

# A framework for the valuation of ecosystem assets

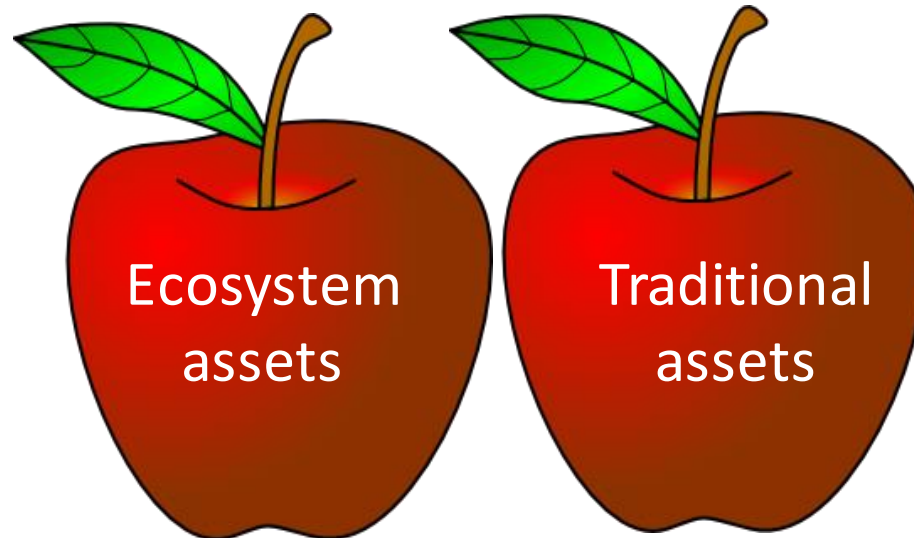
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## Some not to controversial statements about assets

- Capital or assets store wealth & pass opportunities from one period to the next.
- The value of an asset is the net present value of services attributable to that asset. – Sorting out those services can be tricky for real (natural) assets.
- The price of an asset is the change in the value of the asset with a unit change in the quantity of the asset. – Can depend on things other than the quantity of the asset (general equilibrium).
- Assets belong in capital accounts and on balance sheets.
- Value concepts in national accounting and economics are based on exchange.
- There exist essential assets for which the total elimination completely changes the context: Earth without water, DHL or UPS without trucks.

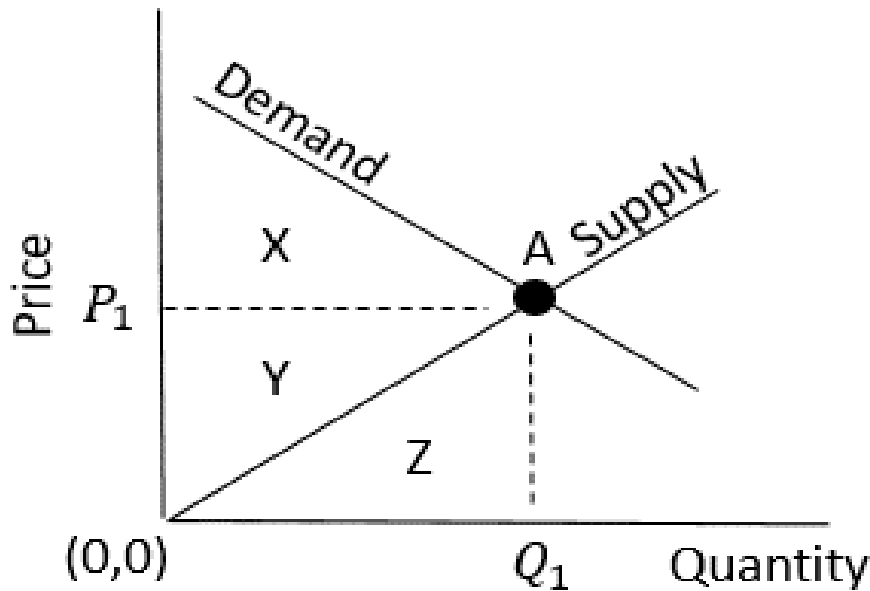


## Core finds of the paper

1. The **value concept is based on exchange** and always **reflects welfare considerations** to the extent the welfare associate with an allocation can be ranked.
2. Changes in welfare and changes in the values recorded in national accounting are connected (approximately) through **index number theory**, if the world is in full general equilibrium.
3. National accountants and economists should be able to **agree on prices and quantities** and approximately on **changes in value** between price-quantity pairs – up to agreeing on account boundaries.
4. National accountants and economists struggle when ecosystem assets are poorly defined, but are very capable of considering price when the physical units of the asset are well defined and mappable to services.
5. A **point of diversion** between economics and national accounts involves the production, asset, and income **boundaries**.
6. A commonality that impairs progress is that economists and national accountants have failed to take advantage of the potential to describe an underlying account structure and **balance sheet that supports measurement of different aggregates**



# Dispelling the exchange – welfare myth (or at least distraction)



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Figure 1. Prices, quantities, producer surplus, and consumer surplus.

Exchange value =  $Y + Z$   
 Gross welfare value =  $X + Y + Z$   
 Net welfare value =  $X + Y$

“Consumer surplus” =  $X$ .

In a perfectly efficient market the Zs here are in the Y’s elsewhere.

In the SNA for production – “total value” is “gross value added” – a marginal concept.

## Dispelling the exchange – welfare myth (or at least distraction)

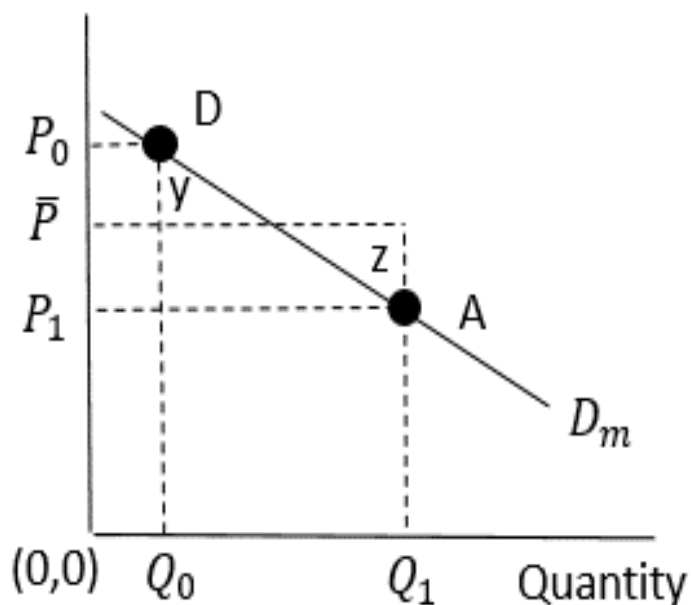


Figure 3. Approximating value changes.

Accounting is at constant prices.

The change in value between  $Q_0$  and  $Q_1$  needs a price index that is  $\bar{P} = 0.5(P_0 + P_1)$ ; Hicks-Harberger price index. Used by Arrow, Dasgupta and other in their wealth accounts.

Other price indices might be preferred, e.g.,  $\sqrt{P_0 P_1}$ , Fisher Ideal Index.

SNA 2008 says to use index numbers for changes.

The concern in the SNA is value of money changes, where money is an index for aggregate capital demand – conceptually the same thing – scarcity!



## Defining value and income

SNA 2008 ““The main objective of the system of national accounts is to provide a comprehensive conceptual and accounting framework that can be used to create a macroeconomic database suitable for analyzing and **evaluating the performance** of an economy.” - Value must be income or consumption based not production based – if there is a difference.

Nordhaus and Tobin (1972) argue that the “value” of interest more broadly are the opportunities for “consumption” that may include, non-consumptive contributions to welfare.

Jorgenson (2018) “While the GDP was intended by its originators as a measure of production, the absence of a measure of welfare in the national accounts has led to widespread misuse of the GDP to proxy welfare. Measures of welfare are needed to appraise the outcomes of changes in economic policies and evaluate the results.”

(Heal 1998) Income in national accounts & economics is Hicksian income or index number based.

Hulten (2006) “when it comes to capital, however, it more a question of what to do than how to do it.” -- The boundaries drawn in the accounts are equity weights.





# Natural v Ecosystem Assets

## Natural assets:

- Are produced by nature in ways that do not respond to market signals;
- Have a single clearly defined unit often associated with a geographic region;
- Their allocation mechanisms can be simple or complex;
- Embody some opportunity to provide a value added service directly or indirectly to people.
- May include things that not really part of an ecosystem, e.g., groundwater.

## Ecosystem assets

- Multi-dimensional & allocation often complex;
- Changes in condition or quality may be more important than quantity for valuation (or changes are discrete);
- Lots of substitution and complementarity impacts on price through expected capital gains;
- Can talk about changes in value but not about prices – without being clear what margin we are talking about.
- **The value of an ecosystem is not the sum of its part without accounting for the interactions among those parts.**



# Valuing Natural Capital and Ecosystem Assets

Present value of net revenue or income

Price can be measured based on

- Current dividends or rents
- “Replacement rate” or “depreciation rate” of the asset
- Interest or discount rate
- Expected price changes (capital gains) to the asset
- Depends on the allocation mechanism or “economic program”

Pretty standard theory.

Functional approximation techniques to get price curves, capn for R.

\* Produces expected capital gains information as a product – not an input.



# Pricing Natural Capital

Extraction process,

$$F(s(t)) = qs(t)x(s(t))^\alpha$$

Changes in stock

$$\dot{s}(t) = rs(t)(1 - s(t)k^{-1}) - F(x(s(t)))$$

Net revenue or resource rents

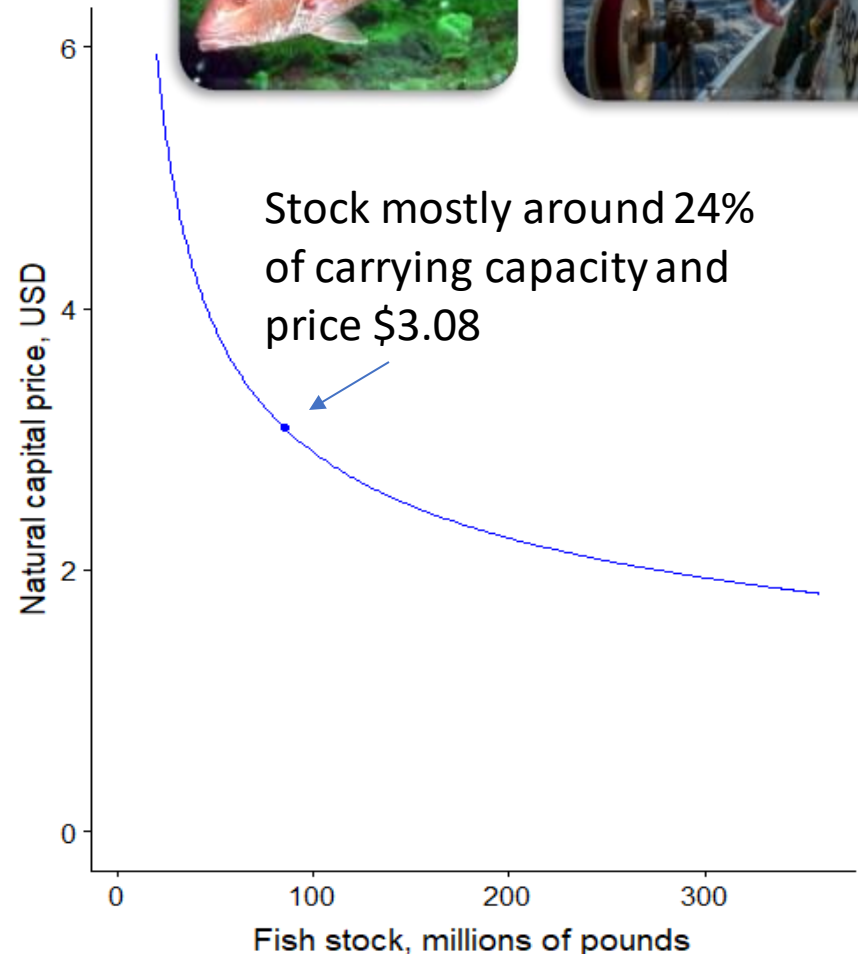
$$W(s(t)) = price \times qs(t)x(s(t))^\alpha - cost \times x(s(t)).$$

Discount rate = 0.02

$r, k, q, \alpha$  are capacity parameters

$\gamma, y$  are allocation parameters

All parameters estimated from fishing logbook data.

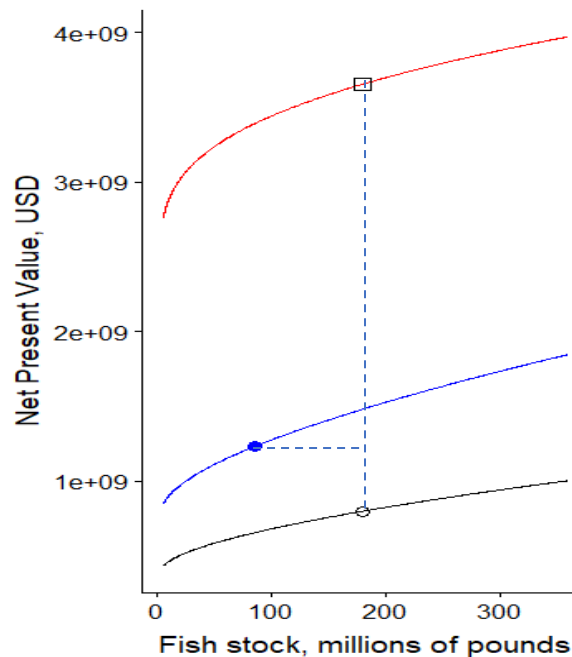
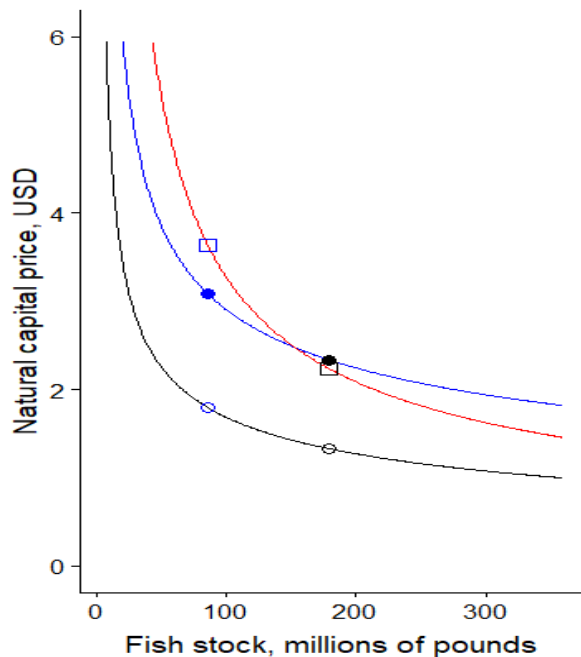


# Valuing changes in natural capital wealth

Thought experiment: what would the change in value of the fish stock, on the balance sheet between two periods be if we move to MSY, 50% of carrying capacity.

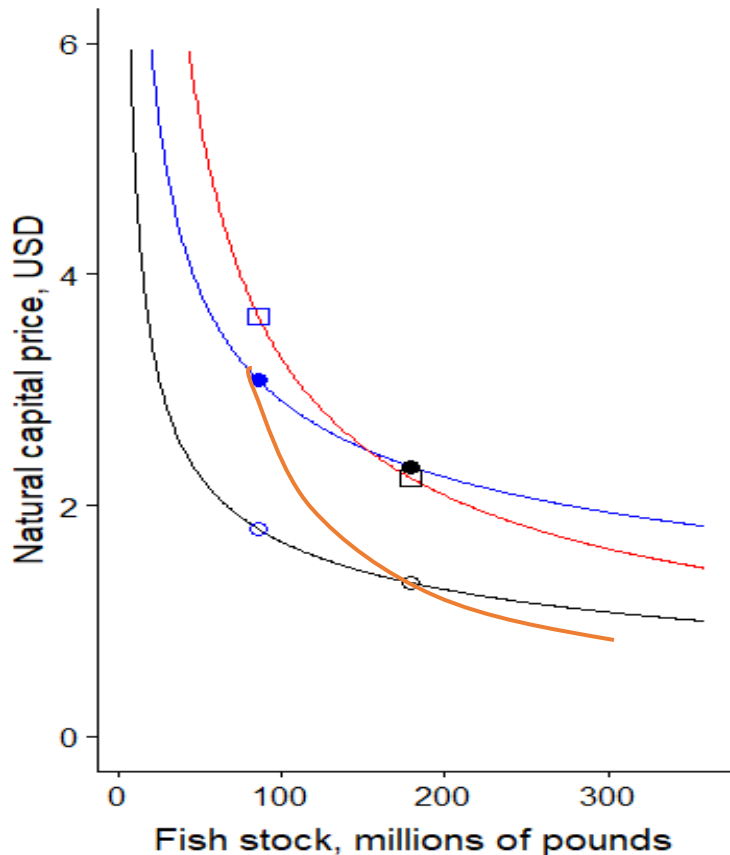
Matters how you achieve the move:

1. Without influencing underlying parameters (not possible in the long-term). blue
2. Change “preference” or incentives of fishers,  $\gamma$ . red
3. Impose gear restriction, change  $\alpha$ . black



Keep in mind the parameter shifts are not the result of general equilibrium – they are “costless.”

# Changes in Value



Institutional and partial v general equilibrium difference not welfare v exchange value difference

## No parameter change:

- Integrating under the curve  $\Delta V = \$247M$  million.
- Hick-Harberger price index,  $\Delta V = \$253M$  million, a 2.5%.
- Fisher Ideal price index:  $\Delta V = \$251M$  million, an error of 1.6%.
- $P_2Q_2 - P_1Q_1 = \$154M$ , 62 % of the actual change in value

## Gear restriction:

- Differencing the integrals:  $\Delta V = -\$435M$  – partial equilibrium assumption or exogenous shift in  $\alpha$ .
- Fisher price index  $\Delta V = 206M$  assumes something like the orange curve so that the change in  $\alpha$  is endogenous – general equilibrium.



## Conclusions

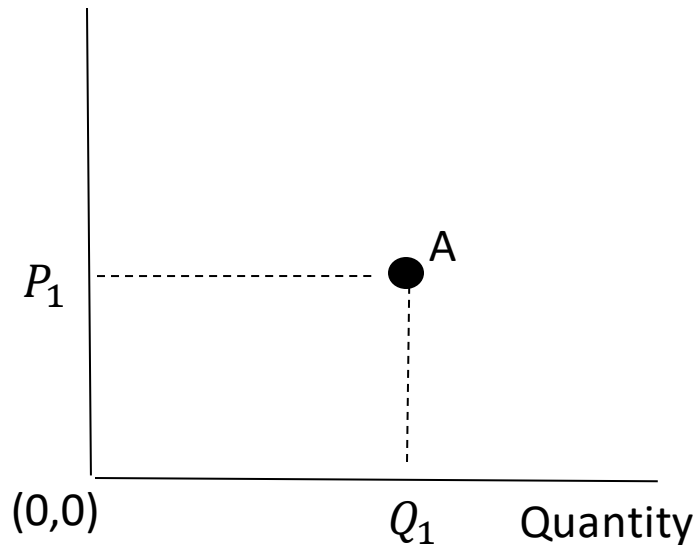
- Feasible methodology exists to value natural and ecosystems assets.
- Need to work at disaggregated scale, but OK (some precision and power tradeoffs).
- Boundaries are the real challenge; boundaries are equity weights.
- Assets matter for production and consumption – the balance sheet should be broad.
- Welfare v exchange value is a distraction for thinking about changes in value.
- Probably worth investing some time in working out the right index number theory.
- “Total value” is either: total value added (marginal concept – so very confusing name) or NPV associated with a give program, not  $P \times Q$ .







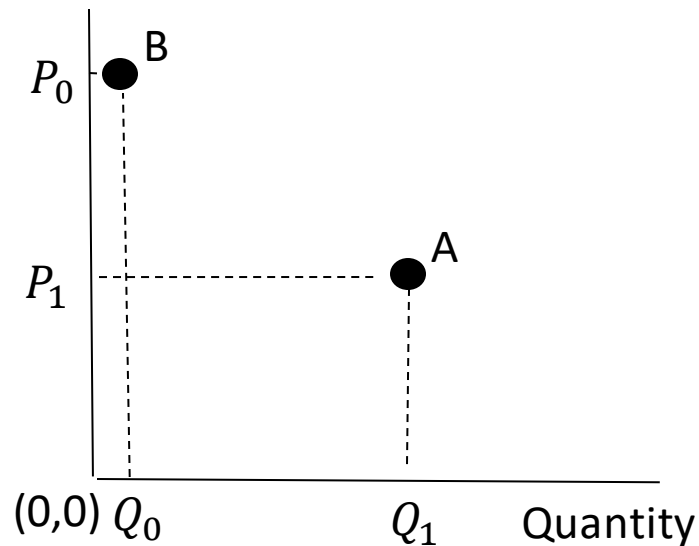
# Dispelling the exchange – wealth myth



1. A P-Q pairs tells us nothing about value.
2. Assume  $Q_1 - Q_0 \approx 0$  or demand is always perfectly elastic – price curve is flat. Give a value concept of  $P \times Q$ .
3.  $P \times Q$  is approximately gross total value added – a marginal concept!



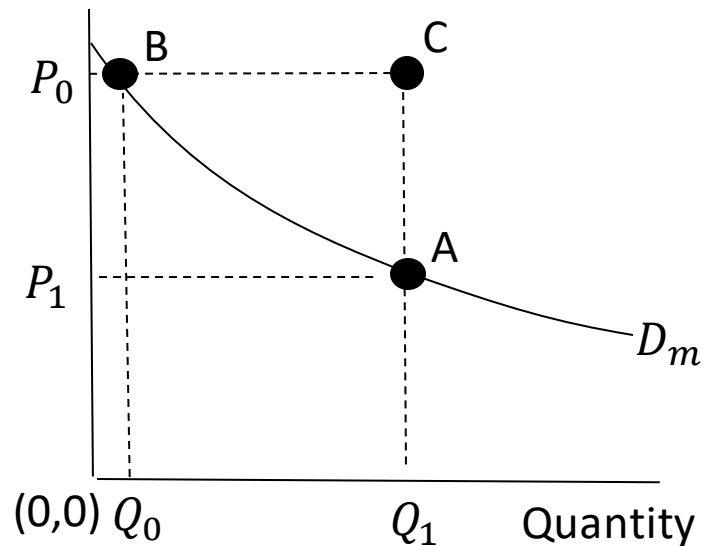
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4. “Total value” must equal the value of a change between  $Q_1$  and zero  $Q$ .
5. But, we observe the pair  $P_0, Q_0$ .
6.  $P_0Q_0 + P_1(Q_1 - Q_0) \neq P_1Q_1$
7. Observing  $P_0, Q_0$  violates the flat price curve assumption.



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7. Observing  $P_0, Q_0$  violates the flat price curve assumption.
8. Observe multiple pairs and estimate a market demand.
9. By defining price as the marginal value of  $Q$  the areas under the demand curve is the change in value.