The green growth narrative and the GRI research programme

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Thanks to Alex Pfeiffer, Alex Teytelboym and Aurora Energy Research

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Suppose that there were a clean, cheap, and unlimited supply of energy…

Source: Jaguar Plant in the United Kingdom

Agenda

1. The "green growth" narrative
2. Is there a problem? If so, what is it?
3. What is the research agenda?
4. Conclusions

Achieving 'green growth' has become a central objective of various international organisations

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UNEP

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BANQUE AFRICAINE DE DEVELOPPEMENT
AFRICAN DEVELOPMENT BANK

Source: Hepburn, Teytelboym & Pfeiffer (2015, forthcoming)

What does ‘green growth’ mean and how does it map onto other concepts?

Low-carbon growth

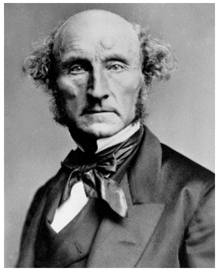
Green growth

Sustainable Development

Sustainable Prosperity

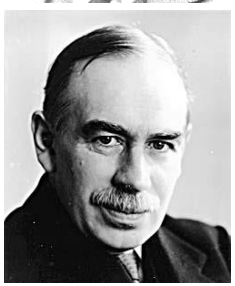
Source: Hepburn, Teytelboym & Pfeiffer (2015, Handbook of Economic Geography, forthcoming)

Throughout history, distinguished economists have asked whether we may need to stop growing

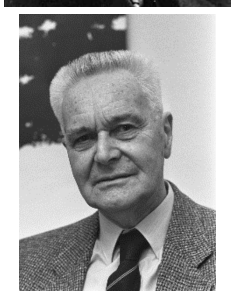


1. **John Stuart Mill:** if we do not deliberately guide the economy towards such a stationary state, an environmental collapse will result.

2. **Sir John Hicks:** that once population is controlled, the 'Stationary State is no longer a horror. It becomes an objective at which to aim.



3. **John Maynard Keynes:** Economic Possibilities for Our Grandchildren



4. **Tinbergen:** Saving the environment will check production growth, and lead to lower levels of national income

Source: Various, see Hepburn and Bowen (2013) for a list of primary references

Why worry about **growth** rather than prosperity?
1 billion still in poverty now

Human population in 2050:

- 9-10 billion people
- 4 billion middle class consumers

Demand by 2030:

% increase in demand*

- **Food:** up to 50% increase
- **Phosphorus:** up to 70% increase
- **Water:** up to 50% increase
- **Energy:** up to 60% increase

'Prosperity without growth' simply not an option

Source: Vivid Economics (2012): Modelling for 2012 World Economic Forum at Davos

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Green growth is theoretically feasible, even without tech change, indeed indefinitely without exhaustibility

$$Y = F(K, R, N)$$

$$\dot{K} = F(K, R, N) - C - \mu R - \delta K$$

$$\dot{N} = E(N) - R$$

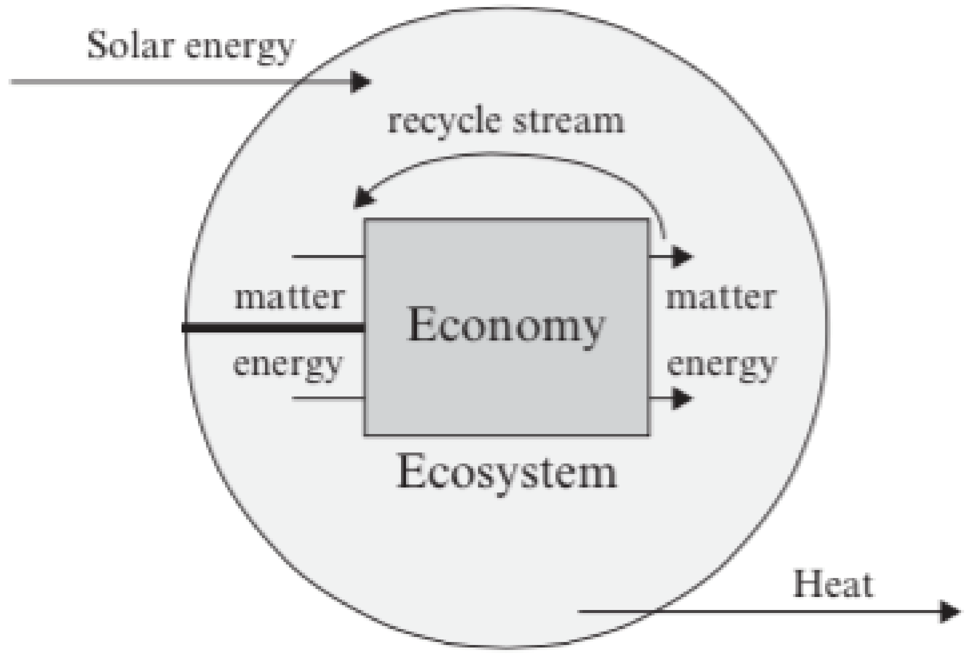
Key conditions:

$$R = E(N) \qquad C < F(K, E(N), N) - \delta K - \mu R$$

Source: Smulders, Toman,, Withagen (2014, Oxford Review) "Growth theory and green growth"

And in principle there is plenty of incoming highly ordered energy and plenty of resources to use

Simplistic relationship between the economy and the environment



Source: Hepburn & Bowen (2013)

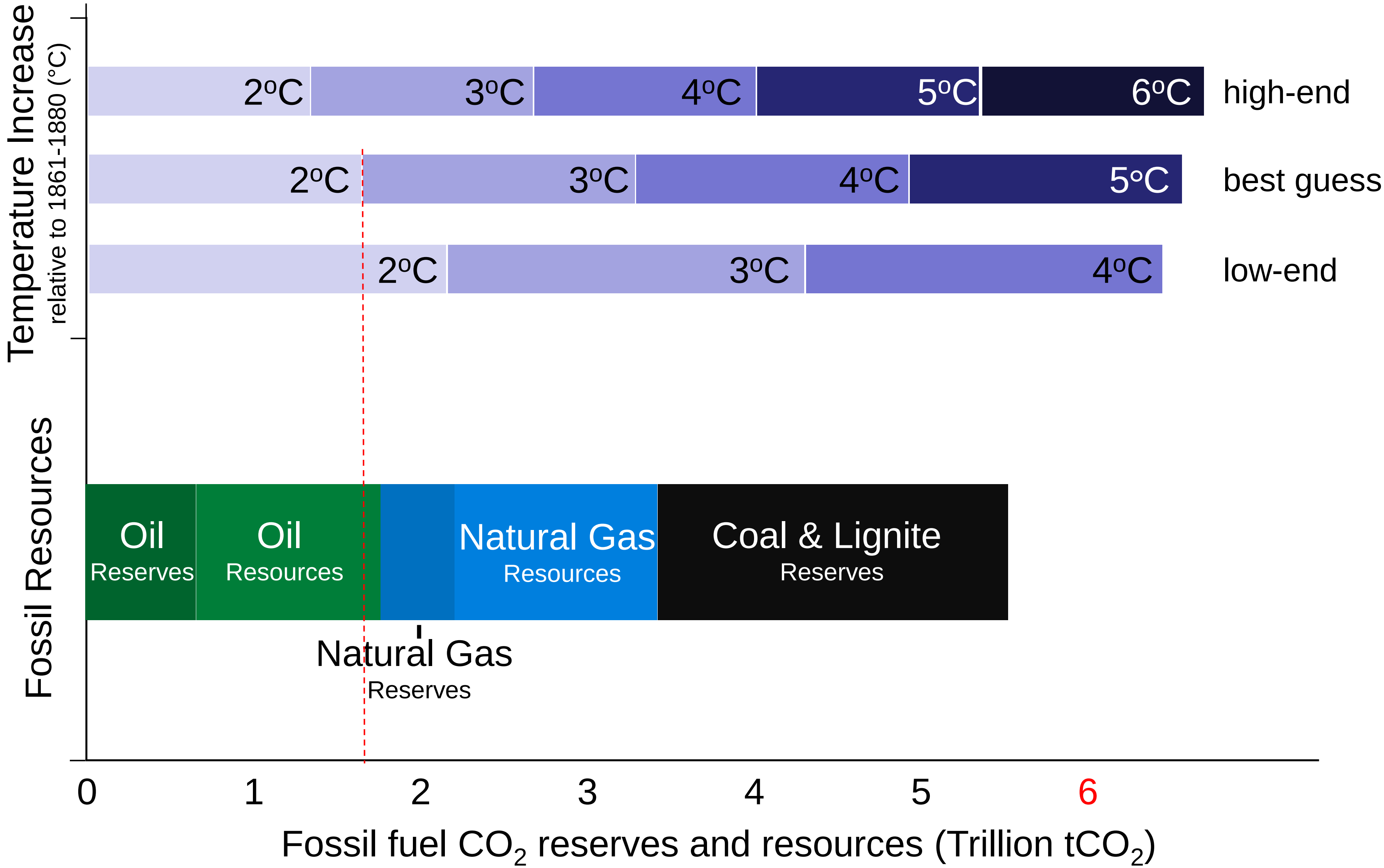
So what are we all worried about?

Forests, ecosystems, etc are **"renewable"** natural capital

Coal, oil, gas is **"exhaustible"** natural capital

Sources: Forest of Dean in Gloucestershire Photo: CORBIS

Ironically, we are 'running out' of our renewable assets, such as atmospheric capacity to take up CO_2



Source: Alexander Otto using data from Aurora Energy Research and IPCC

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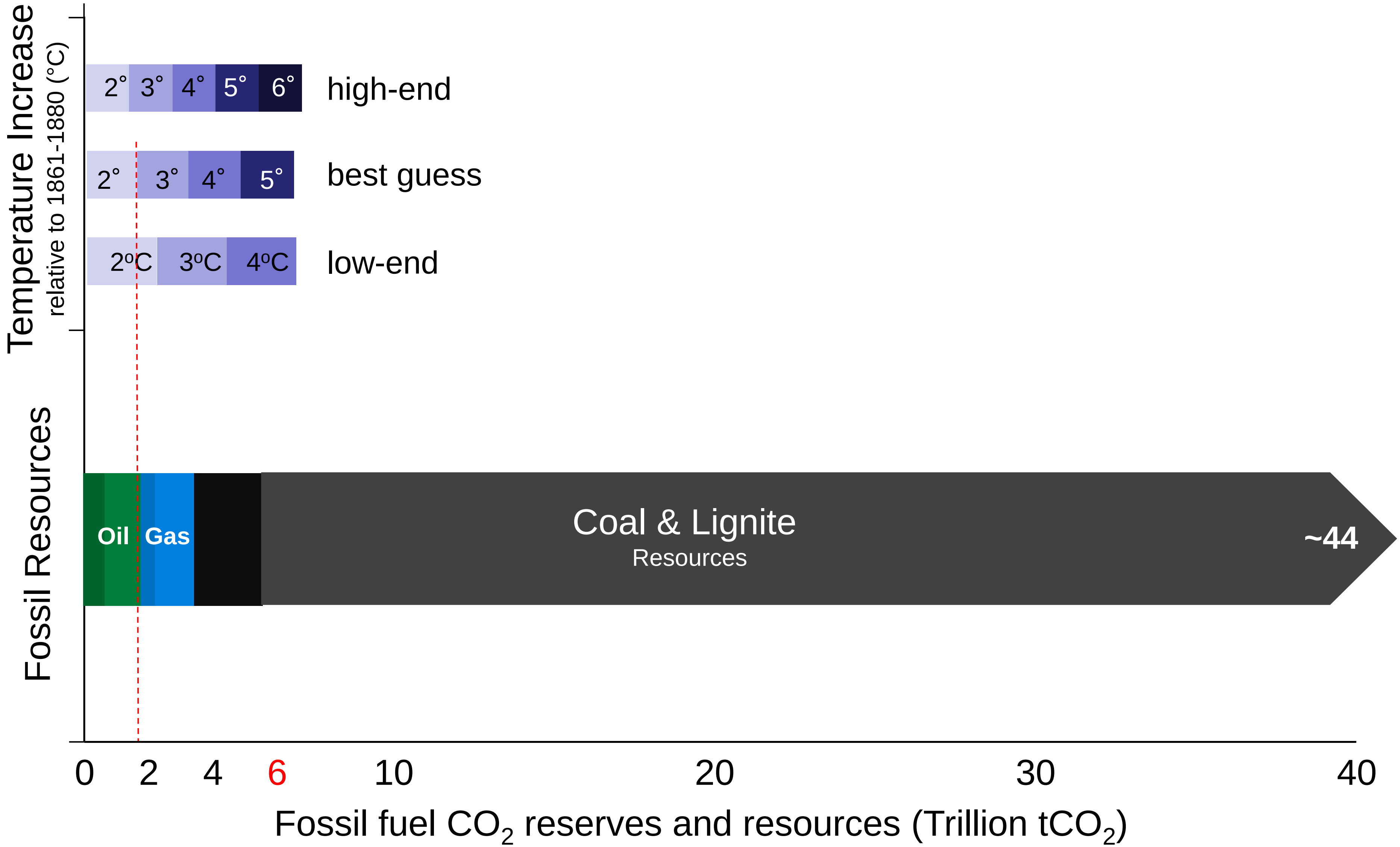
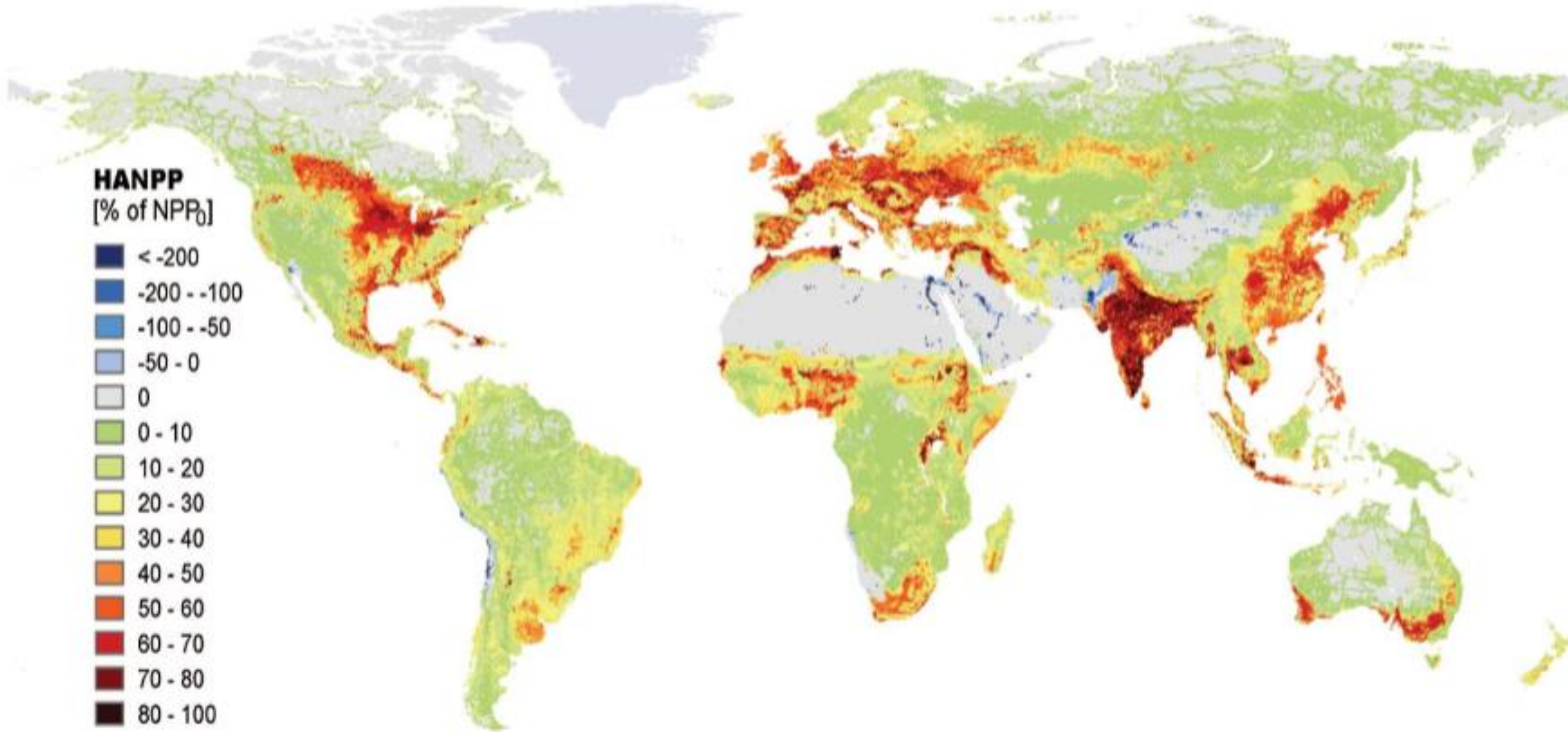


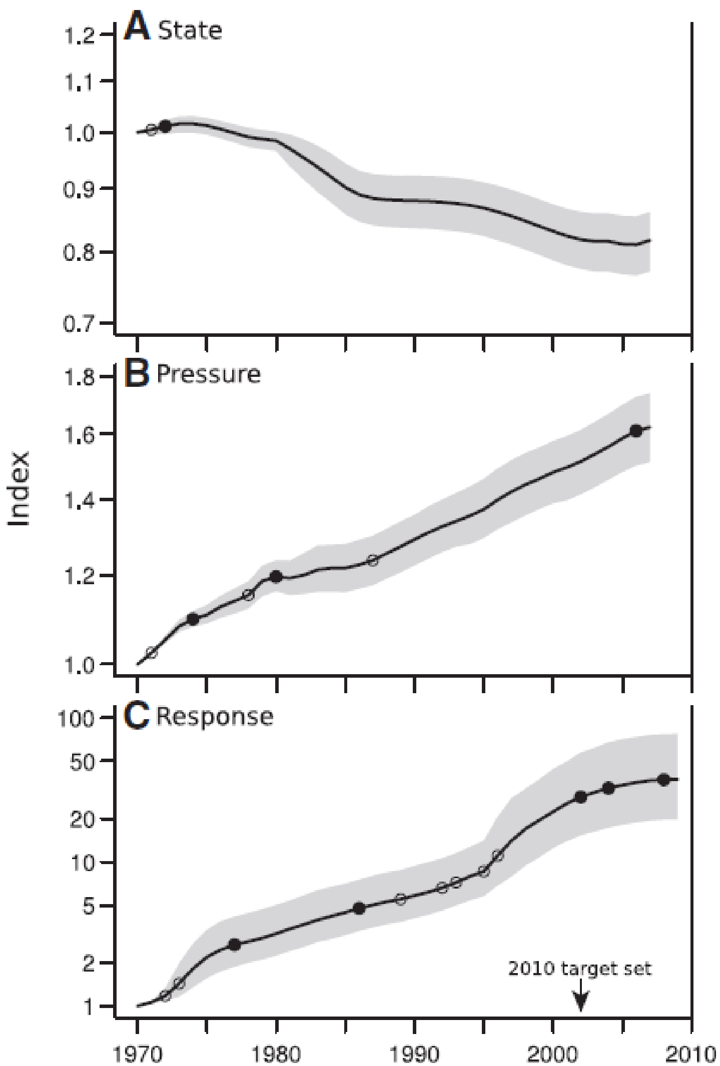
There is now intense and widespread "human appropriation of net primary product"

Human appropriation of net primary product (HANPP) around year 2000



Source: Haberl et al (2007, PNAS) Quantifying and mapping HANPP in Earth's terrestrial ecosystems

Biodiversity (A) is declining, driven by human pressures (B) despite a policy response (C)



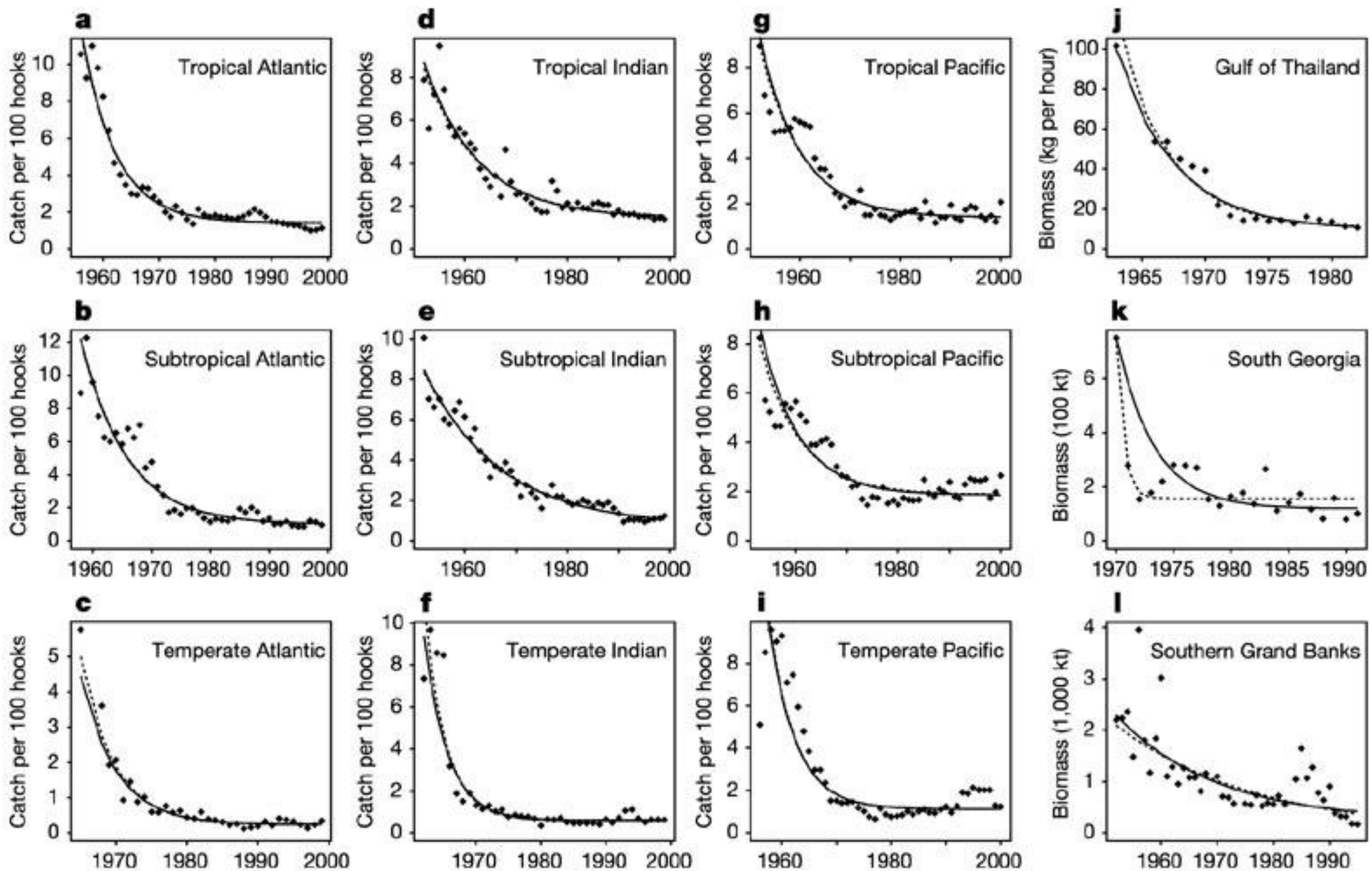
A. State of biodiversity: Aggregate index based on 31 indicators, including species population trends, extinction risk, habitat extent and condition

B. Pressures on biodiversity: Aggregate index including resource consumption, invasive species, nitrogen pollution, overexploitation and climate impacts.

C. Policy response: Extent and biodiversity coverage of protected areas, sustainable forest management, policy against invasive species, biodiversity-related aid

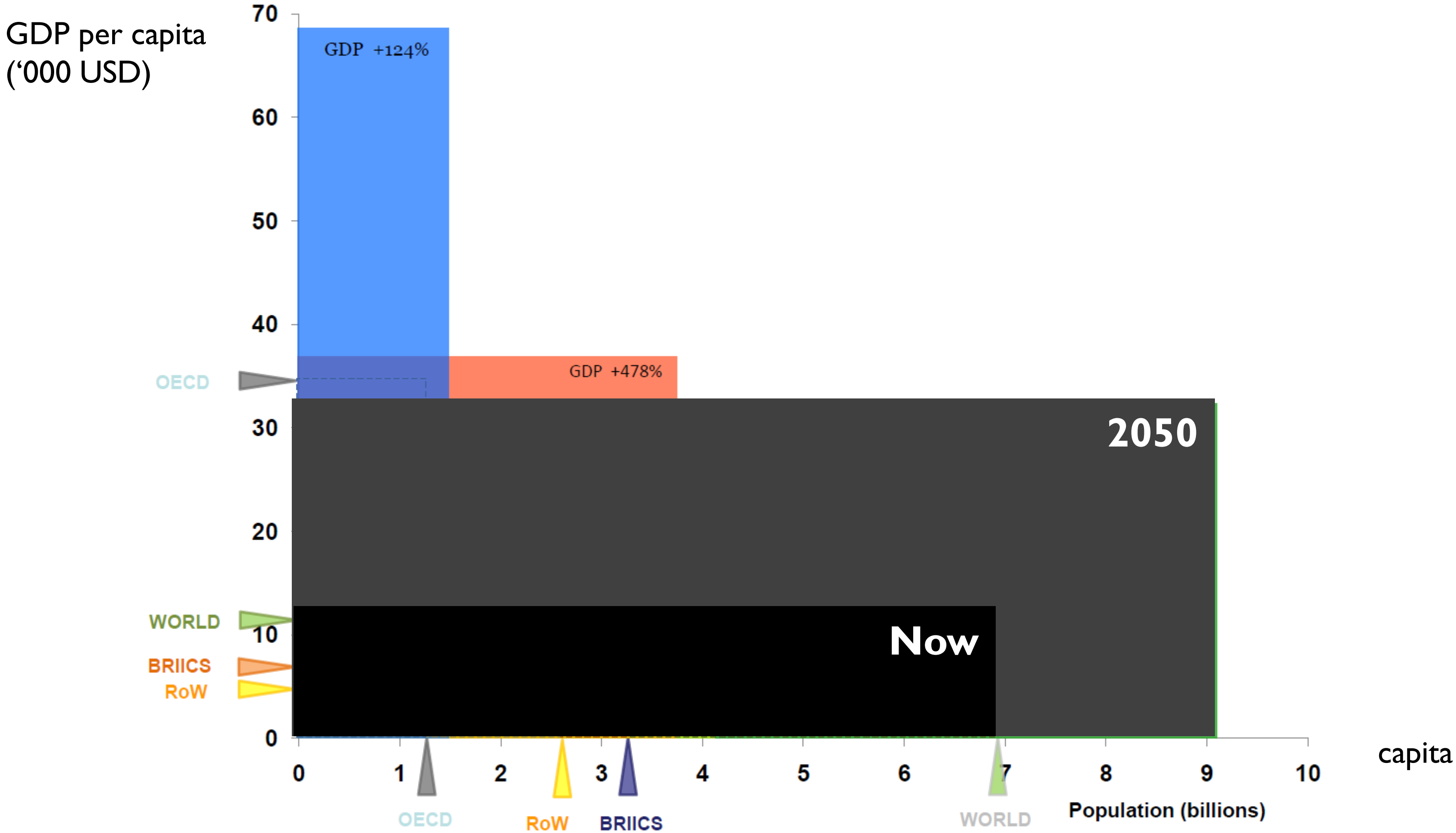
Source: Butchart et al (2010, Science) Global biodiversity: Indicators of Recent Declines

Fishery catches have declined almost everywhere around the world



Source:

And if that seems like a bad report card, we haven't seen anything yet…



Source: OECD (2012): OECD Environmental Outlook to 2050

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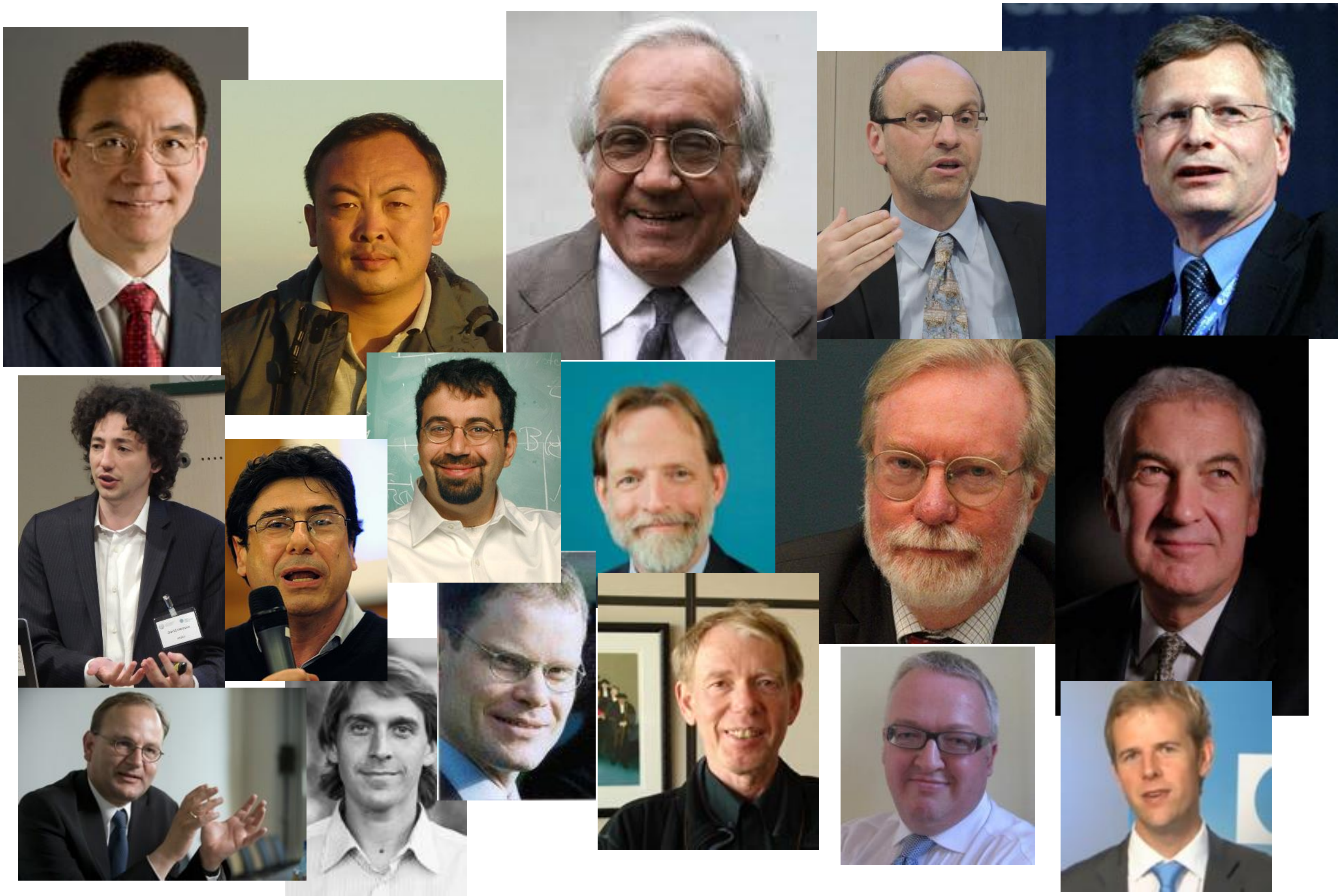
Autumn 2014 issue of *Oxford Review* is on Green Growth (notable gender bias)



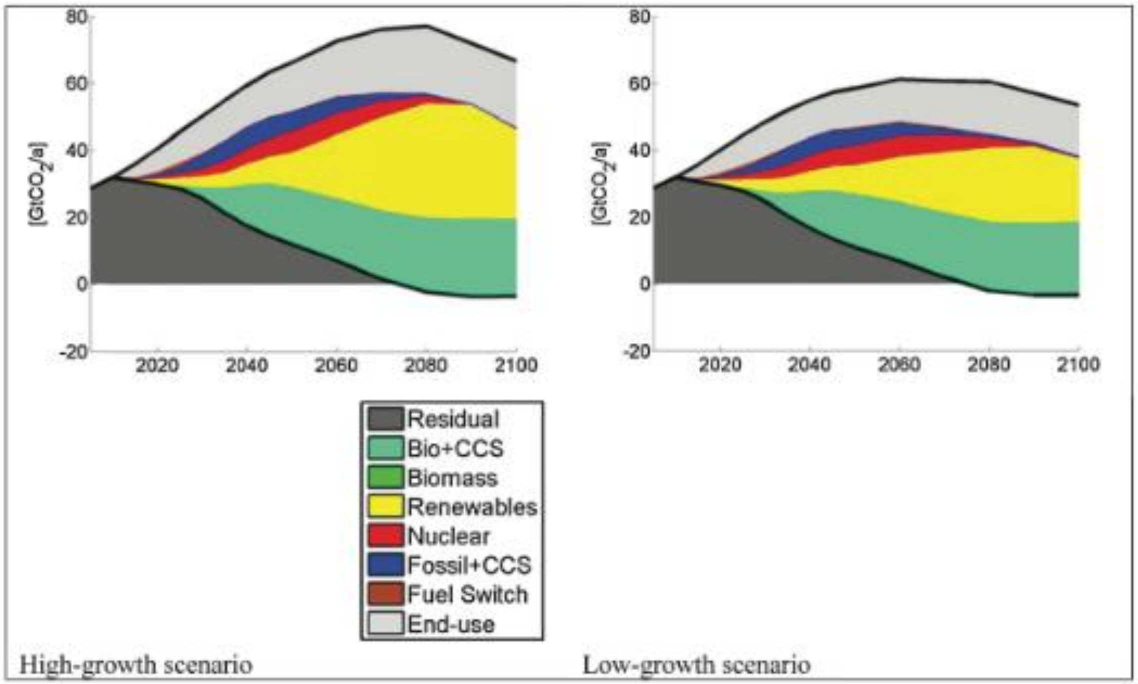
Source: Various

The green growth research agenda has included the several key questions

1. How do we measure green growth? Edenhofer and Jakob conclude that a single indicator is not enough – a dashboard is required
2. To what extent is merely internalising externalities (including knowledge) enough? Rodrik concludes more is required
3. What is the role of directed technical change? Aghion et al suggest a short-term (i.e. several decades) big push might be enough
4. Can green growth be pro-poor? Dercon concludes there are important short-run trade-offs.
5. Poverty reduction continues to dominate environmental protection in India (Parikh) but things are changing in China (Lin and Xu)
6. Political economy of the transition needs to be tackled head on (Collier and Venables)

Do we have to sacrifice economic growth to achieve our climate targets?

Technology portfolios to achieve a 450ppm CO2 target under scenarios assuming high (2.8% p.a., left) and low (1.7% p.a., right) rates of economic growth, respectively[1]



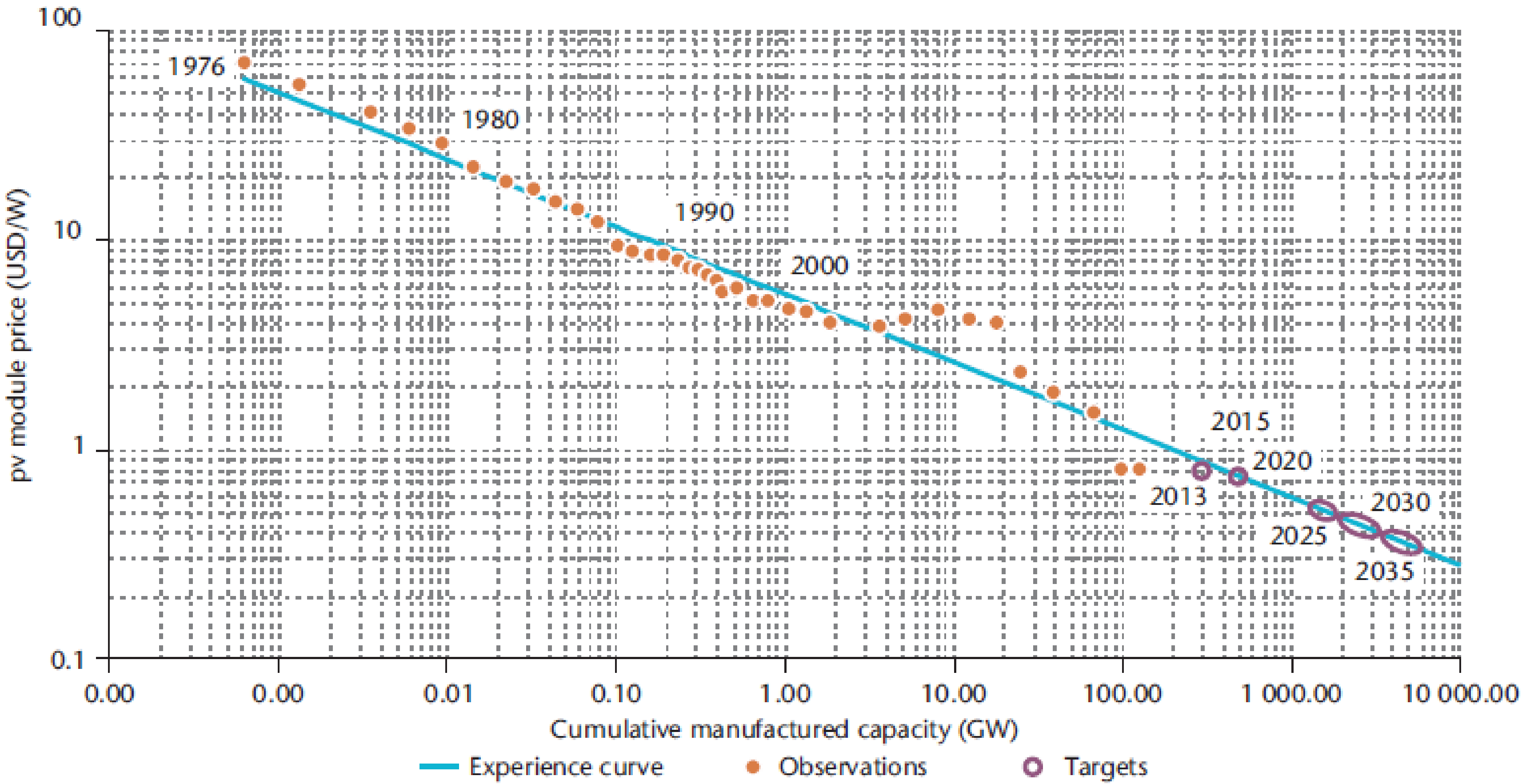
- A low-growth strategy does address the undeniable technological risks

- **But instead of reducing economic growth, tackling these risks directly via well-tailored policy instruments would be more efficient**

Source: Jakob & Edenhofer (2014, Oxford Review of Economic Policy)

Improvements in solar are faster than most other technologies studied. Why?

Figure 10: Past modules prices and projection to 2035 based on learning curve



Notes: Orange dots indicate past module prices; purple dots are expectations. The oval dots correspond to the deployment starting in 2025, comparing the 2DS (left end of oval) and 2DS hi-Ren (right end).

At current production growth, a simple projection suggests solar dominates by 2030

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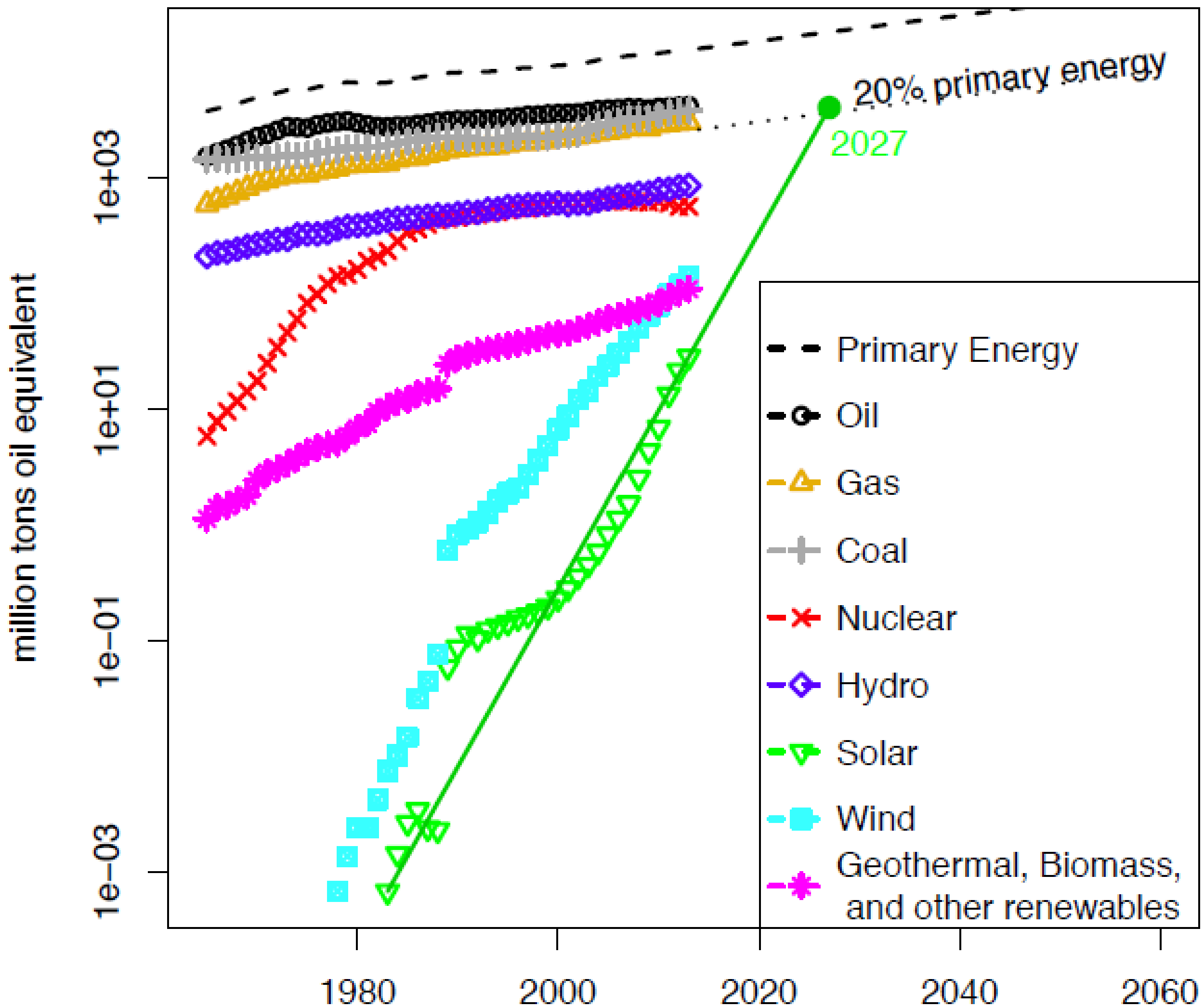

Source: Farmer, D. (2015) Predicting Rates of Technological Progress, Seminar at 'Paris and Beyond', Oxford University; BP Statistical Review of Energy

But obviously all energy technologies reach saturation point at some level

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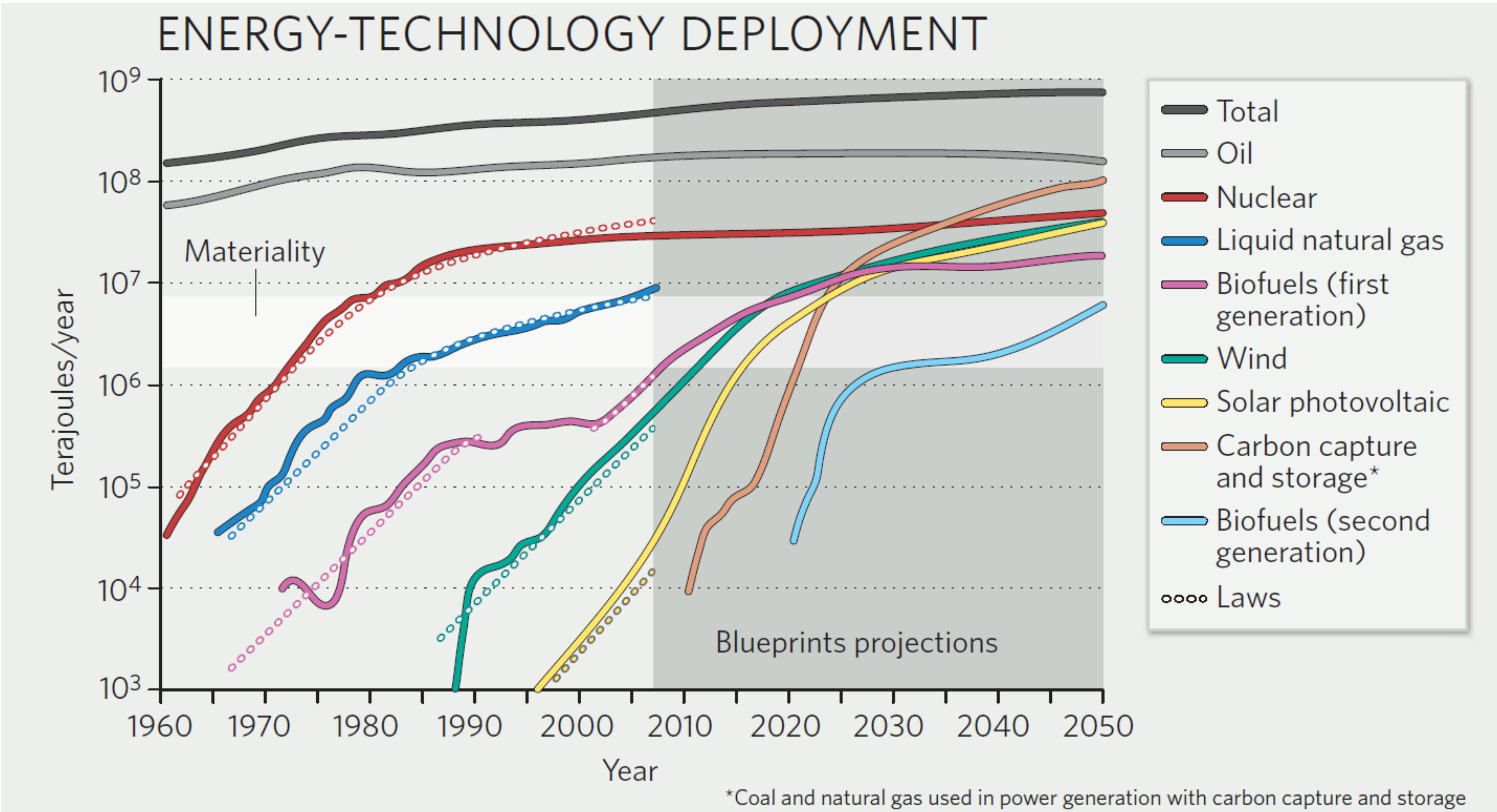

Source: Kramer and Haigh (2009, Nature),

All of these innovations have been possible by combining existing ideas together

- Even that idea about ideas is not new (and there have been many other ideas about ideas since)
- But we could still do well to think about the 'production function' for new knowledge in relation to cleantech

THE
QUARTERLY JOURNAL
OF ECONOMICS

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RECOMBINANT GROWTH*

MARTIN L. WEITZMAN

This paper attempts to provide microfoundations for the knowledge production function in an idea-based growth model. Production of new ideas is made a function of newly reconfigured old ideas in the spirit of the way an agricultural research station develops improved plant varieties by cross-pollinating existing plant varieties. The model shows how knowledge can build upon itself in a combinatoric feedback process that may have significant implications for economic growth. The paper's main theme is that the ultimate limits to growth lie not so much in our ability to generate new ideas as in our ability to process an abundance of potentially new ideas into usable form.

I. INTRODUCTION

As has generally been recognized for some time now, the long-term growth of an advanced economy is dominated by the behavior of technical progress. This elusive factor has variously been labeled the "stock of knowledge," the "state of technology," the "effectiveness of labor," the "residual," a "measure of our ignorance," a "parameter to be varied," or, most directly, the "mystery variable." Because so much of importance is riding on its behavior, a central goal of growth theory has long been to get inside the black box of innovation and pull out an explicit model of knowledge production. This does not promise to be an easy task

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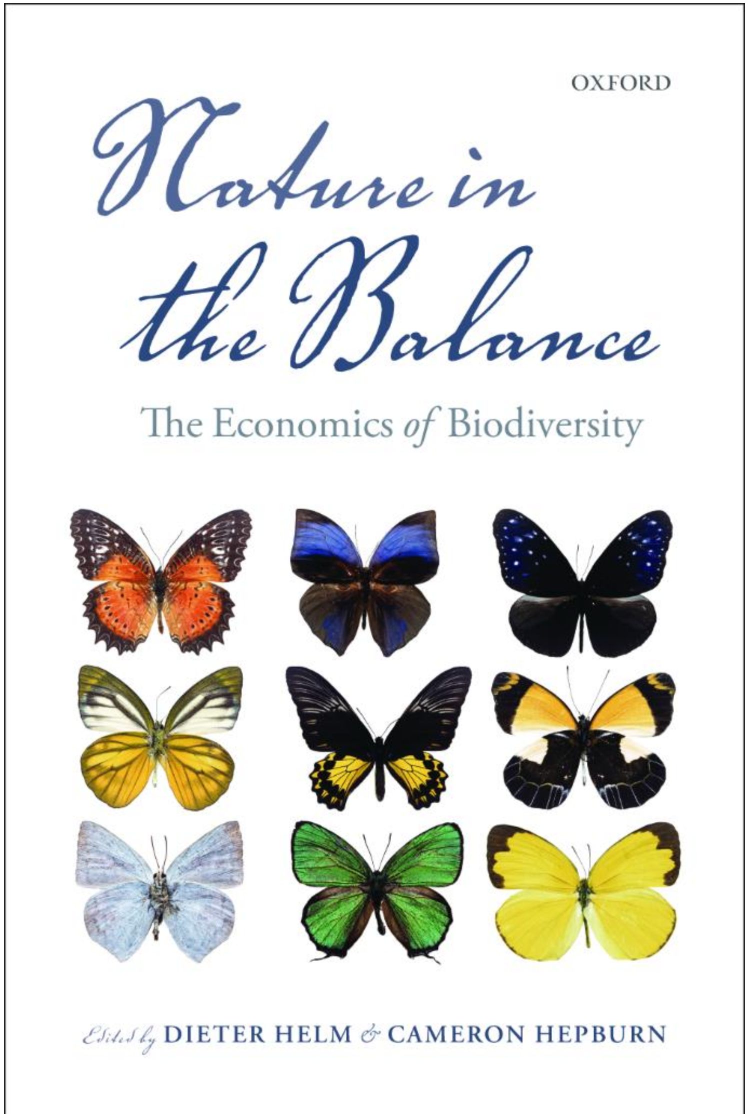
Conclusions

1. Zero growth is neither necessary, desirable nor feasible
2. Green growth – growth preserving natural capital – is necessary
3. It is the renewable (not exhaustible) natural capital that we need to be worried about, because they are often not priced
4. Green technical change might even lead to exciting new technologies (and cleaner local environments)
   - In contrast, reducing economic output to reduce emissions is the most expensive form of abatement – clean technology is much better
5. The key to simplifying the economics and politics is reducing the costs of clean technology, and key to reducing costs is support for innovation (including early stage R&D)

The academic and evidentiary basis for policy in some areas of green growth remains weak



1. Biodiversity is massively under researched
2. Biodiversity is special because there are limits to substitutability
3. We are likely to be beyond the point at which reducing biodiversity is logical for human welfare
4. We are spending billions trying to solve the problem
5. But we don't know what works and what doesn't!
6. Policy should be **made to be evaluated** so we stop wasting money

Asia shows that agricultural intensification is possible, at least the short term

Africa: 2.5-fold increase in ***area*** used for cereal production

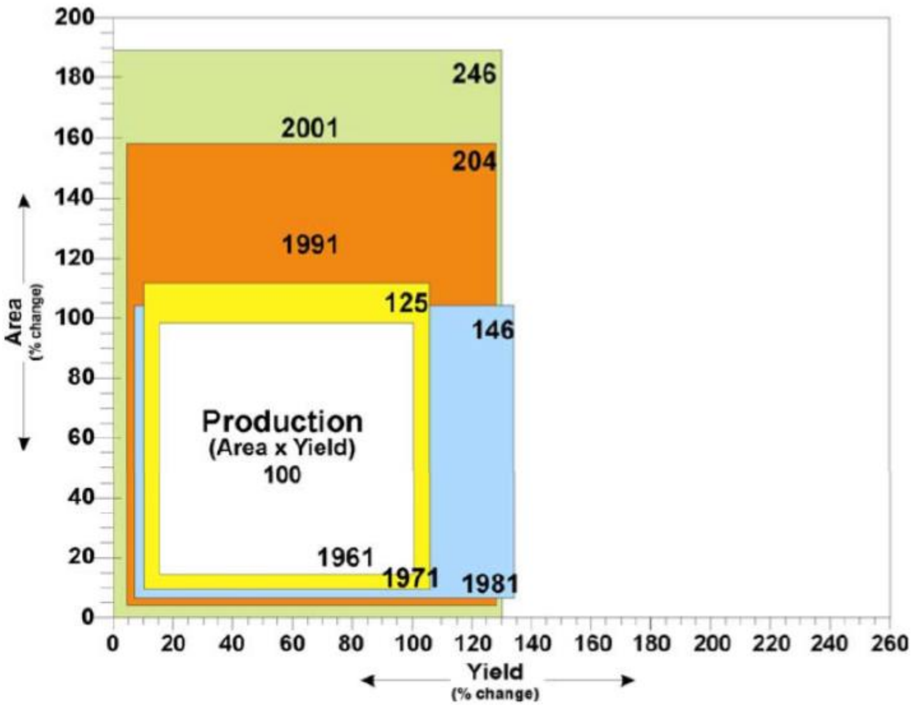


Figure 1. Changes in Cereal Production in Sub-Saharan Africa Due to Changes in Area and Yield (1961 = 100)

Asia: 2.5-fold increase in ***yields***; no new area under cultivation

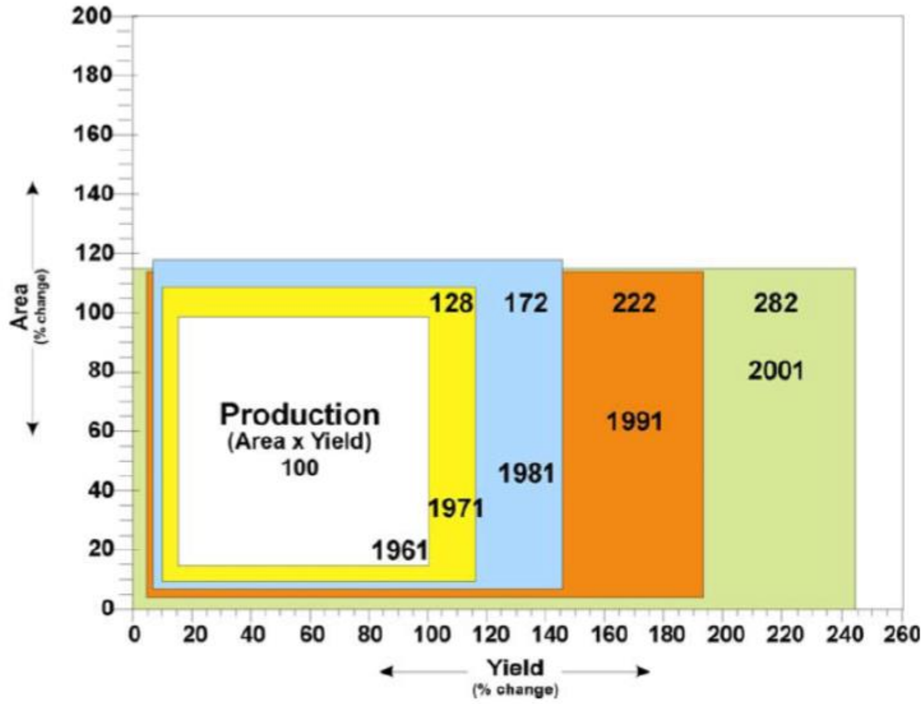
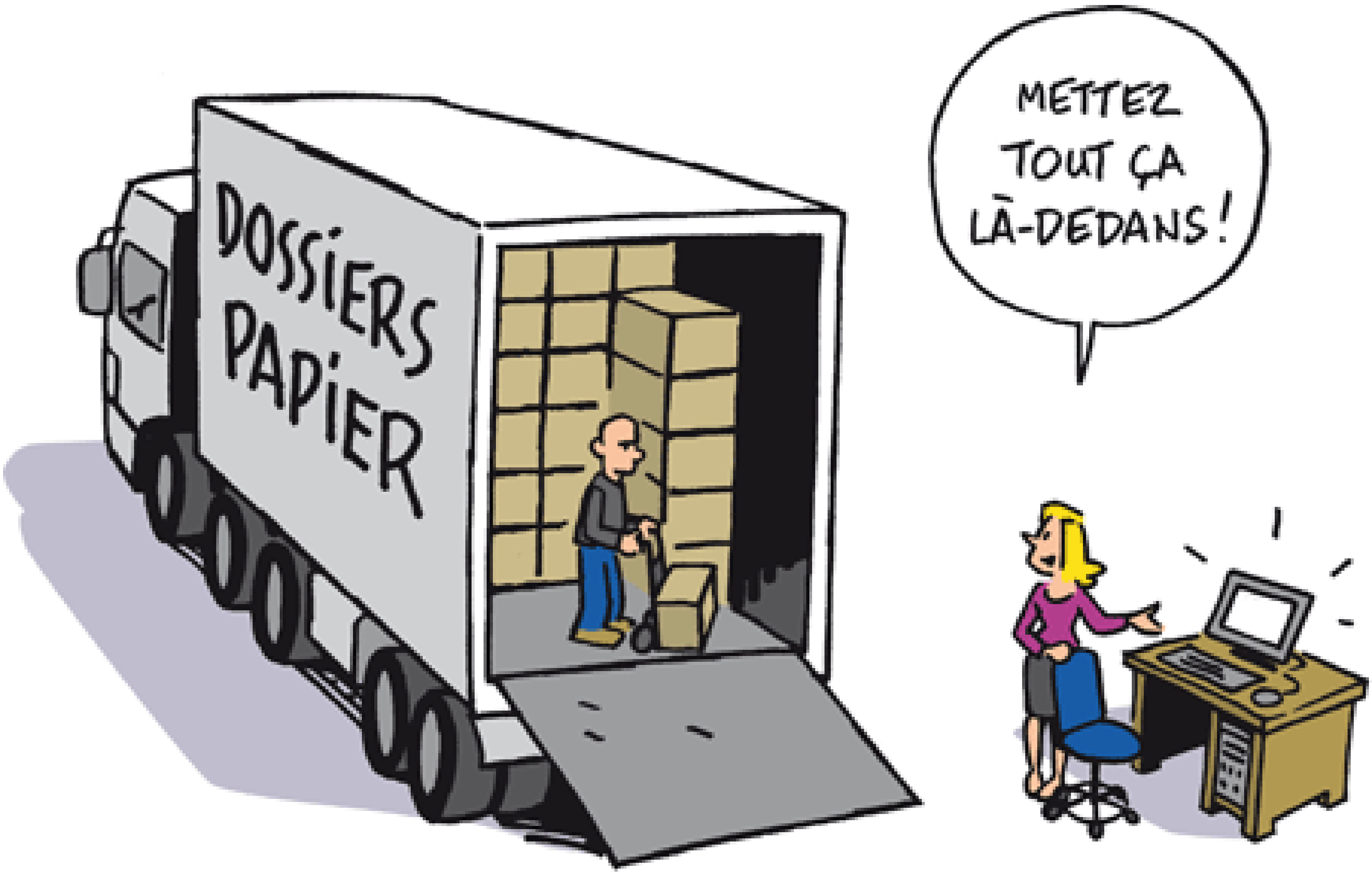


Figure 2. Change in Cereal Production in Asia Due to Changes in Area and Yield (1961 = 100)

Source: Henao and Baanante (2006, IFDC Technical Bulletin) "Agricultural production and soil nutrient mining in Africa"

And gradual dematerialisation of the economy won't hurt



Thank you!

Strong green growth: protecting natural capital involves no trade-off in the short or the long term

Strong green growth

Time horizon

Economic growth

	Short term	Long term
Absolute: Is the economic growth rate positive?	✓	✓
Relative: Is the growth stronger than non-green growth?	✓	✓

- Green growth as utopian growth: In the short- and long-run positive economic growth that is even higher than traditional 'dirty' and environmental degrading growth

- **Appears less likely to hold**

Source: Hepburn, Teytelboym & Pfeiffer (2015, forthcoming)

Weak green growth: protecting natural capital involves short term trade-off with business as usual

Weak green growth

Time horizon

Economic growth

	Short term	Long term
Absolute: Is the economic growth rate positive?	✓	✓
Relative: Is the growth stronger than non-green growth?		✓

- In the short run, investments in transition to green growth will lead to a sacrifice of growth (compared to BAU) but growth probably still positive in absolute terms
- In the long run, however, stronger growth (e.g. because of less environmental degradation)

- **Appears more likely to hold**

Source: Hepburn, Teytelboym & Pfeiffer (2015, forthcoming)

Backup

- Cobb-Douglas production functions normally starts from the assumption that inputs are capital and labour

Total factor productivity

Output

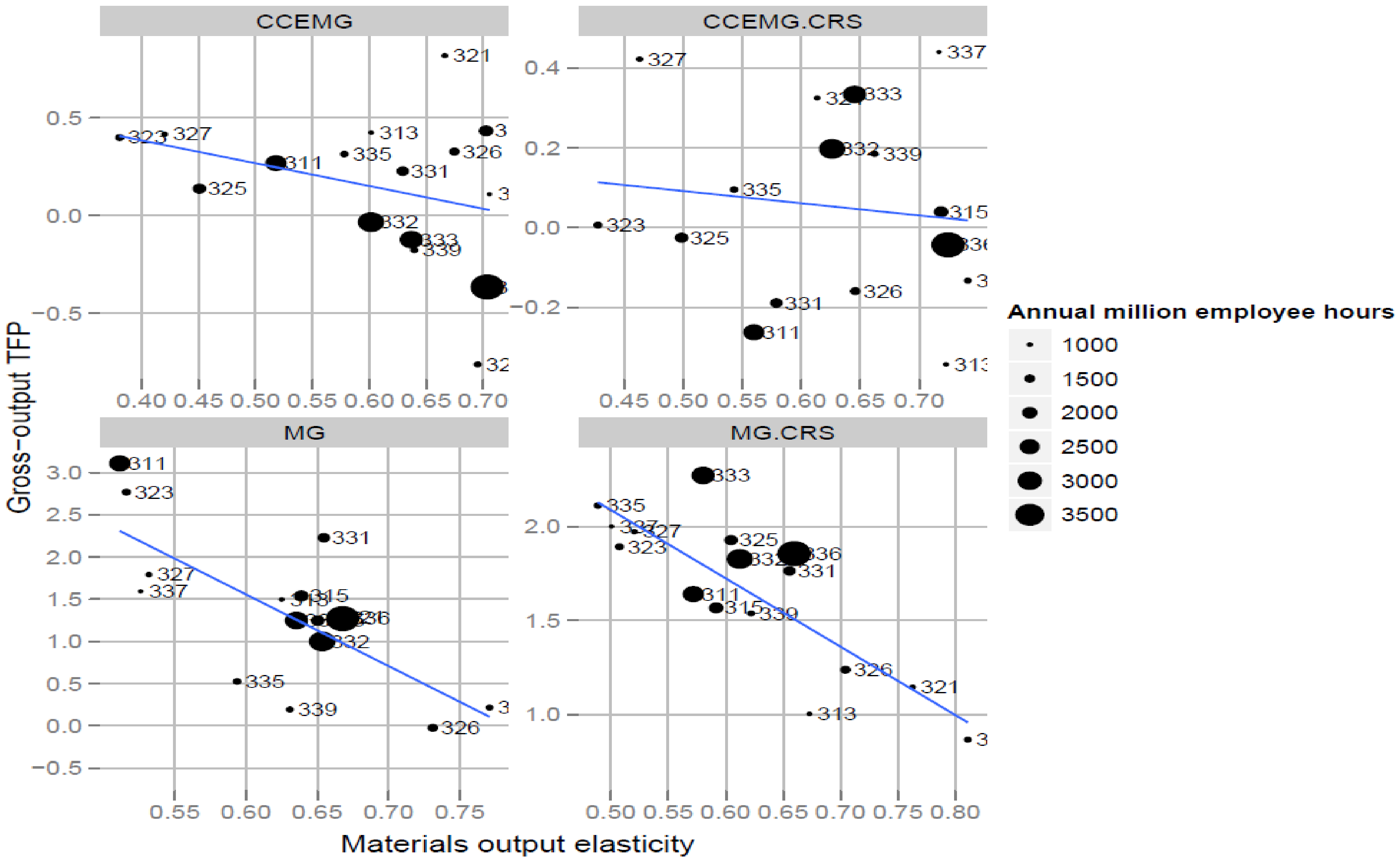
“Technology”

$$Y = AK^{\beta_K} L^{\beta_L}$$

Inputs

- We include incorporate materials in the production function
- We allow ‘technology’ to differ from sector to sector; we estimate technology from US data, test if factor intensity is related to productivity

Firms with lower material intensity show higher total factor productivity



Source: Baptist and Hepburn (2011)

Future pressure on resources is bound to increase with another 3 billion middle class people

Human population in 2050:
- 9-10 billion people
- 4 billion middle class consumers

Demand by 2030:

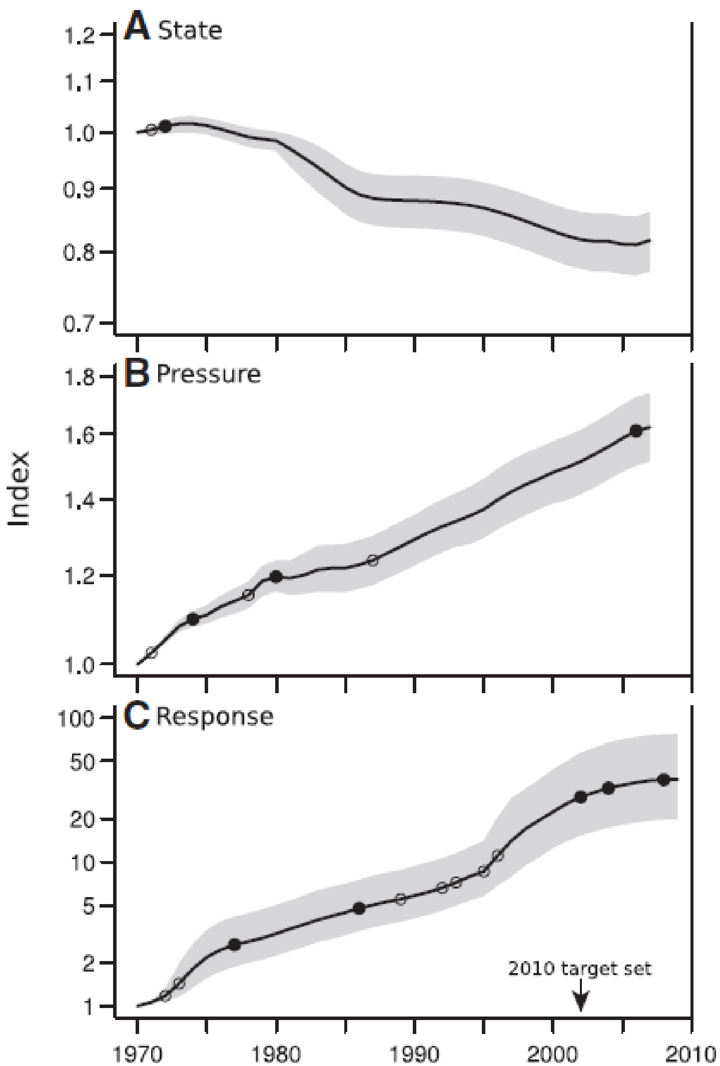
% increase in demand*
- **Food:** up to 50% increase
- **Phosphorus:** up to 70% increase
- **Water:** up to 50% increase
- **Energy:** up to 60% increase

Will reducing material intensity constrain or enhance economic growth?

'Green growth' or **'Prosperity without growth'** ?

Source: Vivid Economics (2012), Modelling for 2012 World Economic Forum at Davos

Biodiversity (A) is declining, driven by human pressures (B) despite a policy response (C)



A. State of biodiversity: Aggregate index based on 31 indicators, including species population trends, extinction risk, habitat extent and condition

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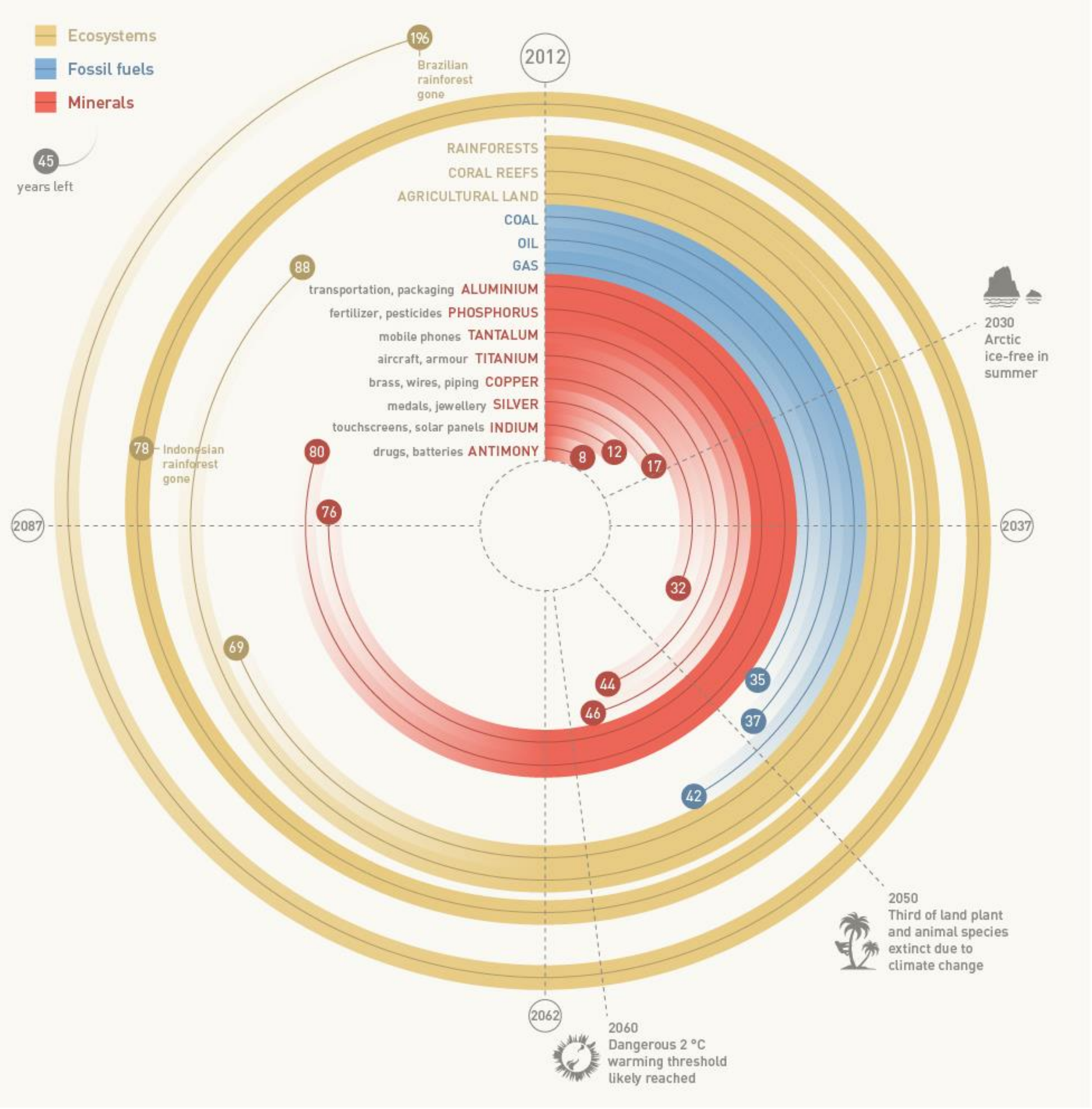
C. Policy response: Extent and biodiversity coverage of protected areas, sustainable forest management, policy against invasive species, biodiversity-related aid

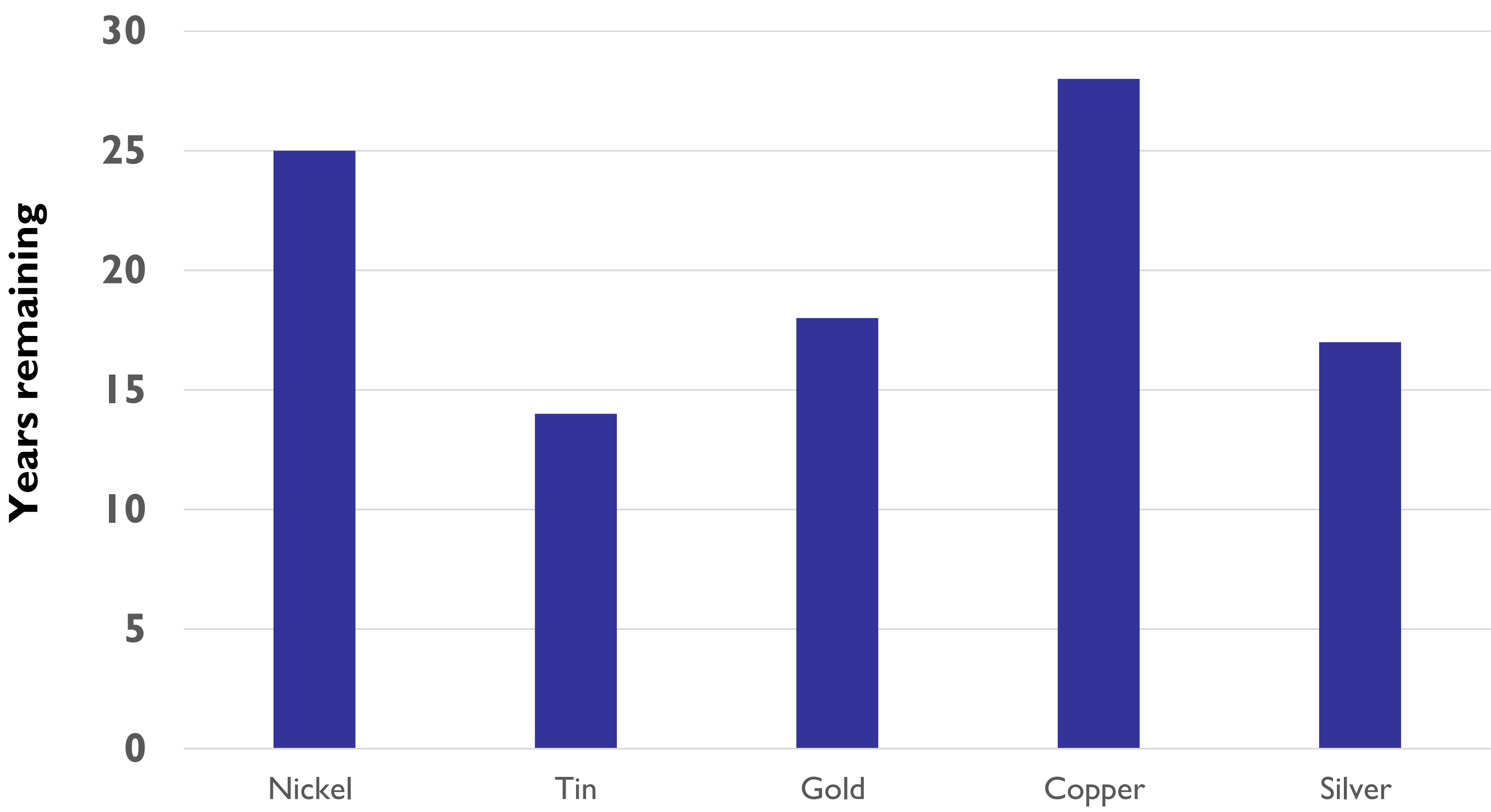
The BBC published a 'stock check' in 2012 of when we will run of various resources



McKinsey Global Institute: we need a resource revolution to cope, given commodity prices

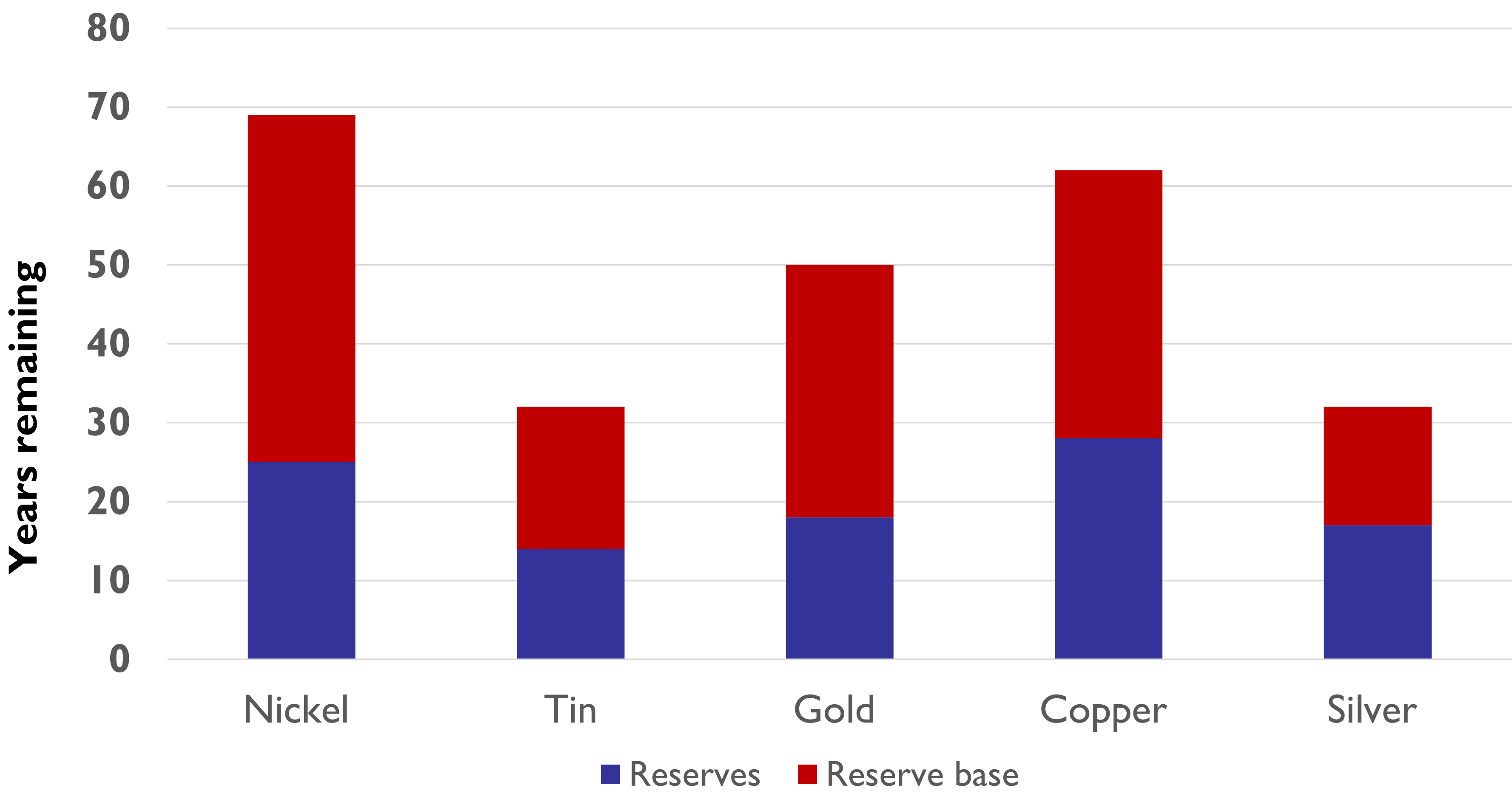
USGS data suggests at current production rates (which are increasing), we only have 10-30 years left

At current rates of production, we will 'run out' (exhaust the base of reserves) of key commodities within 10 to 30 years



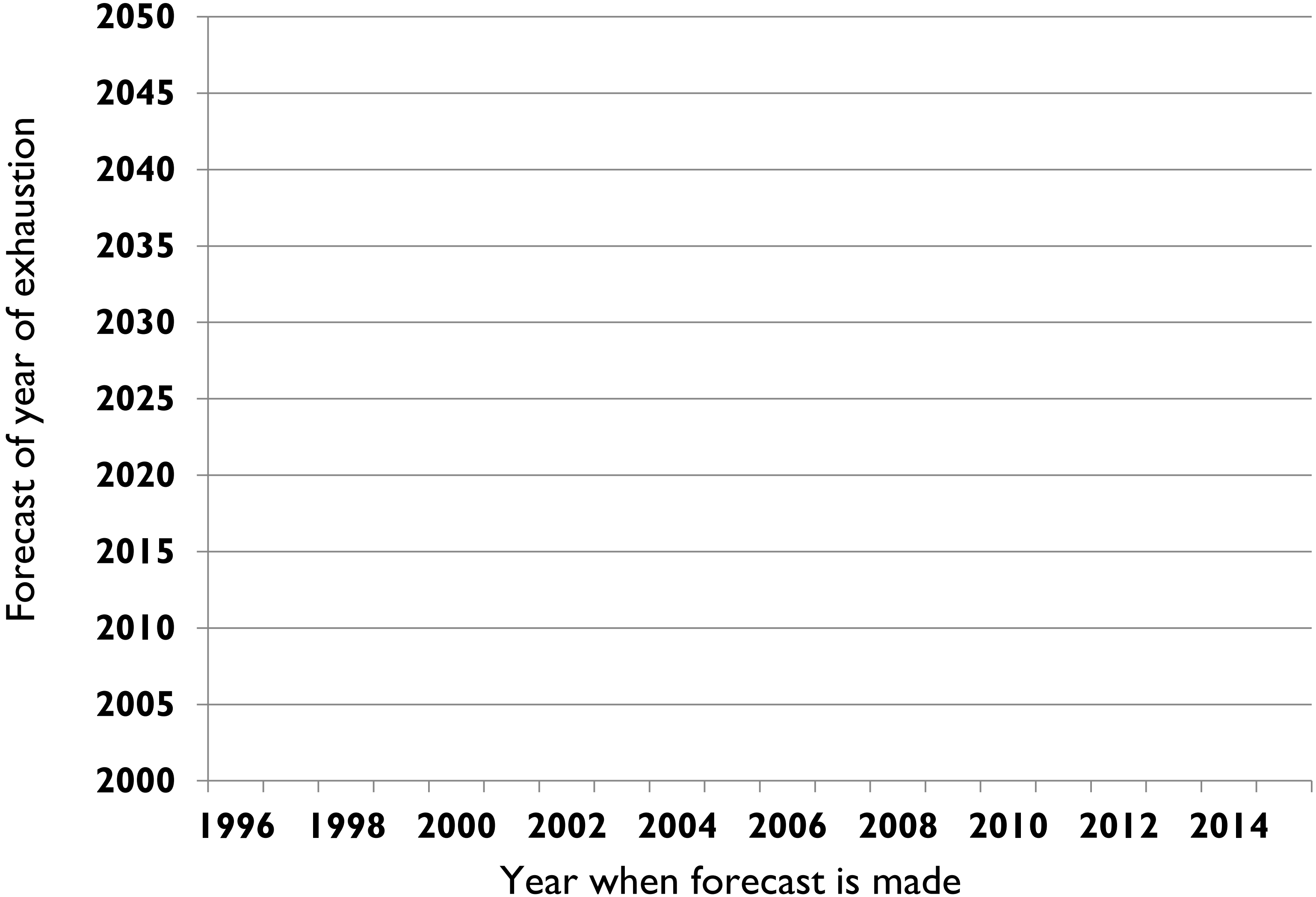
Source: Hepburn, Teytelboym & Pfeiffer (2015, forthcoming); United States Geological Survey Data

Picture looks a little better when you include the wider resources, but still seems concerning…

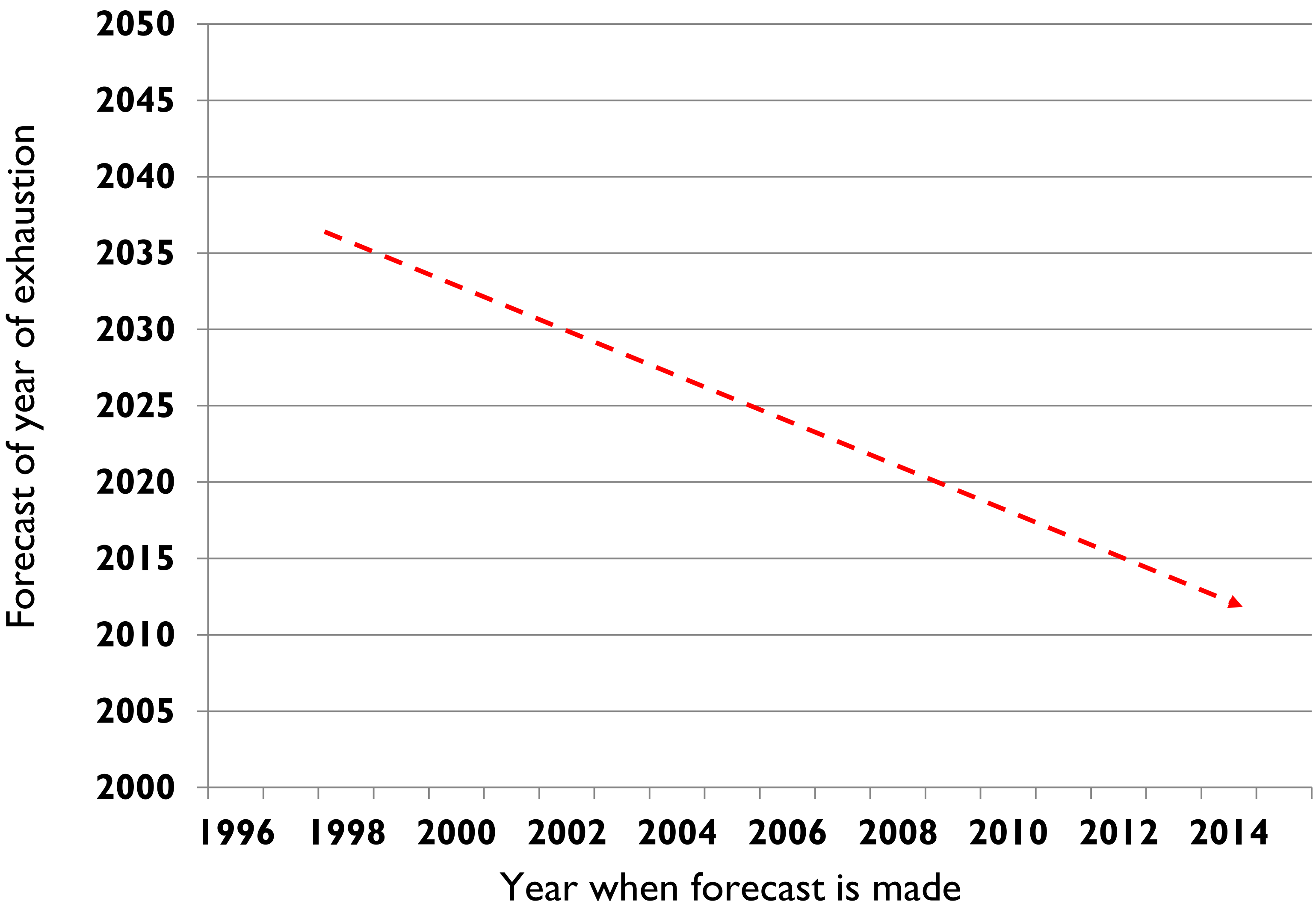


Source: Hepburn, Teytelboym & Pfeiffer (2015, forthcoming); United States Geological Survey Data

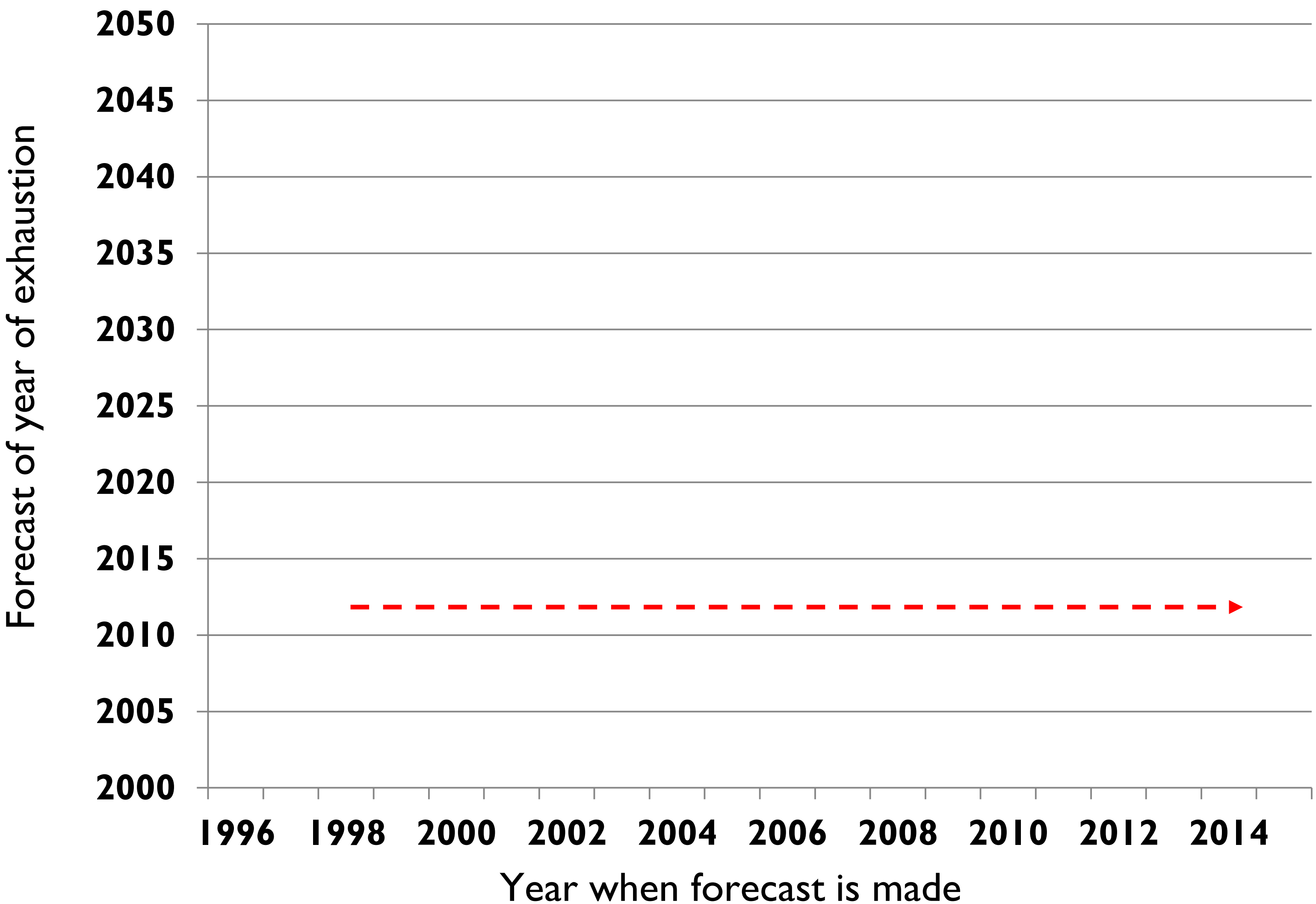
A quick look into the past is revealing…how to previous forecasts stand up to scrutiny?



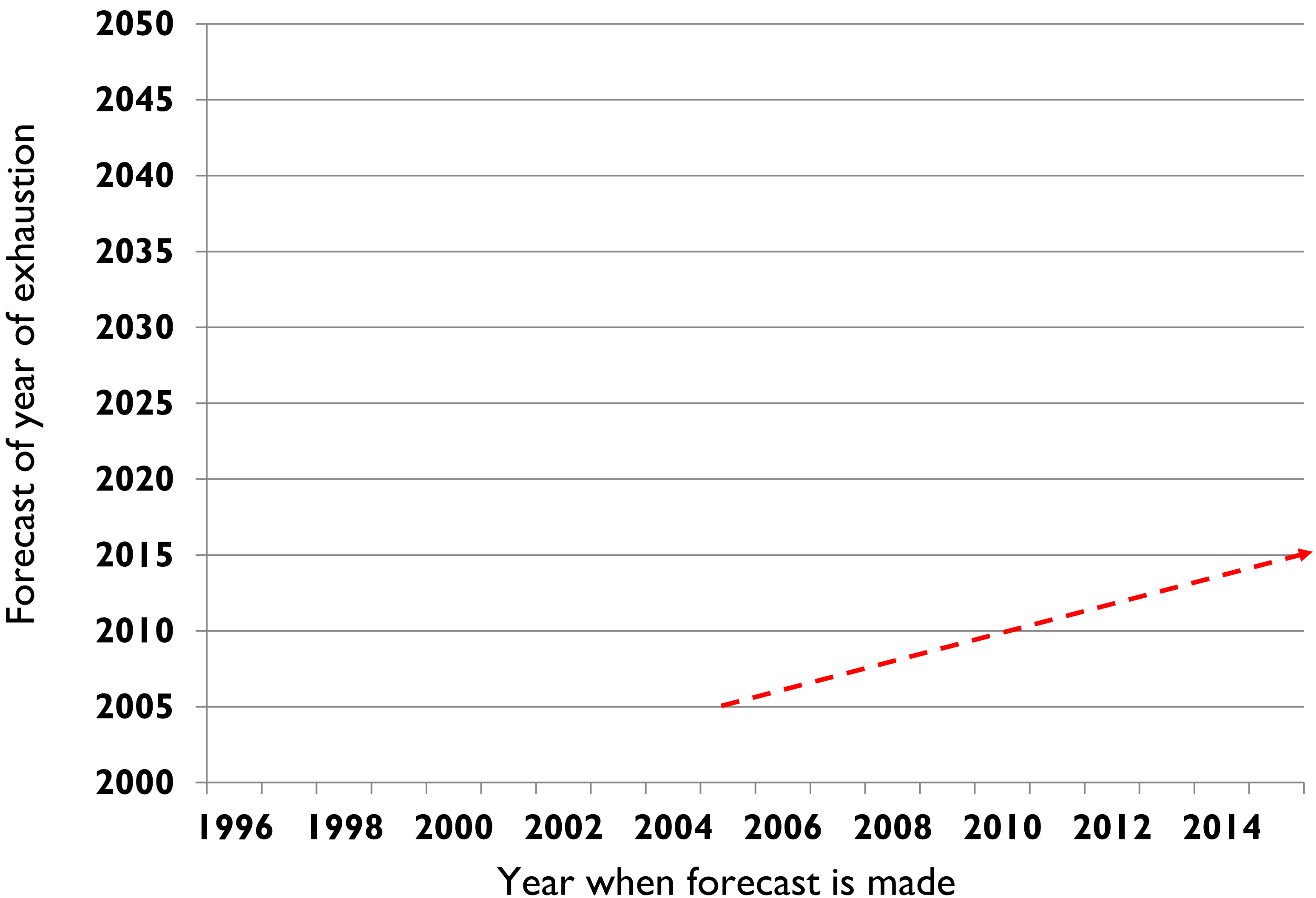
If current production increasing and reserves are static, then exhaustion date moves closer to today



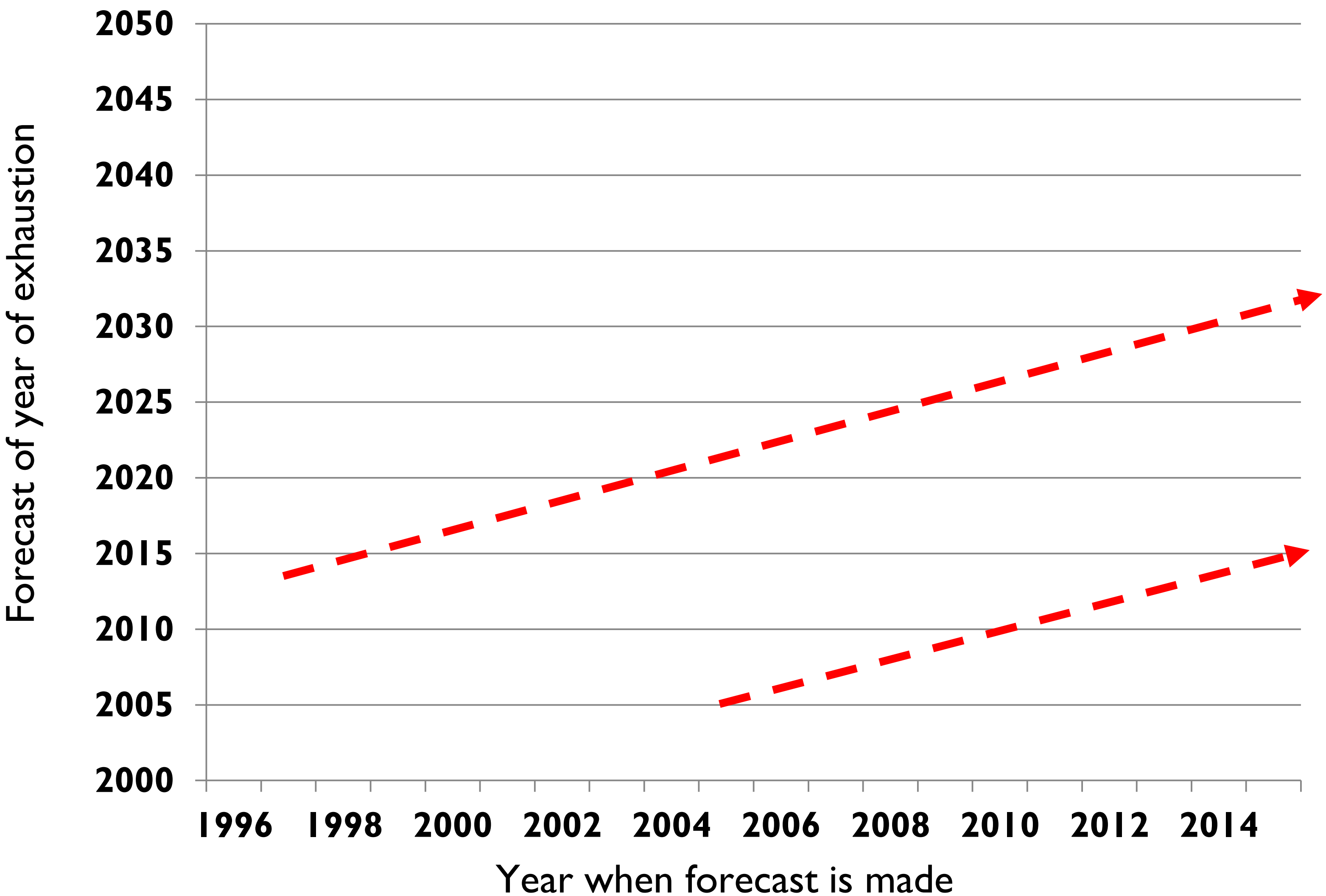
If current production is static and reserves are static, then forecast exhaustion date is steady over time



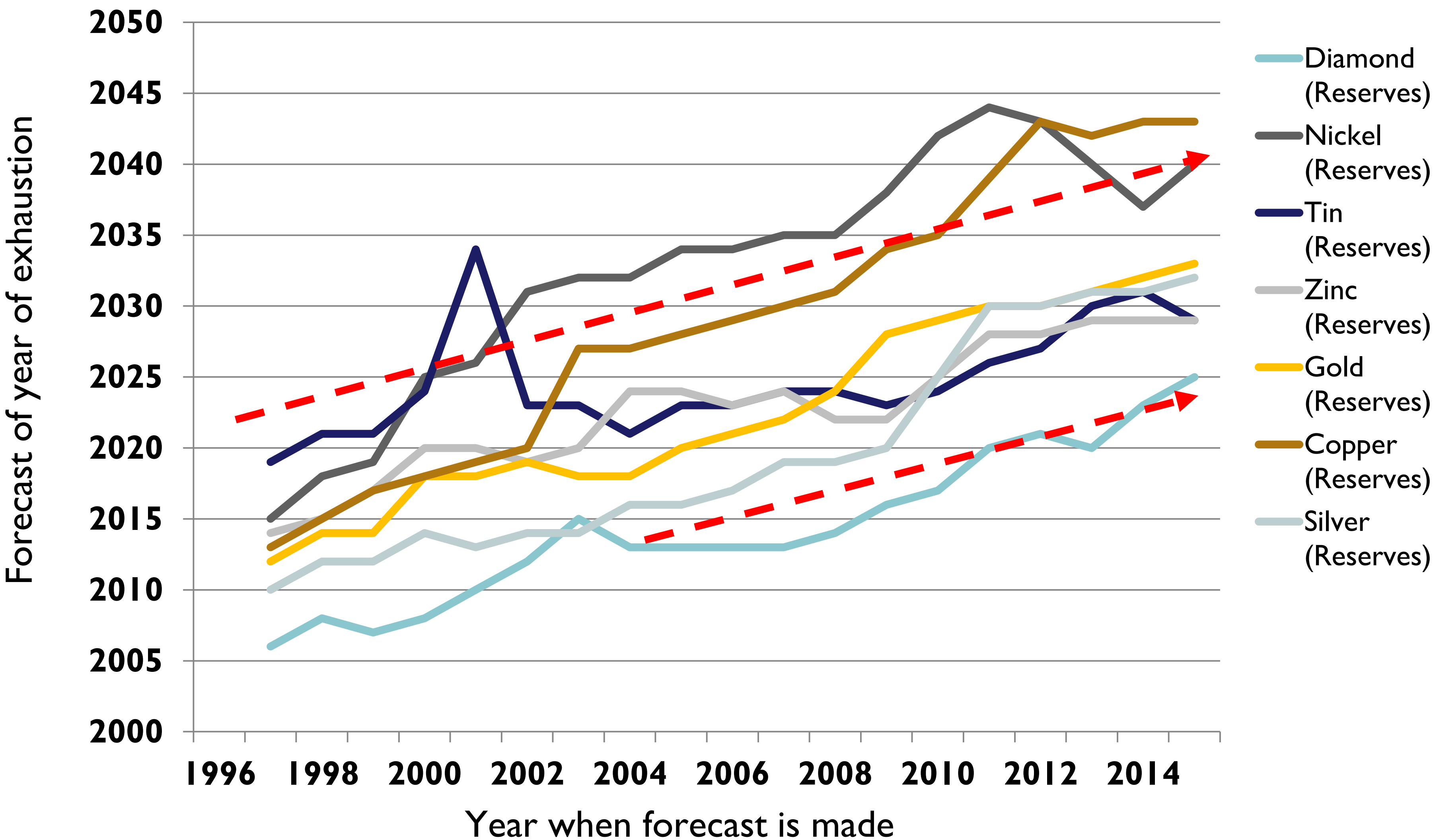
If new reserves replace production, then exhaustion moves a year into the future ever year



And here is a parallel line to guide you

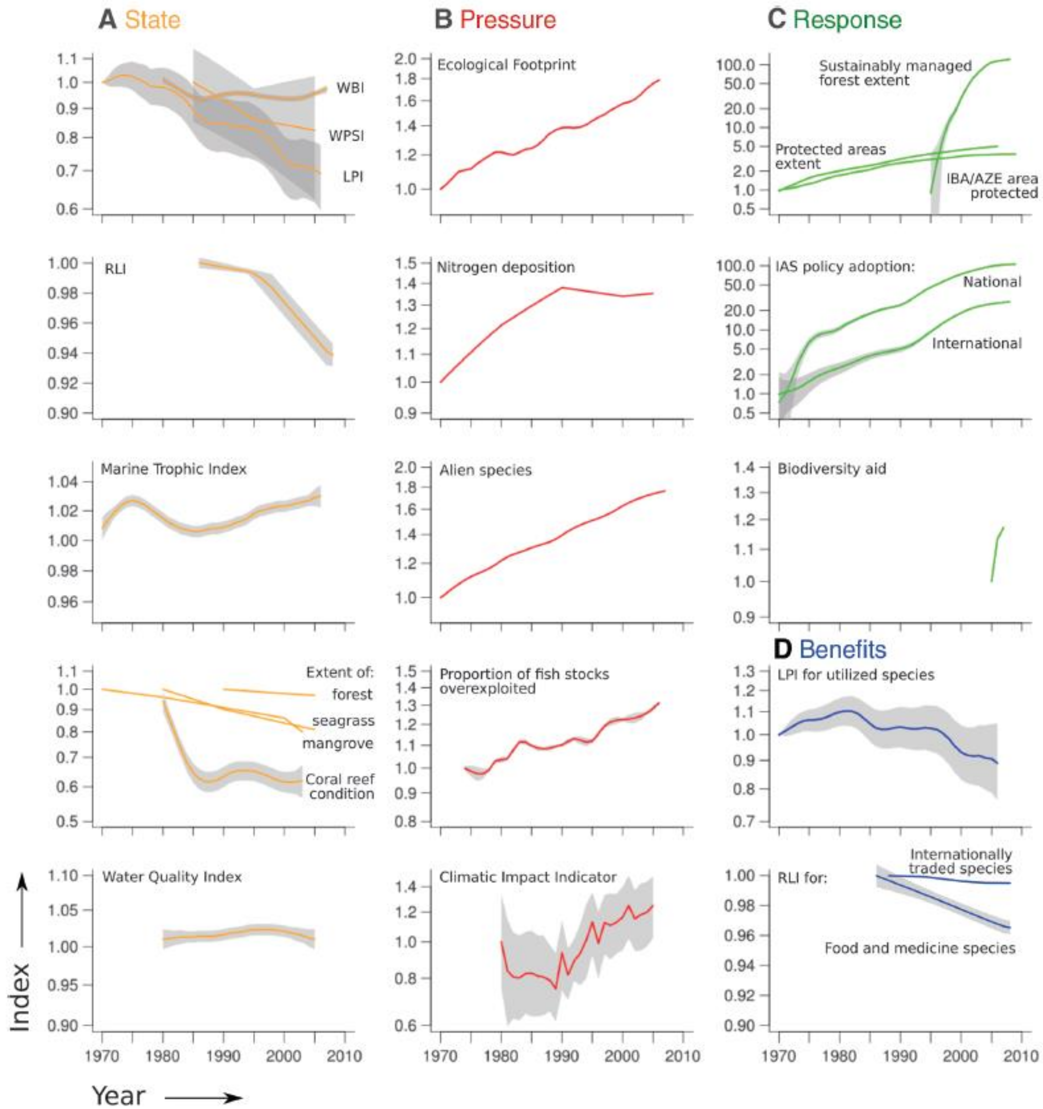


And that is exactly what we find across a range of commodities – steady replacement of reserves



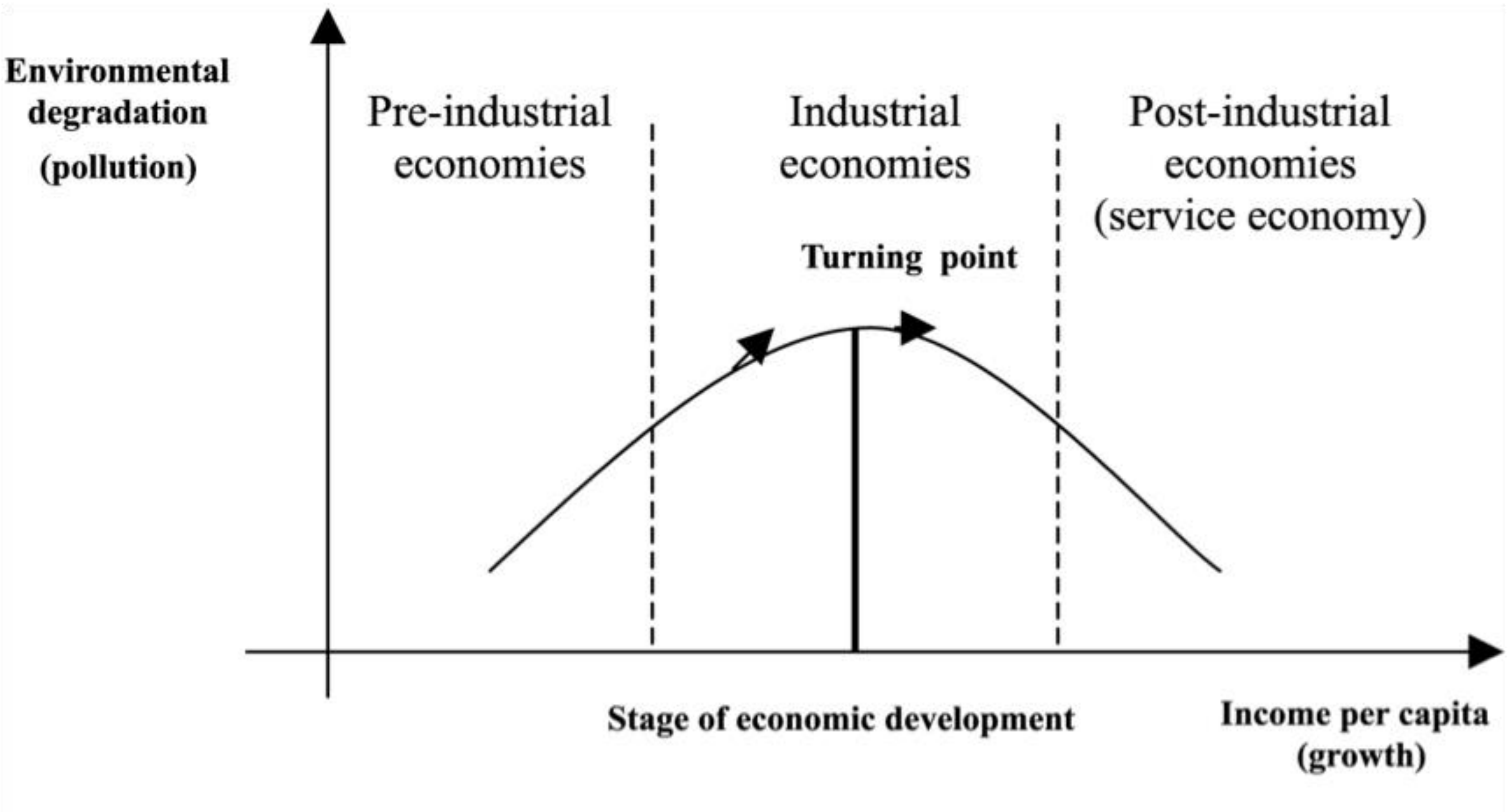
Source: Hepburn, Teytelboym & Pfeiffer (2015, forthcoming); United States Geological Survey Data

Biodiversity decline sub-indices



Do we have to sacrifice economic growth to achieve our climate targets?

The Environmental Kuznets Curve (EKC):[1] Is there a robust relationship between the evolution of a country's per capita GDP and its level of environmental degradation?



1 E.g. Panayotou (1993), Brock & Taylor (2010), Stokey (1998)

Sharpen our focus: The lever that really matters is how ***clean*** the system is

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Consider an energy decomposition:

$$\boldsymbol{Emissions = Popln \times \frac{GDP}{Popln} \times \frac{Energy}{GDP} \times \frac{Emissions}{Energy}}$$

Force people not to procreate? No.

Empower women? Yes.

Want this to go up!

Useful but often overplayed. Beware the curse of Jevons.

Showtime! This is where the action has to be.

Anaerobic digestion – cows 20 times more efficient than world leading ADs

Source: iStock/Gerard Koudenberg

Summary

1. A key question in climate economics is how to accelerate the rate of cost reductions in clean technologies relative to dirty
2. Standards, carbon prices and markets help pull through cleantech, but we know that direct R&D support is also required
3. Given that public R&D in energy is pitifully low, understanding where to direct the available R&D funds is very important
4. This requires understanding and modelling innovation processes much more deeply than we currently do
5. Greater computation allows us to return to Smith and Pareto and to model the economy as a complex dynamic system
6. These techniques may also prove useful in developing new IAMs