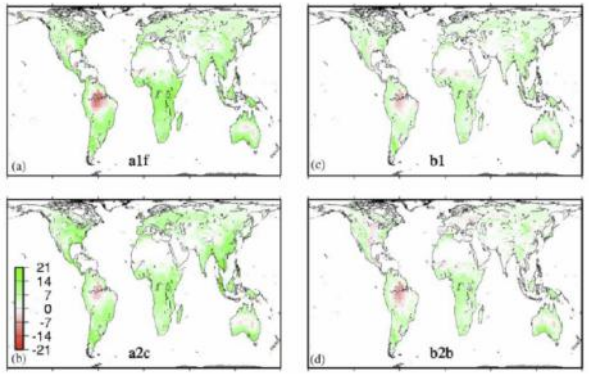
Food Security



% Δ on rainfed cereal production

Fischer et al . 2005. Socio-economic and climate change impacts on agriculture: an integrated assessment, 1990–2080. *Phil. Trans. R. Soc. B* 360: 2067. Fig. 6.

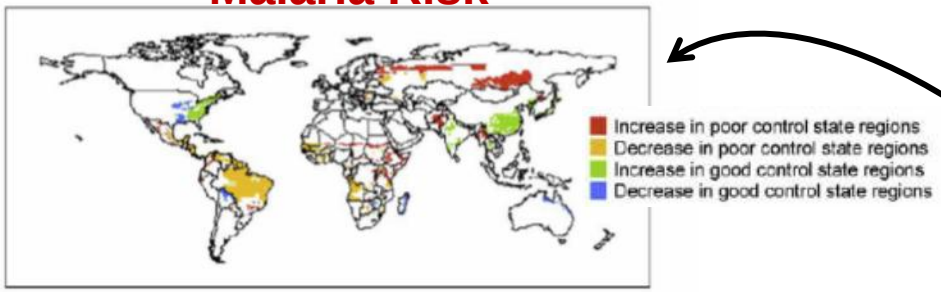
Carbon Cycling



Predicted ΔTotal Carbon 1990-2100

Levy et al. 2004. Modelling the impact of future changes in climate,CO_2 concentration and land use on natural ecosystems and the terrestrial carbon sink. *Global Env. Change* 14: 21. Fig. 6.

Malaria Risk

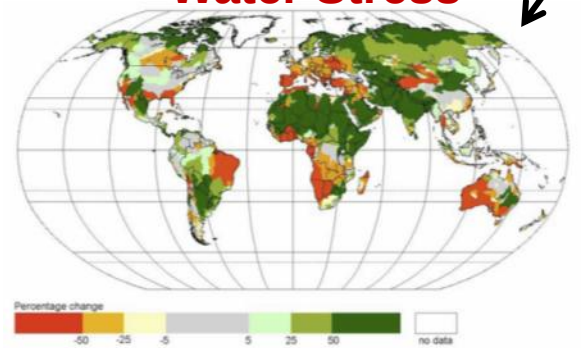


Δ Vulnerability to 2080 (A1FI)

van Lieshout et al. 2004. Climate change and malaria: analysis of the SRES climate and socio-economic scenarios. *Global Env. Change* 14: 87. Fig. 7.

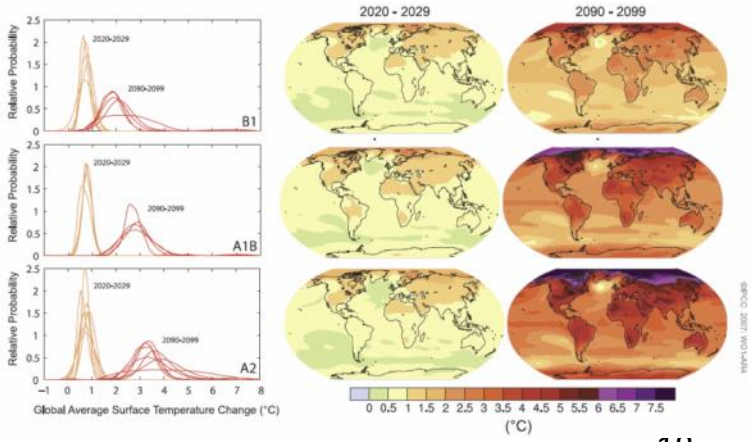
Water Stress

Predicted Δ Avg. Water Availability 1961-1990 and 2050 (A2 Scenario)



Alcamo et al. 2007. Future long-term changes in global water resources driven by socio-economic and climatic changes. *Hydrological Sciences* 52(2): 247. Fig. 7.

Changing Climate



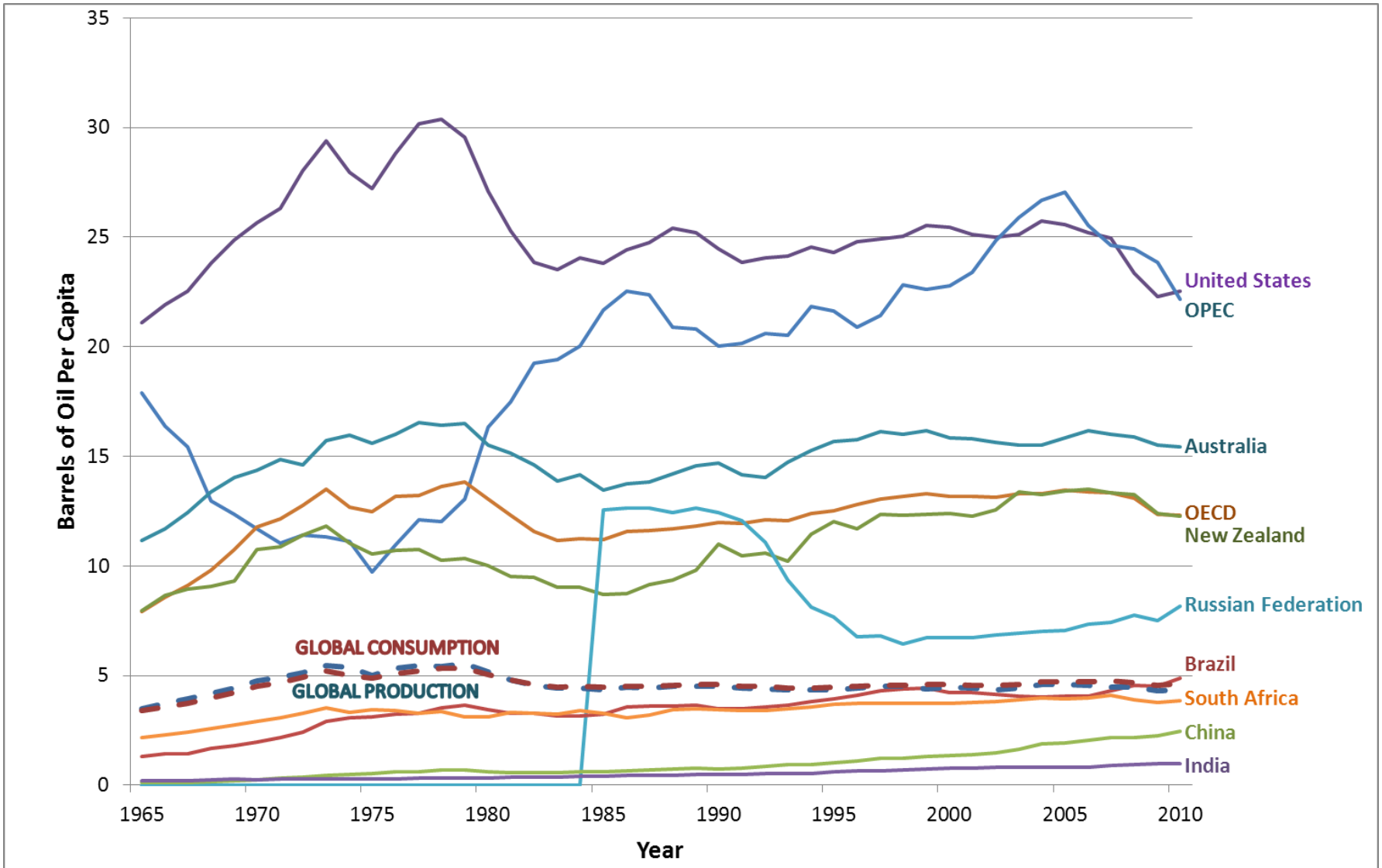
Energy

- Energy consumption & production expected to increase
- Conventional oil fields declining at ~5-6% per annum (IEA)
- Substantial increase in non-OECD production & consumption – but still below per-capita OECD rates
- Uncertainties centre on ability of non-conventional resources to replace conventional resources
- Depends on relative rates/costs
  - Development of new sources
  - Growth in energy consumption
  - Efficiency increases

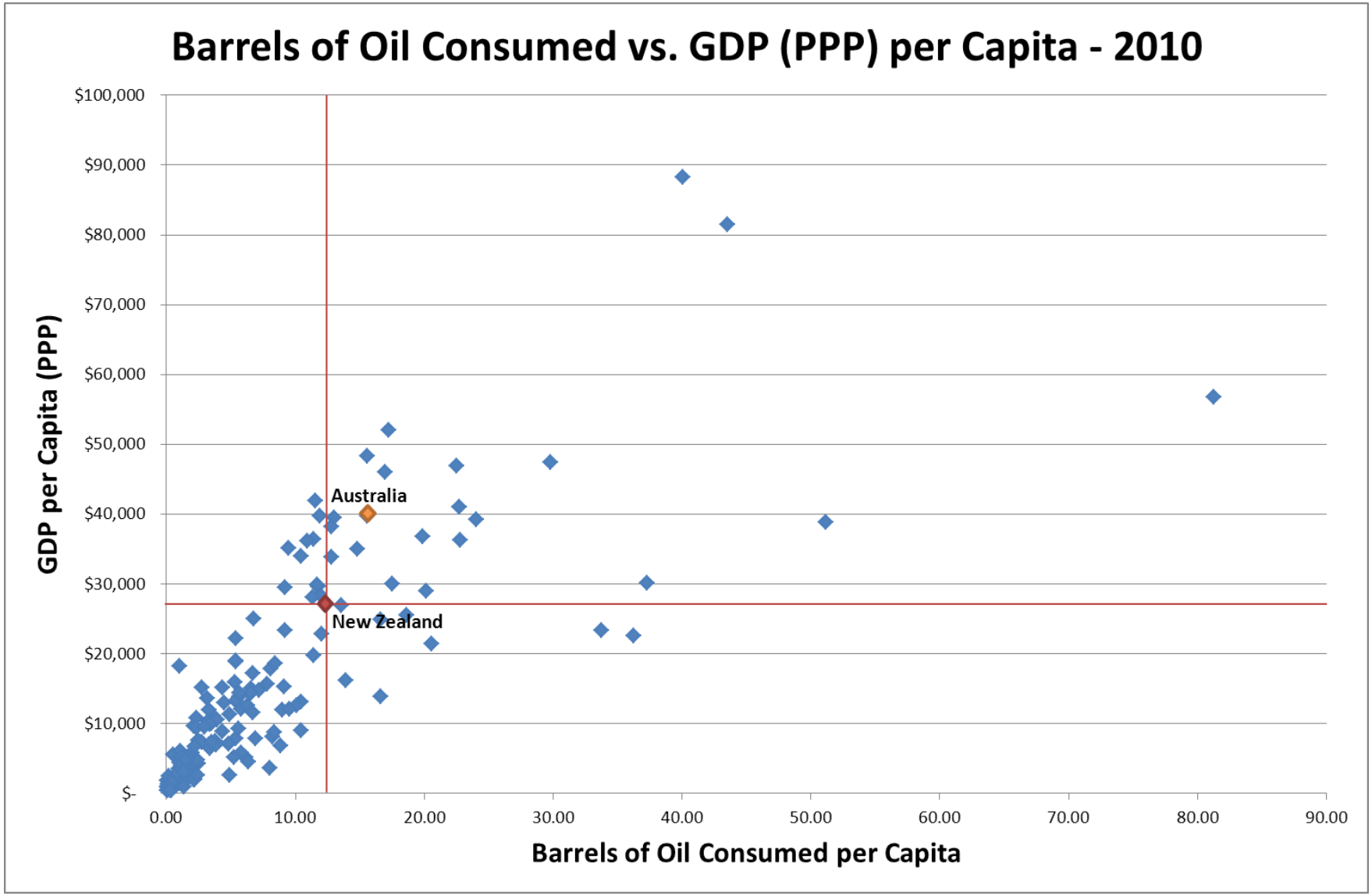
Energy		2007	2035	Growth (%)	Units
CONSUMPTION					
OECD		245.7	280.7	14.4	10^{15} Btu
Non-OECD		249.5	458.0	83.6	
PRODUCTION					
Conventional Liquids		81.4	110.6	30.4	10^{6} barrels / day
Unconventional Liquids		3.5	13.0	271.4	
Natural Gas	OECD	1.1	1.3	18.2	10^{12} m^3 / year
	Non-OECD	1.9	3.1	63.2	
Coal	OECD	41.6	49.3	18.5	10^{15} Btu
	Non-OECD	91.1	157.5	72.9	
Electricity	OECD	10.1	13.6	34.7	10^{15} watts / year
	Non-OECD	8.6	21.6	151.2	

Source: US Energy Information Agency
World Energy Outlook 2010, Reference Case

Historic Trends in Oil Resources



Data Sources: BP Statistical Review of World Energy 2011; UN Population Prospects, 2010 Revision



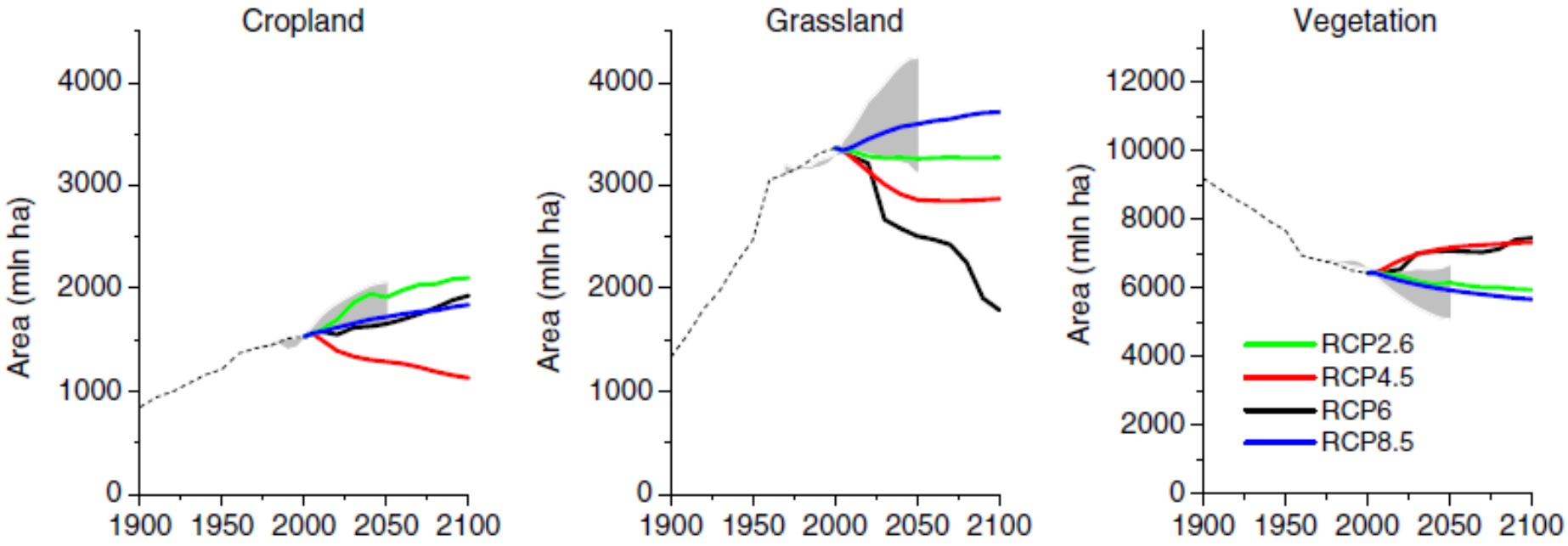
Data Sources: BP Statistical Review of World Energy 2011; CIA World Factbook 2012; UN Population Prospects, 2010 Revision

Globalisation

- Historic global trends towards globalisation and free trade
- Difficulties with global free trade agreements
- Increasing rise of regional or multi-party agreements (e.g, bilaterial or multi-lateral free trade agreements)
- Assumptions about globalisation & regionalisation trends usually a key driver in global scenario studies

Agreement	Year	Members
South Pacific Regional Trade and Economic Cooperation Agreement	1981	Australia, New Zealand and developing islands in Pacific Islands Forum
Australia New Zealand Closer Economic Relations Trade Agreement	1983	Australia, New Zealand
NZ-Singapore Closer Economic Partnership	2001	New Zealand, Singapore
Trans-Pacific Strategic Economic Partnership (P4)	2005	Brunei, Chile, New Zealand Singapore.
NZ-Thailand Closer Economic Partnership	2005	New Zealand, Thailand
NZ-China Free Trade Agreement	2008	New Zealand, China
ASEAN-Australia-NZ Free Trade Area	2010	ASEAN countries, Australia, New Zealand
New Zealand-Malaysia Free Trade Agreement	2010	New Zealand, Malaysia

Global Land Use



Source: van Vuuren et al. 2011. Climate Change 109: 5-31.

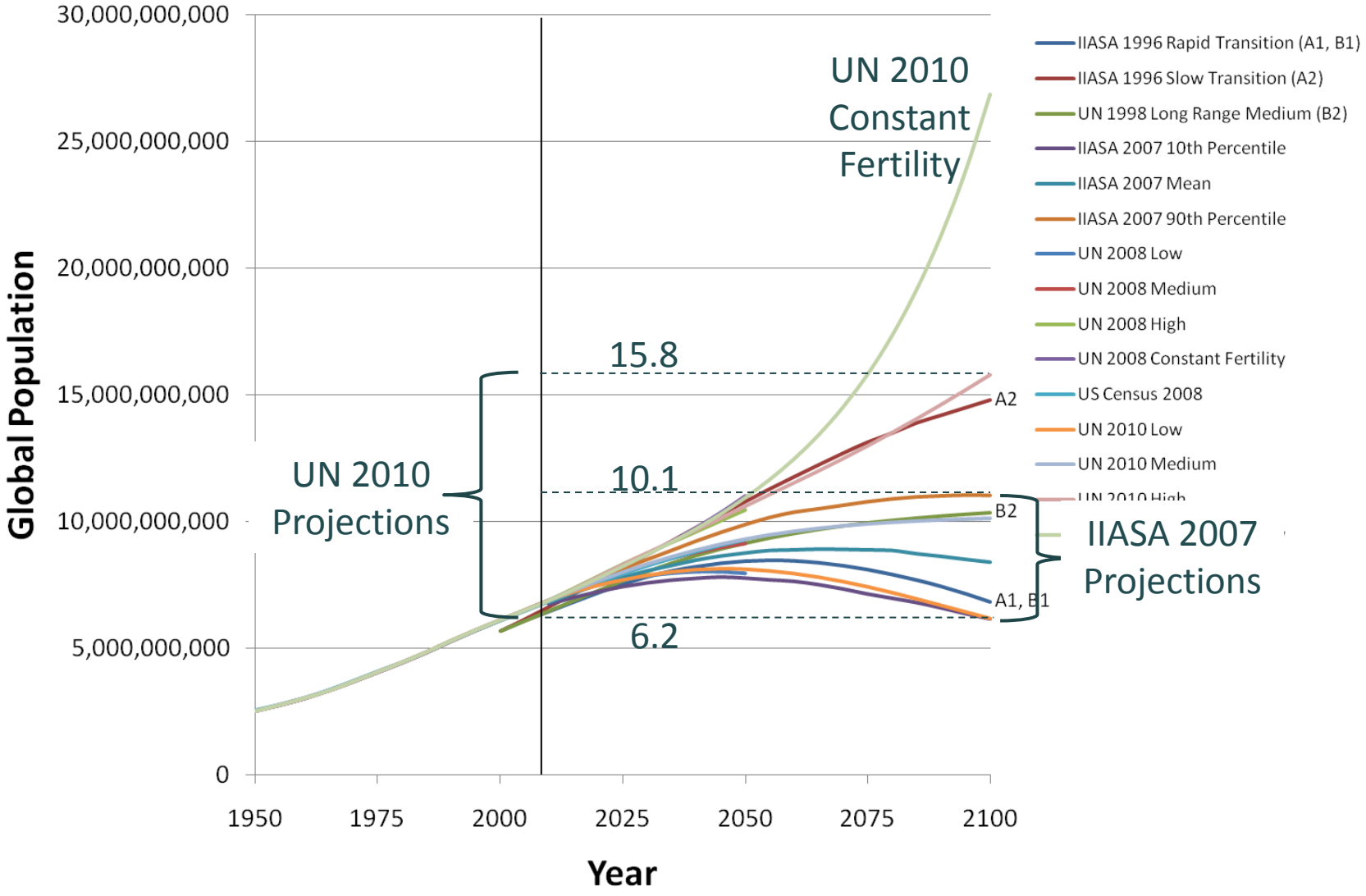
Mineral Resources

- Long-term trends
  - Increasing extraction rates
  - Lower ore quality (e.g. g/tonne)
  - Increasing access to previously uneconomic reserves
- Key minerals for NZ
  - Agricultural
    - Phosphate
    - Potash
    - Calcium
    - Sulphur
    - Iron
  - Construction/manufacturing
    - Aluminium
    - Iron ore (for steel)
  - High tech – rare earths
- Competing trends affecting supply/demand balance
  - Rate of demand growth
  - Technology
  - Recycling (for some)

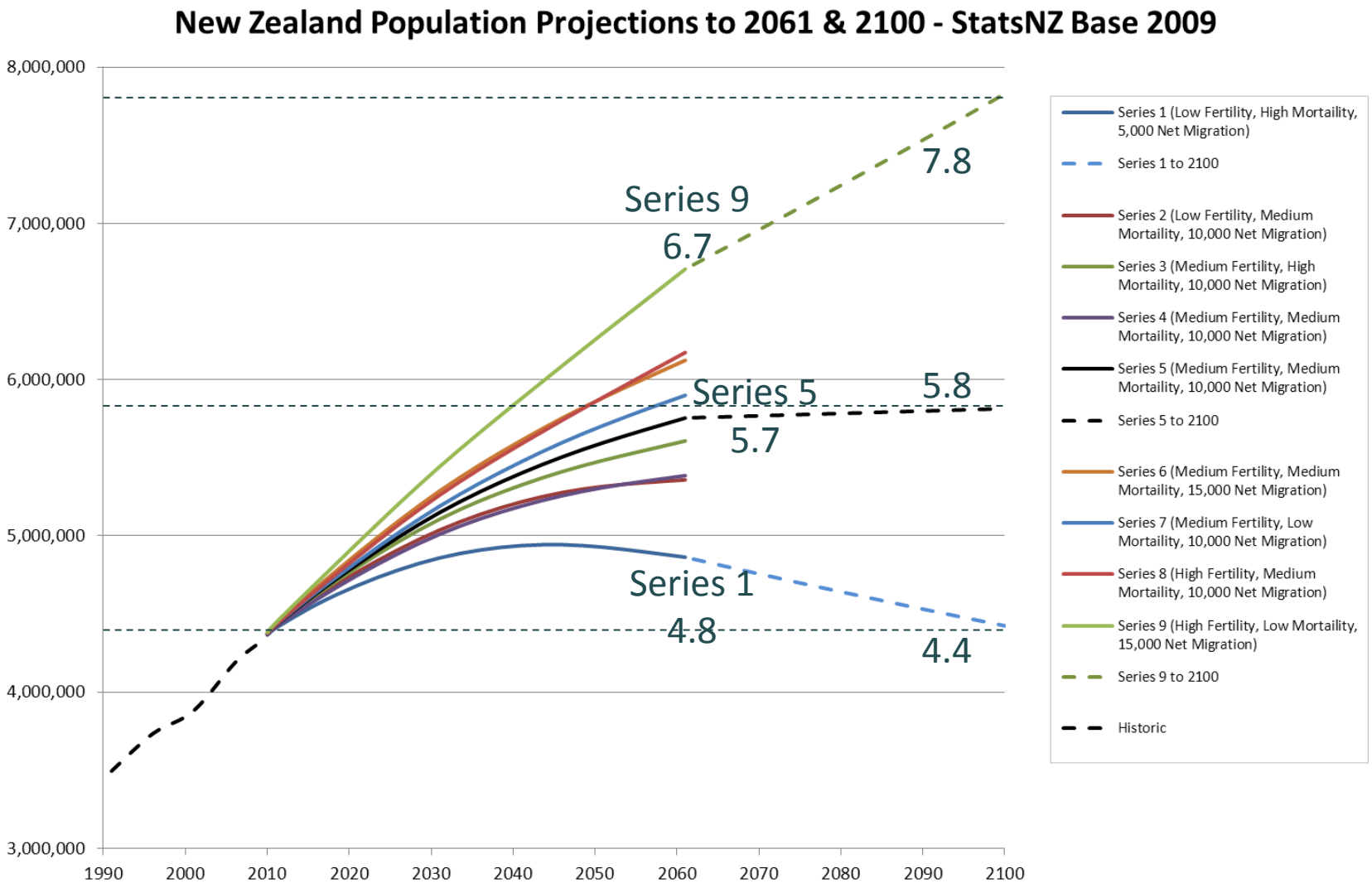
	Supply Remaining (Years)		
Mineral	0% Growth	1% Growth	3% Growth
Phosphorus	301	140	78
Potash	500	180	94
Bauxite	185	105	64
Iron	73	55	39
Beryllium	444	170	90
Bismuth	117	78	51
Rare Earths	1210	259	122
Titanium	240	123	71
Vanadium	633	200	101

Source: US Geological Survey 2009

Population & Migration

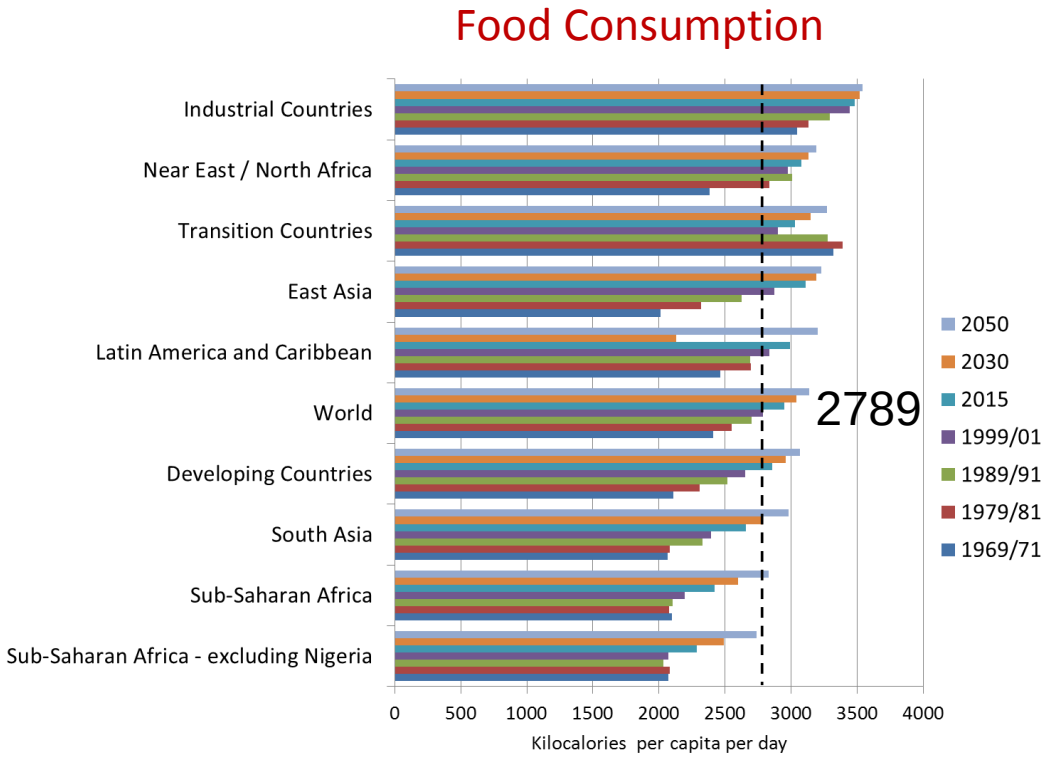


NZ Population & Migration



Societal Preferences for Food & Fibre

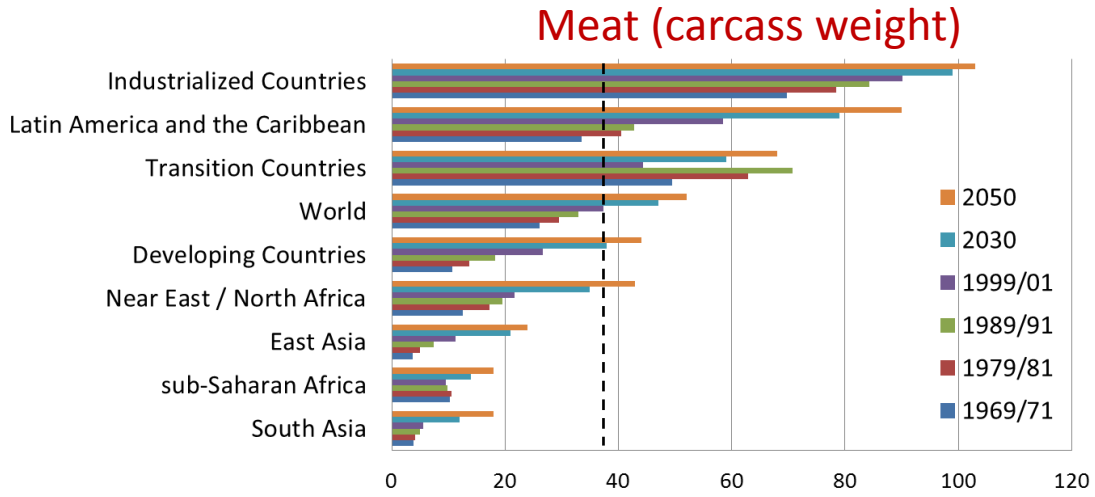
- Increasing historic and projected future consumption

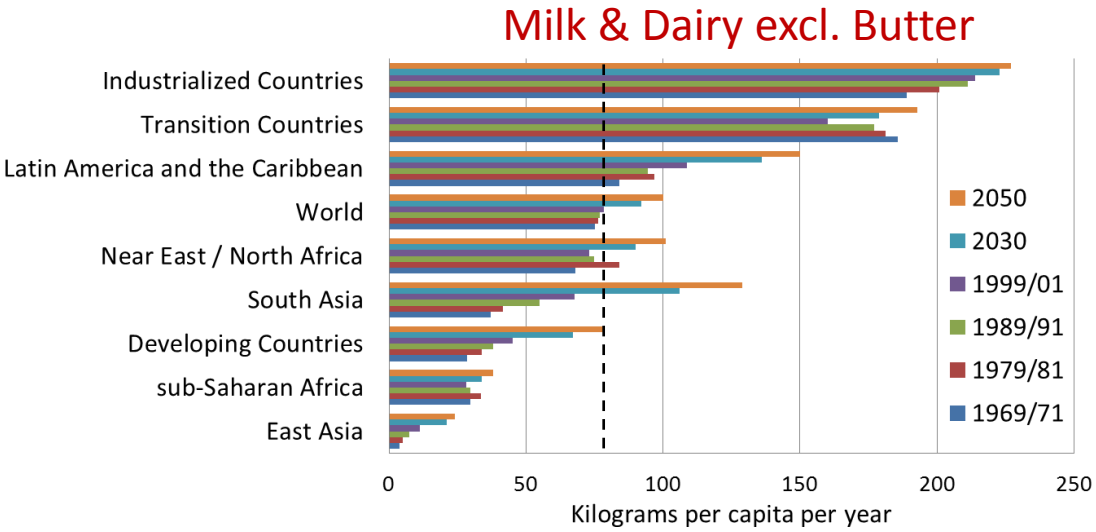


FAO 2006. World Agriculture: Towards 2030/2050. UN Food and Agriculture Organisation Report.

Societal Preferences for Food & Fibre

- Increasing historic and projected future consumption
- Increased demand for meat & dairy
  - Meat: 231 to 483 (+90%) Billion Kg per Year
  - Dairy: 483 to 928 (+109%) Billion Kg per Year





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- Increasing historic and projected future consumption
- Increased demand for meat & dairy
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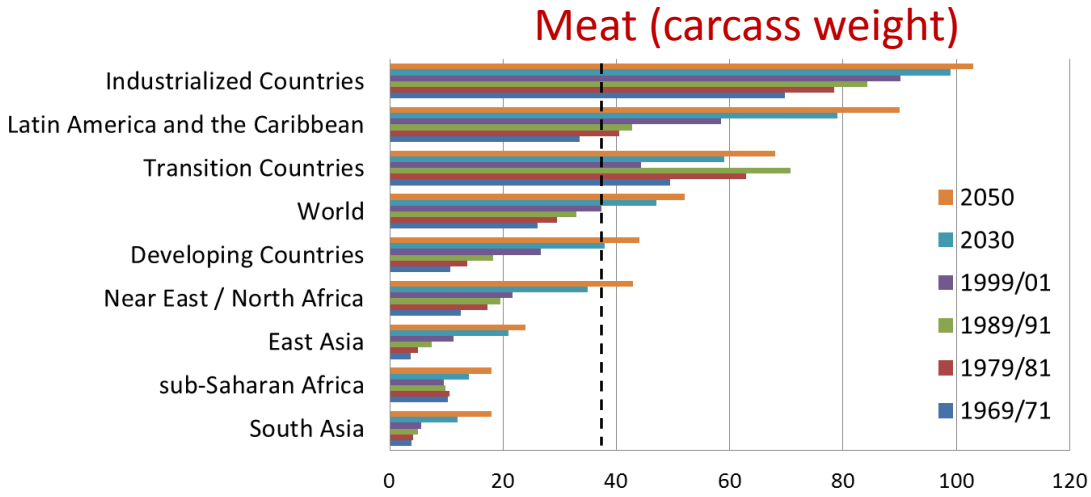
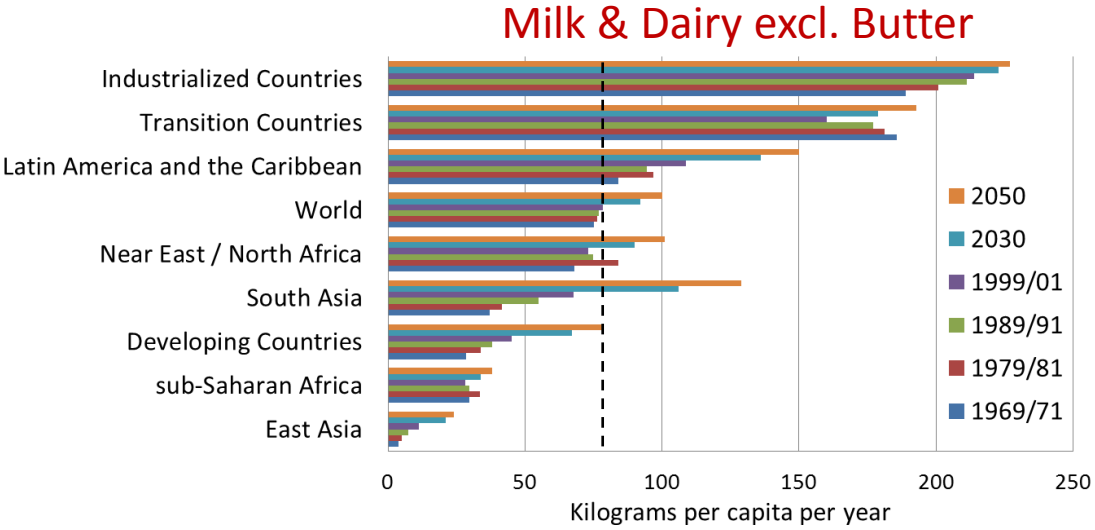
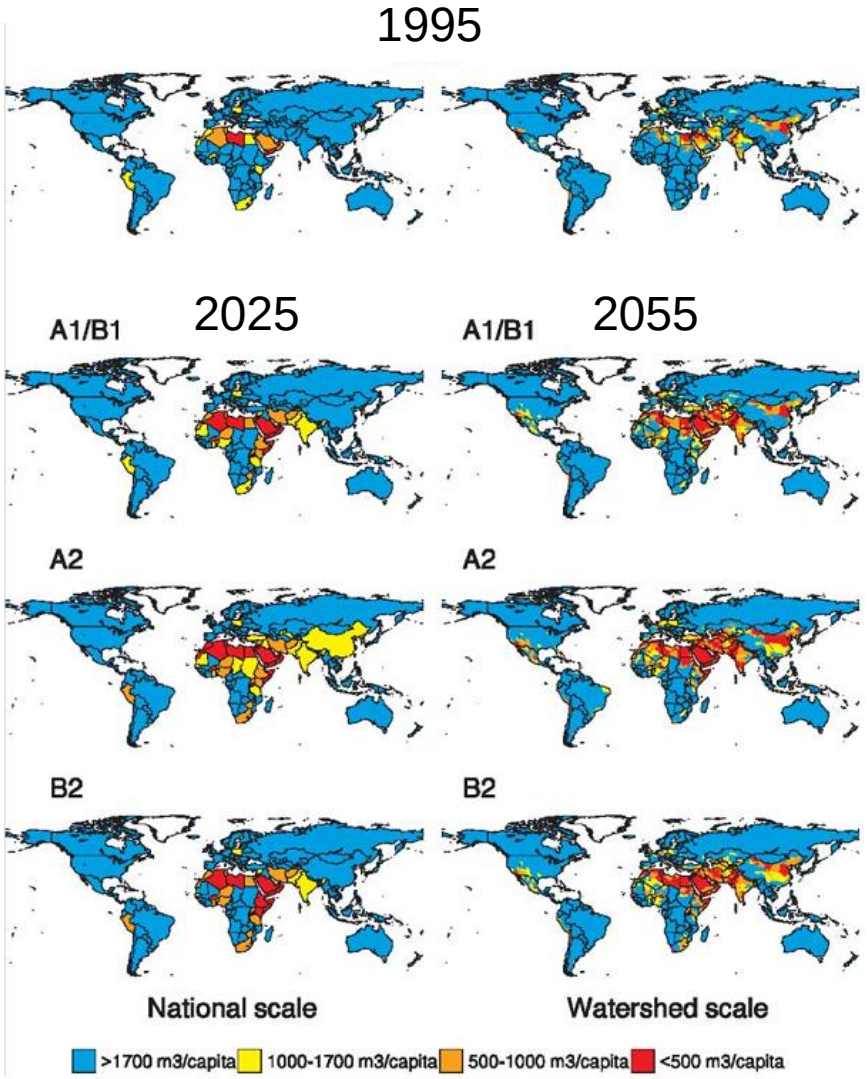
- “Other food” demand increases from 216 to 340 kg / capita /year (+63%)





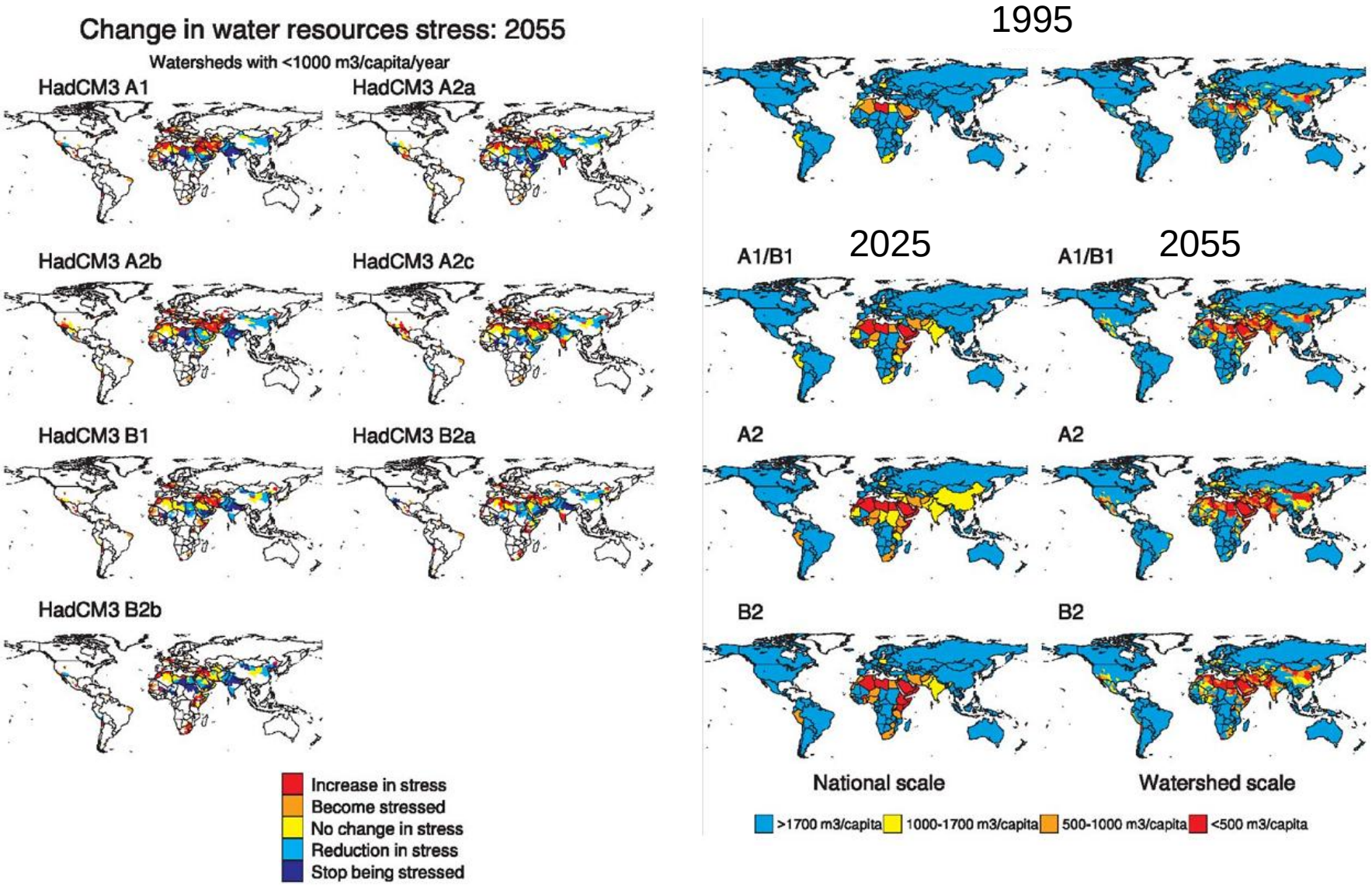
Water

- Changes to water resources highly heterogeneous
- Equatorial countries of Asia, Africa and meso America could be hardest hit
- Modelling trends by country can tend to mask trends within countries



Arnell 2004. Climate change and global water resources: SRES emissions and socio-economic scenarios. *Global Environnemental Change* 14: 31-52. Figures 4 and 5

Water



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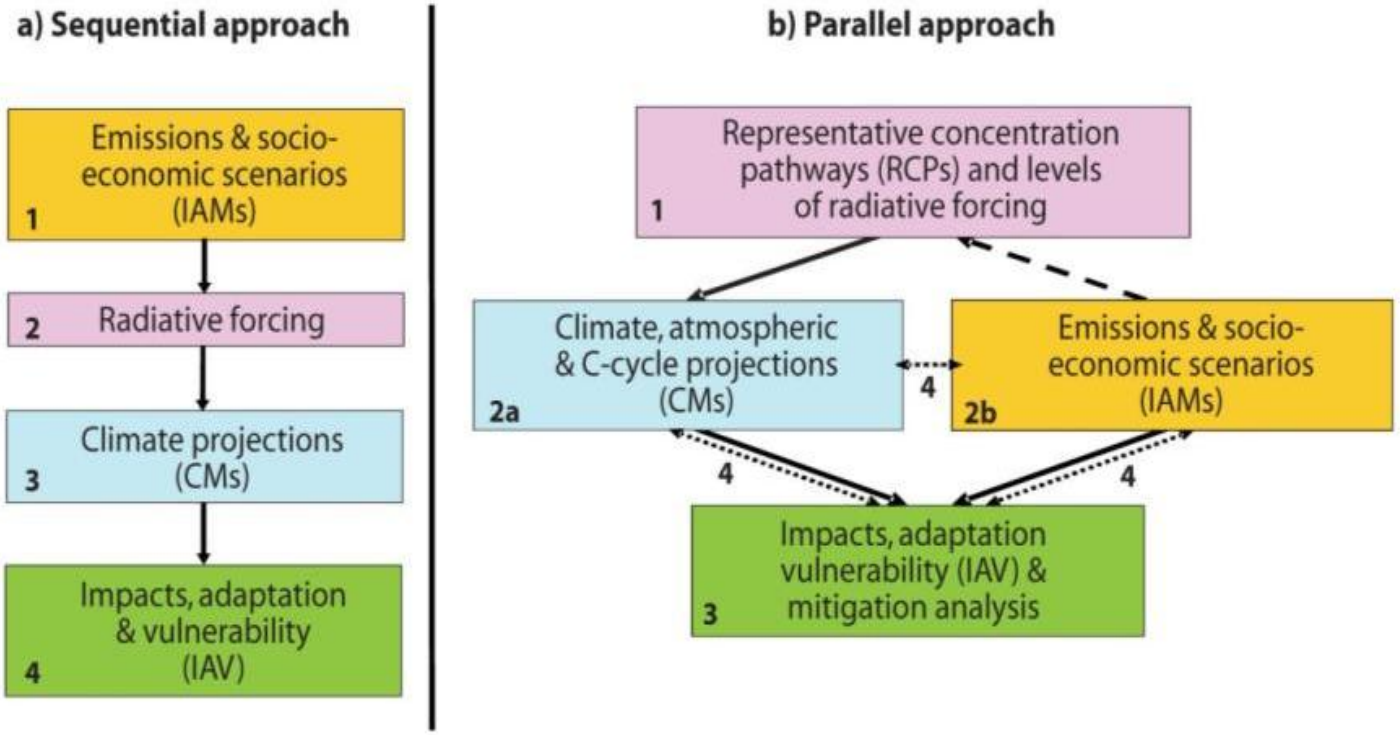
IPCC AR5:
The New Global Context

AR4 AR5



IPCC AR5: The New Global Context

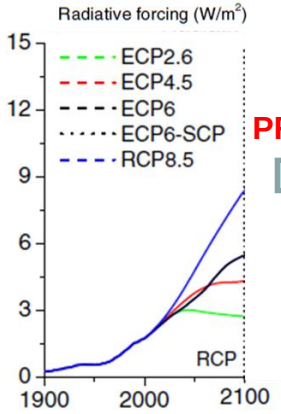
GLOBAL PERSPECTIVE

PARTLY DRIVE & ALSO INFORM

GLOBAL SCENARIOS
Population
Economics
Energy
Emissions
Land Use/Land Cover
Etc.

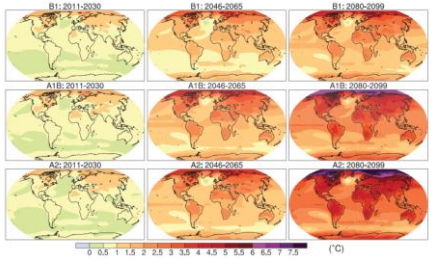
DRIVE

GLOBAL CLIMATE MODELLING



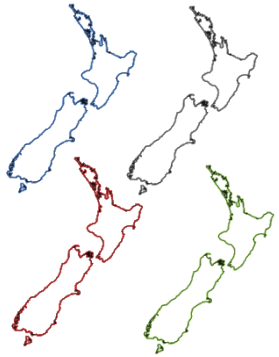
PROJECTS

POTENTIAL GLOBAL CLIMATE CHANGE (TRENDS, VARIABILITY) INCL. NZ

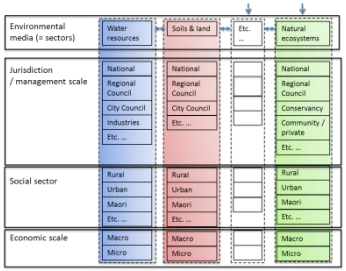


Global mean warming (°C)	2011–2030	2046–2065	2080–2099	2180–2199
A2	0.64	1.65	3.13	
A1B	0.69	1.75	2.65	3.36
B1	0.66	1.29	1.79	2.10

INFORMS



NZ CLIMATE CHANGE + ASSOCIATED NZ IMPACTS & IMPLICATIONS



- Global assumptions (scenarios) drive climate change modelling
- Impacts & implications are a function of
  - Climate change
  - Other assumptions/trends
  - All of the above interacting in various ways & degrees

IPCC AR5: The New Global Context

PARTLY DRIVE & ALSO INFORM

Integrated Assessment (IAM)

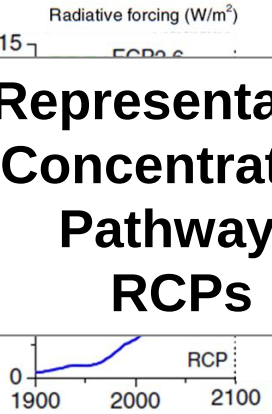
GLOBAL CLIMATE MODELLING

Shared Socioeconomic Pathways SSPs

Etc.

DRIVE

Representative Concentration Pathways RCPs



S

POTENTIAL GLOBAL CLIMATE CHANGE (TRENDS, VARIABILITY) INCL. NZ

Climate Change Trends & Variability CMs

Global mean warming (°C)				
	2011–2030	2046–2065	2080–2099	2180–2199
A2	0.64	1.65	3.13	
A1B	0.69	1.75	2.65	3.36
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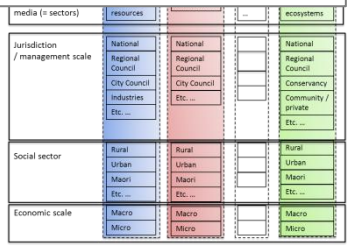
INFO

Impacts Adaptation & Vulnerability IAV



- Global assumptions (scenarios) drive climate change modelling
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Personal Footnote

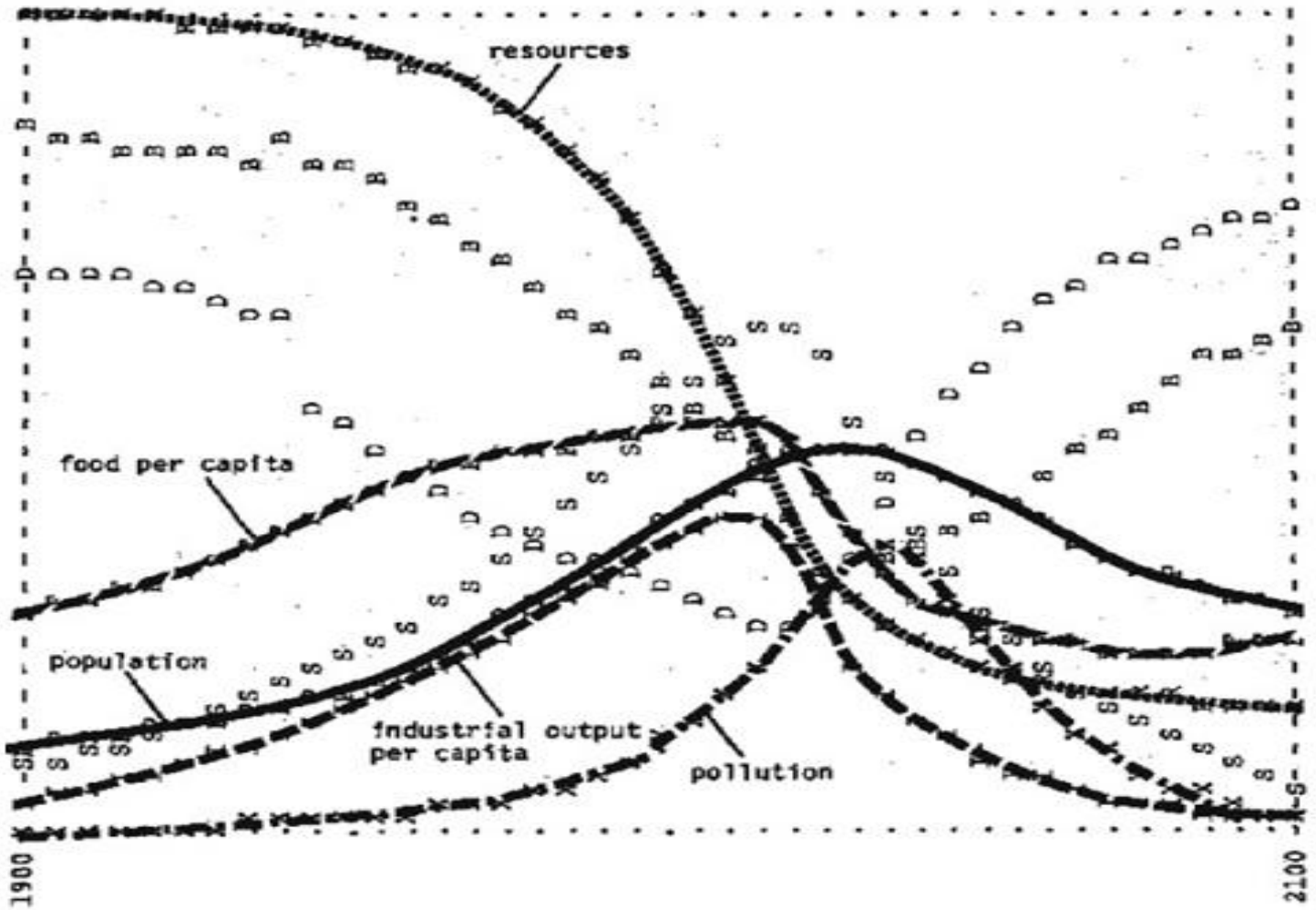
- 2012 marks the 40th anniversary of the publication of *The Limits to Growth*

- After 40 years of research, *The Limits to Growth* still represents one of the most robust analyses of global trends to 2100 undertaken

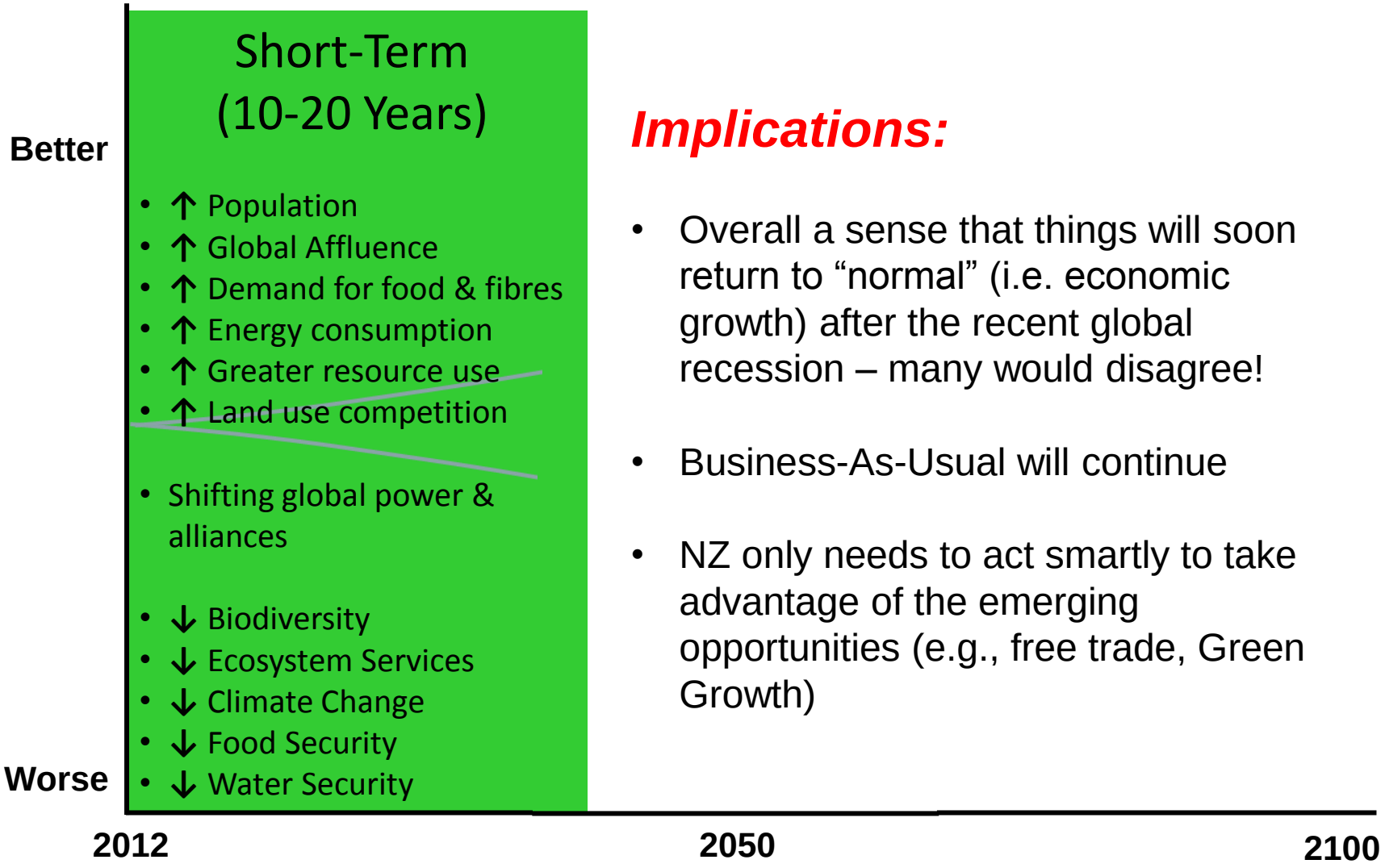
- Why? Because unlike even modern efforts in AR5, the *Limits to Growth* model ("World3") was a true systems model that dynamically linked economy, environment, society and allowed for feedbacks and exploration of non-linear effects.

- Graham Turner from CSIRO published a paper recently that compared historic trends over the past 30 years to *The Limits to Growth* scenarios. His conclusion was that we are currently tracking the Standard Run (e.g., Business as Usual).

Limits to Growth
Standard Run



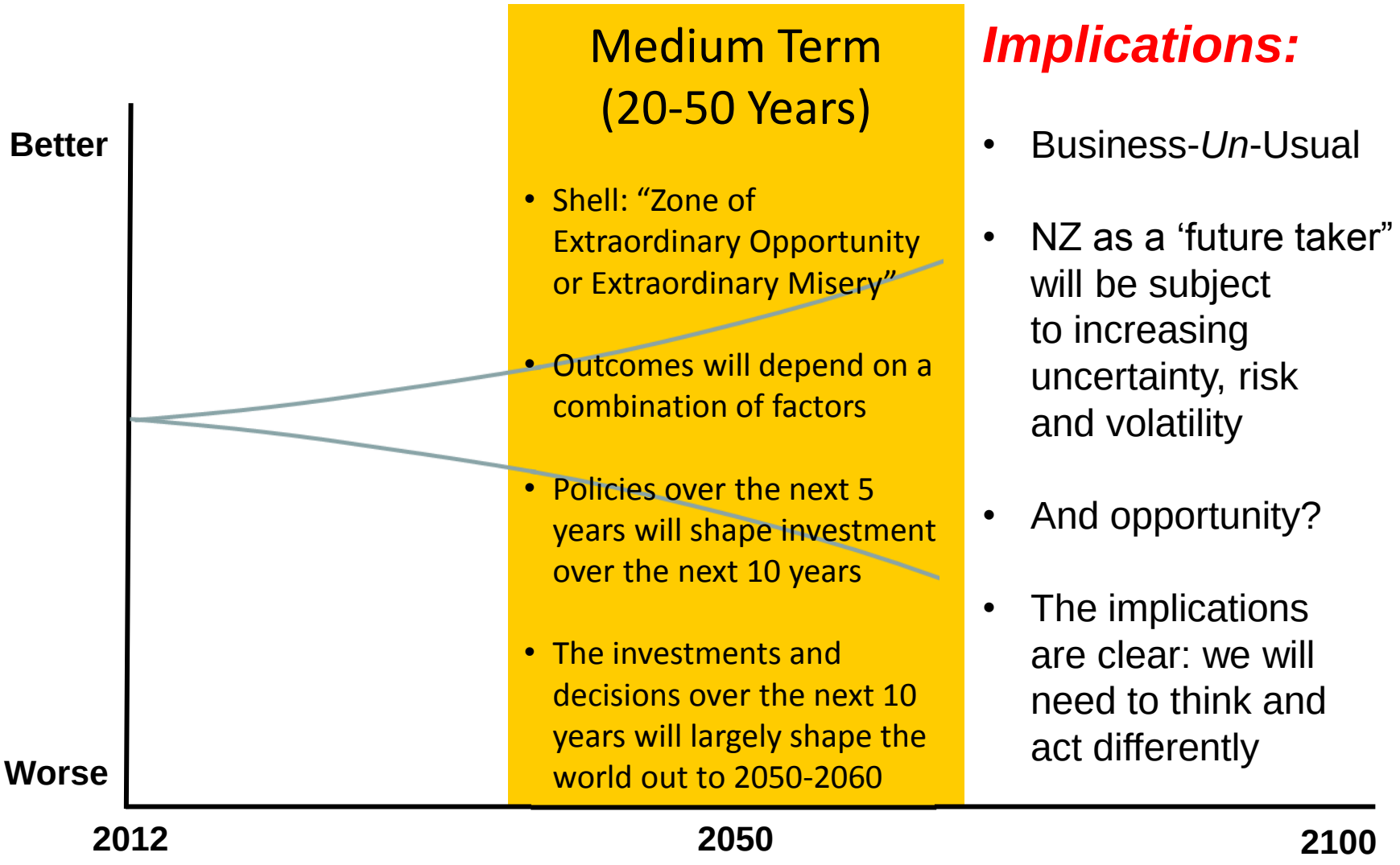
Implications for New Zealand



Implications:

- Overall a sense that things will soon return to "normal" (i.e. economic growth) after the recent global recession – many would disagree!
- Business-As-Usual will continue
- NZ only needs to act smartly to take advantage of the emerging opportunities (e.g., free trade, Green Growth)

Implications for New Zealand



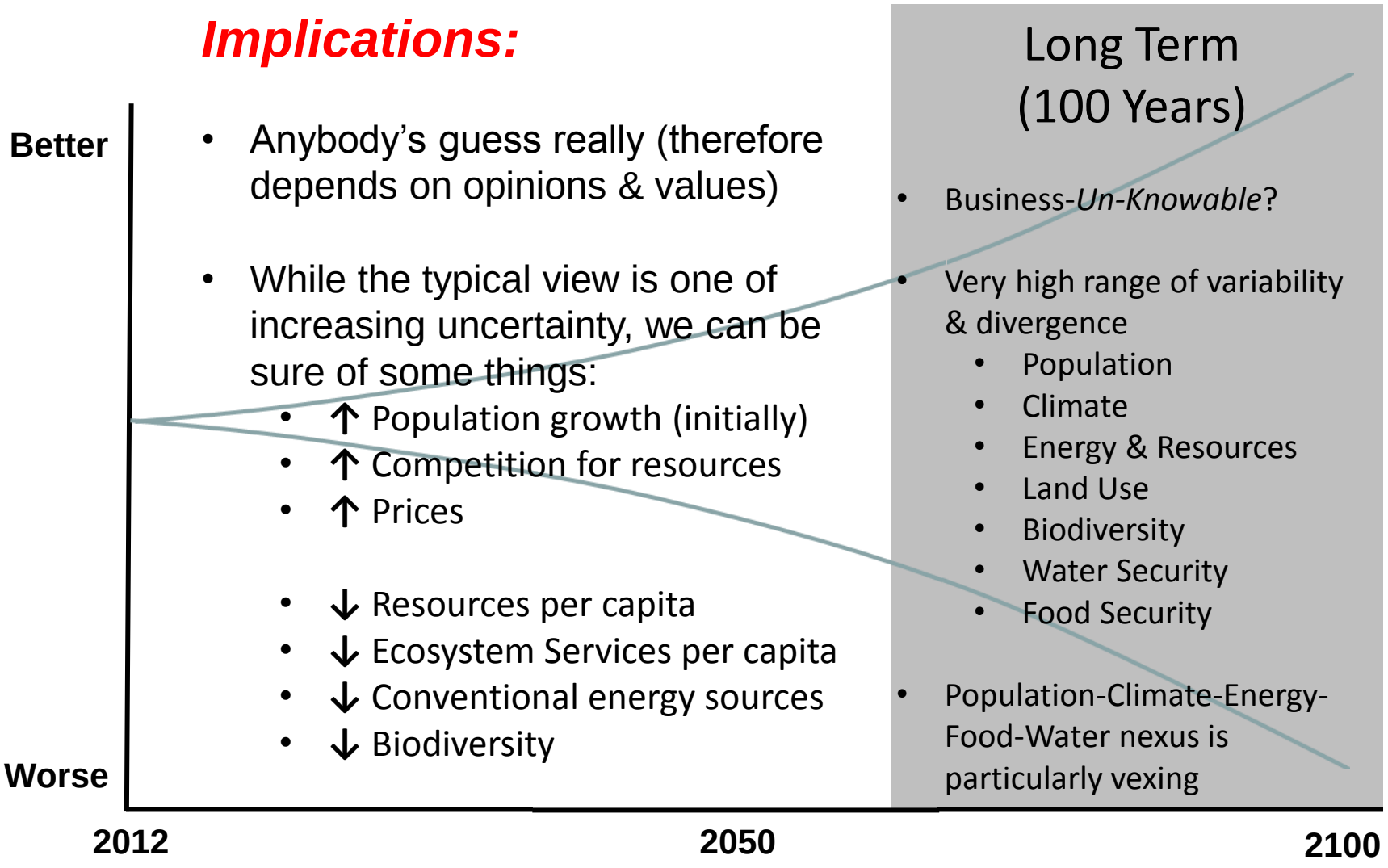
Medium Term (20-50 Years)

- Shell: "Zone of Extraordinary Opportunity or Extraordinary Misery"
- Outcomes will depend on a combination of factors
- Policies over the next 5 years will shape investment over the next 10 years
- The investments and decisions over the next 10 years will largely shape the world out to 2050-2060

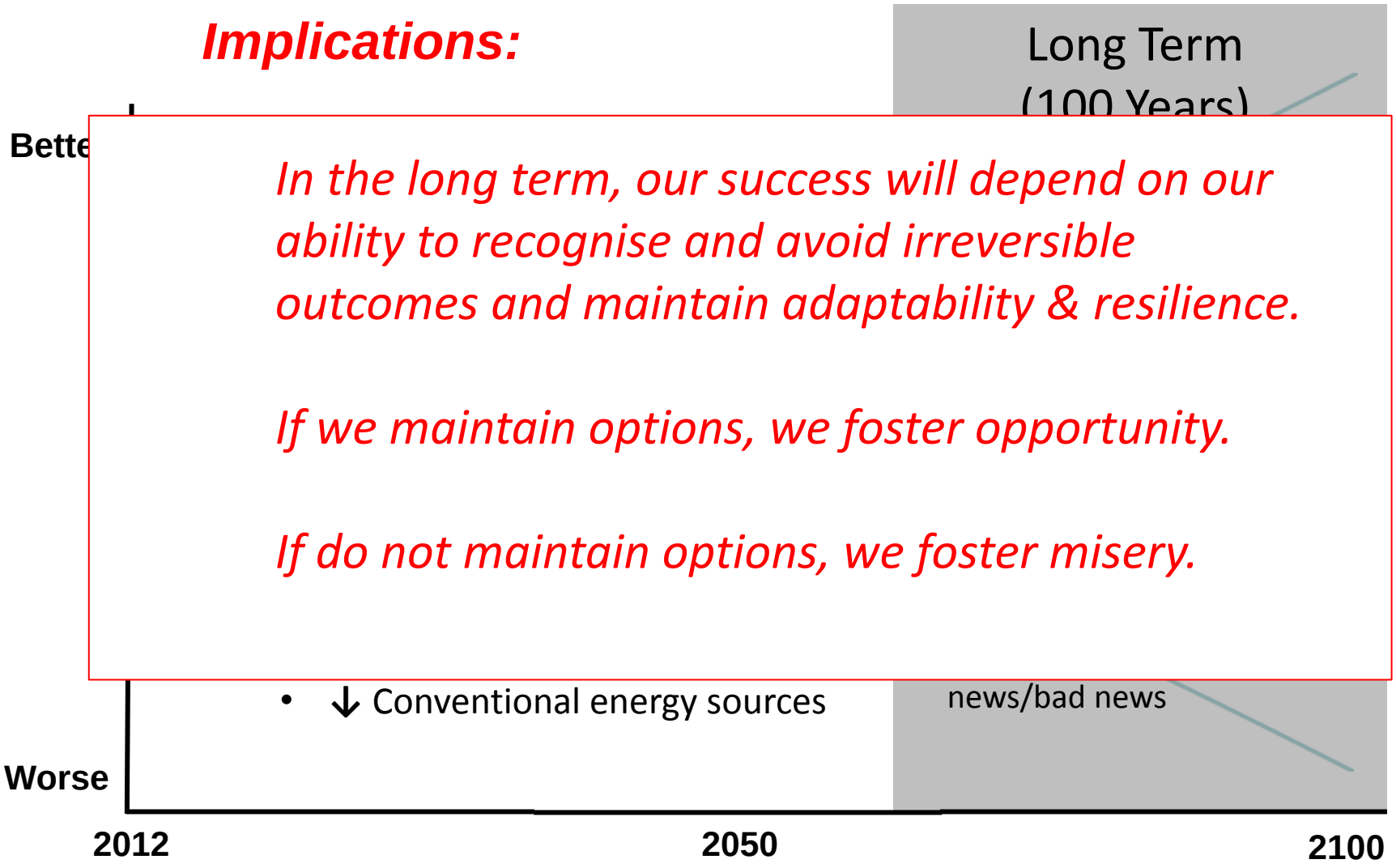
Implications:

- Business-*Un*-Usual
- NZ as a 'future taker" will be subject to increasing uncertainty, risk and volatility
- And opportunity?
- The implications are clear: we will need to think and act differently

Implications for New Zealand



Implications for New Zealand



Kia ora

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