Spatial green accounting for terrestrial ecosystems: from theory to practice

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- From theory to practice
- Simulated Exchange Value (SEV)
- Applications: case studies and RECAMAN

From theory to practice

Green accounting

- Conventional System of National Accounting (SNA)
  - Value of all the goods produced in an economy
  - Remuneration of productive factors (workers and capital)
  - GDP, GNP, NNP

- Green National Accounting
  - Ecosystem services (recreation, biodiversity …)
  - Natural capital
  - Hicksian Income, Green NNP

Green accounting: Approaches

- Theoretical General Equilibrium Models
  - Optimal control
  - Hamiltonian
  - Green NNP

- Applications
  - Top-down
  - Bottom-up (as SNA accounts are created)

- Spatial green accounting:
  - The goal is a green accounting system that can be used at any spatial scale (allowing the use of GIS)

Theory versus practice

	Bottom-up applied green accounting	Green accounting theory	Cost-benefit analysis (theory)
Prices times quantity for commercial goods	Yes	Yes	No
Prices times quantities for all ecosystem services	Yes	Yes	No
Consumer surplus (commercial and ecosystem services)	No	Yes / No	Yes
Information of the year suffices	No	Yes	No

Inter-temporal general eq. model (forest)

$$\max_{i,h} \int_{t}^{\infty} U(c, a(R)) e^{-r(s-t)} ds$$

$$\dot{K} = i - \delta K$$

$$\dot{R} = g(R) - h$$

$$F(K, h) = c + \phi(i) + \psi(h)$$

U = utility

c = consumption

a = *amenities* of forest

K = human-made capital

i = investments

R = forest biomass

g = biomass growth

h =biomass harvested

r =discount rate

F = production

Hamiltonian = Green NNP

Hamiltonian

$$\mathrm{H} = U(c, a(R)) + \lambda\left(i - \delta K\right) + \mu\left[g(R) - h\right]$$

Hamiltonian (affine)

$$\mathrm{H} = S(c, a(R)) + c\frac{\partial U}{\partial c} + a(R)\frac{\partial U}{\partial a} + \lambda\left(i - \delta K\right) + \mu\left[g(R) - h\right]$$

Hamiltonian = Green NNP

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Hamiltonian "price times quantity"

$$\mathrm{H} = S(c, a(R)) + cp + a(R)\frac{\partial U}{\partial a} + p_i\left(i - \delta K\right) + \left(p_w - p_h\right)\left[g(R) - h\right]$$

Marginal utility of consumption constant:

$$\frac{\partial U}{\partial c} = p$$

First order conditions:

$$\lambda = \phi'(i)\,p = p_i$$

$$\mu = \frac{\partial F}{\partial h}\,p - \psi'(h)\,p = p_w - p_h$$

Hamiltonian = Green NNP

Hamiltonian

$$H = U(c, a(R)) + \lambda\left(i - \delta K\right) + \mu\left[g(R) - h\right]$$

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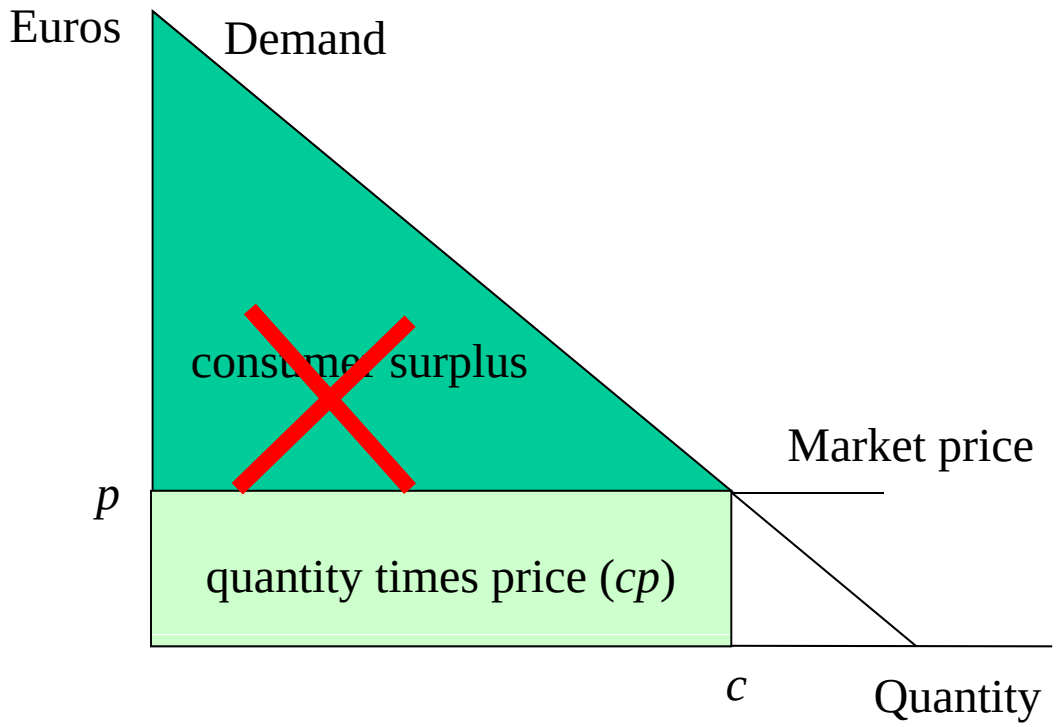
$$H = S(c, a(R)) + cp + a(R)\frac{\partial U}{\partial a} + p_i\left(i - \delta K\right) + \left(p_w - p_h\right)\left[g(R) - h\right]$$

Green Net National Product (linearized Hamiltonian)

$$NNP_G = cp + a(R)\frac{\partial U}{\partial a} + p_i\left(i - \delta K\right) + \left(p_w - p_h\right)\left[g(R) - h\right]$$

We eliminate the consumer surplus

No consumer surplus



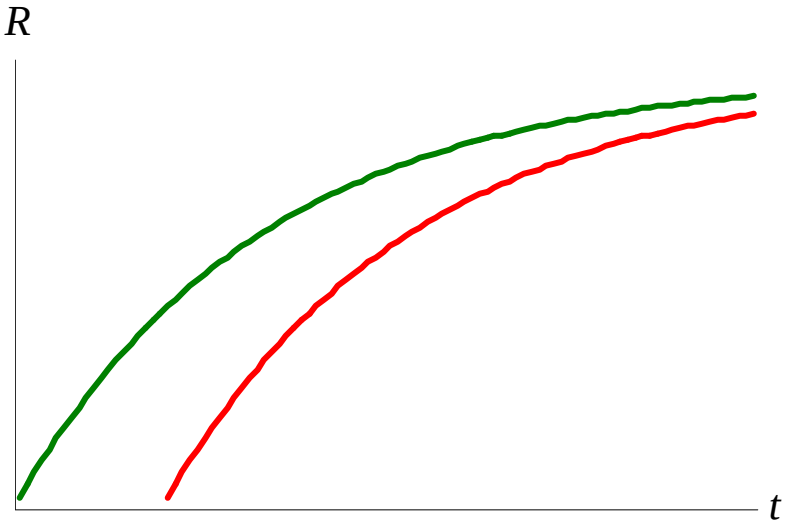
• To get NNP = linearized Hamiltonian we eliminate the consumer surplus

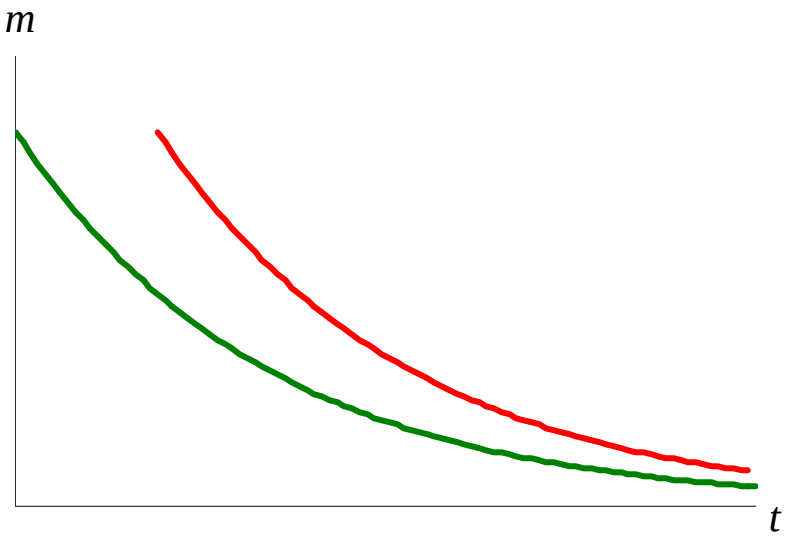
•This corresponds to a linear, and hence additive, index of intertemporal welfare (this allows spatial aggregation)

Summary

	Bottom-up applied green accounting	Green accounting theory	Cost-benefit analysis (theory)
Prices times quantity for commercial goods	Yes	Yes	No
Prices times quantities for all ecosystem services	Yes	Yes	No
Consumer surplus (commercial and ecosystem services)	No	No, for linearized Hamiltonian = NNP	Yes
Information of the year suffices	No	Yes	No

Natural capital (forests)





The result that information of the year (instant) sufices to estimate natural capital variations

$$NNP_G = cp + p_i\left(i - \delta K\right) + ap_a + \left(p_w - p_h\right)\left[g(R) - h\right]$$

dependes on the following assumptions:

- All species follow the same growth function
- Growth decays exponentially
- Only aggregate accounts are relevant (no spatial disaggregation)

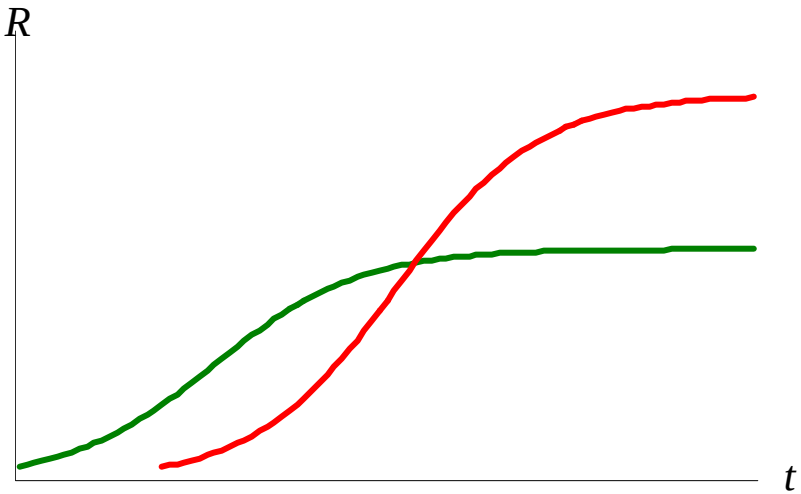
$$R(t) = \int_0^t m(t, b(s), s)dz - \int_0^t h(t)dz$$

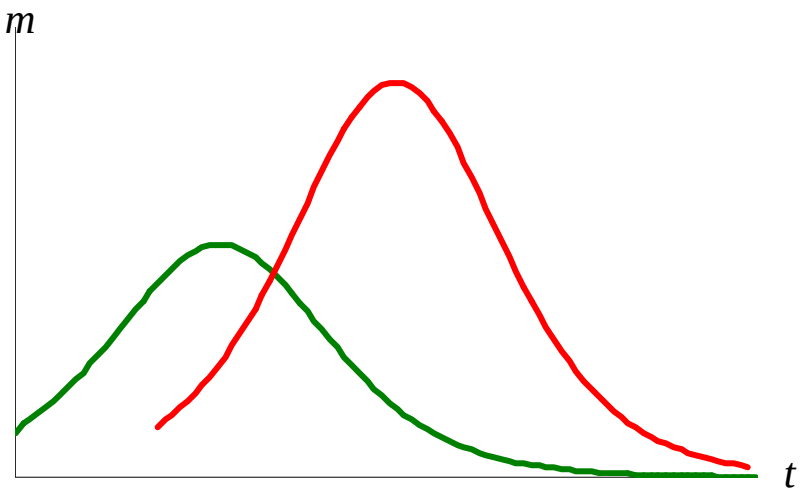
$$m(t, b(s), s) = m(t, b, s) = Ge^{-b(t-s)}$$

$$\dot{R}(t) = \left[G - b\int_0^t Ge^{-b(t-s)}dz\right] - h(t) = \left[G - bR(t)\right] - h(t)$$

$$\dot{R}(t) = g(R(t)) - h(t)$$

Natural capital (forests)





However, if:

- NOT all species follow the same growth function
- and/or growth does NOT decay exponentially
- and/or spatially explicit results are relevant

$$R(t) = \int_0^t m(t, b(s), s)dz - \int_0^t h(t)dz$$

$$R(t) = \int_0^t g(t, b(s), s, h)dz$$

Natural capital (forests)

$$\max_{i,h,x} \int_{t}^{\infty} U(c, a(R)) e^{-r(s-t)} ds$$

$$\dot{K} = i - \delta K$$

$$\dot{R}(t) = g(R(t)) - h(t)$$

$$F(K, h) = c + \phi(i) + \psi(h)$$

Natural capital (forests)

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$$F(K, h) = c + \phi(i) + \psi(h)$$

$$\mathrm{H} = U(c, a(R)) + \lambda\left(i - \delta K\right) + \int_t^{\infty} g(s, b(t), t, h)\mu(z) dz$$

Summary

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Prices times quantity for commercial goods	Yes	Yes	No
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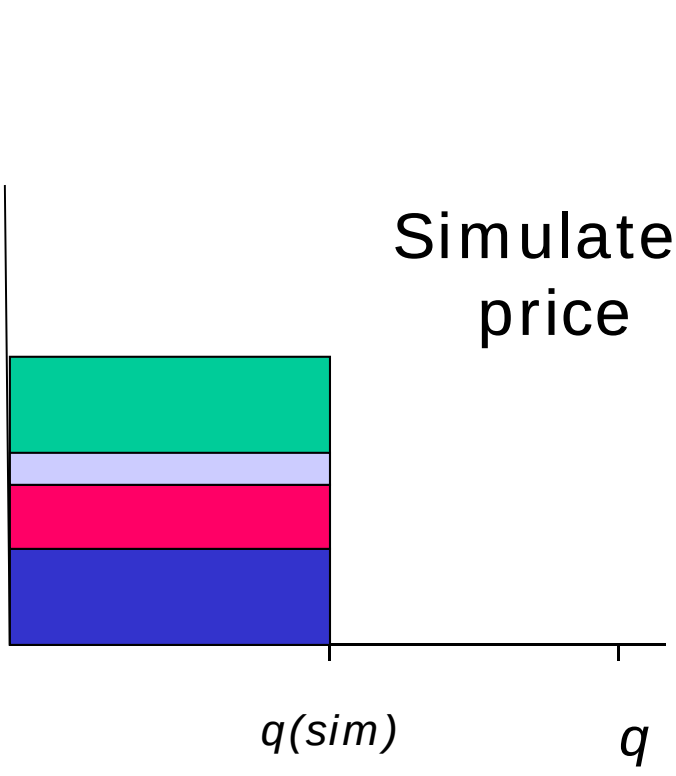
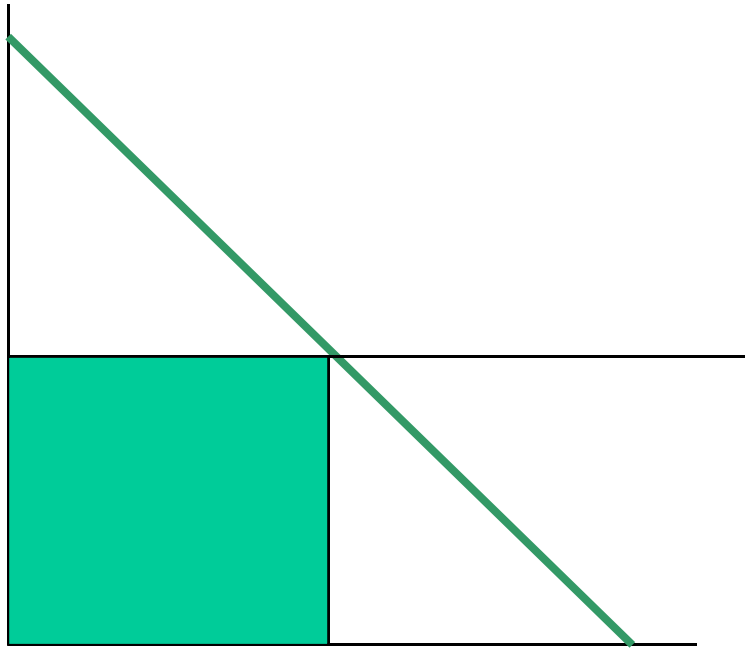
Consumer surplus (commercial and ecosystem services)	No	No, for linearized Hamiltonian = NNP	Yes
Information of the year suffices	No	No, if unrealistic assumptions are removed	No

Simulated Exchange Value (SEV)

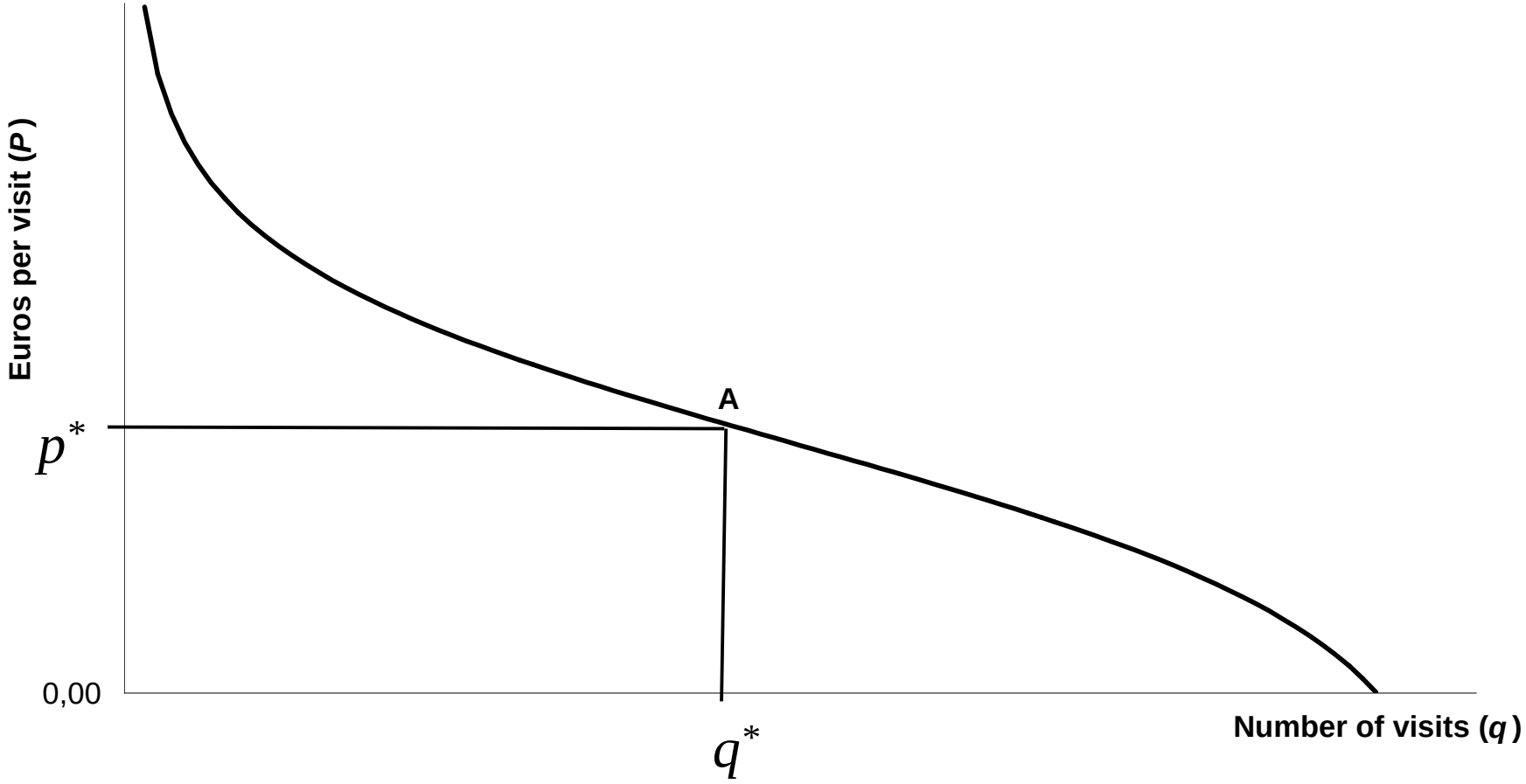
Environmental marginal values



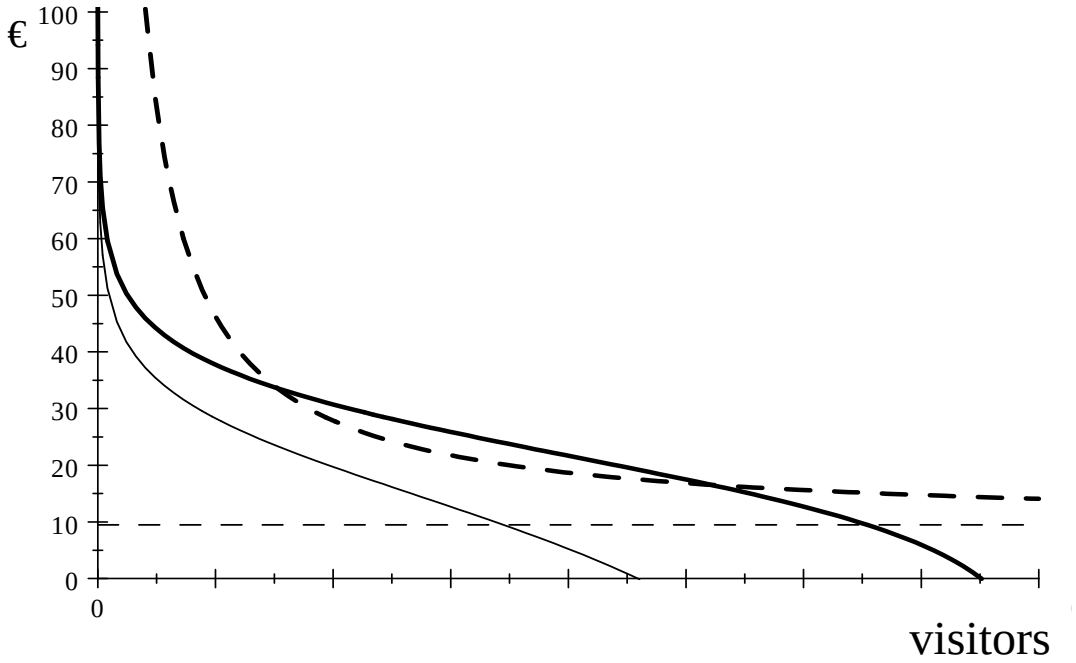


Hipotetical market

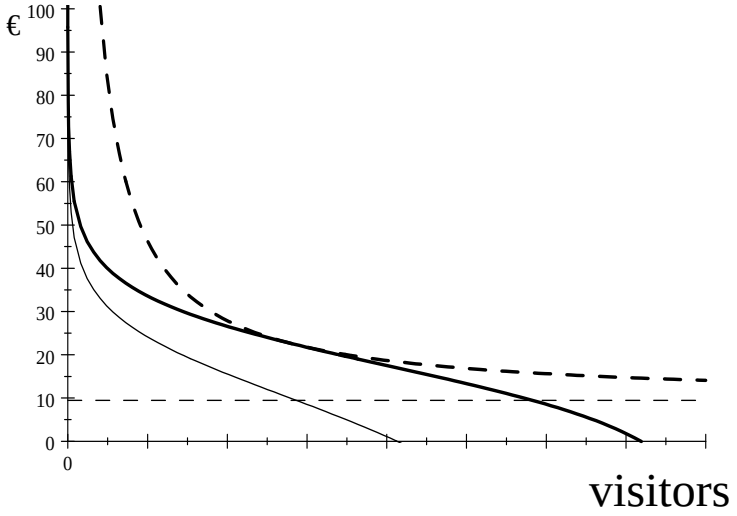
Free access recreational services (demand)



Perfect / Monopolistic competition



Short-term

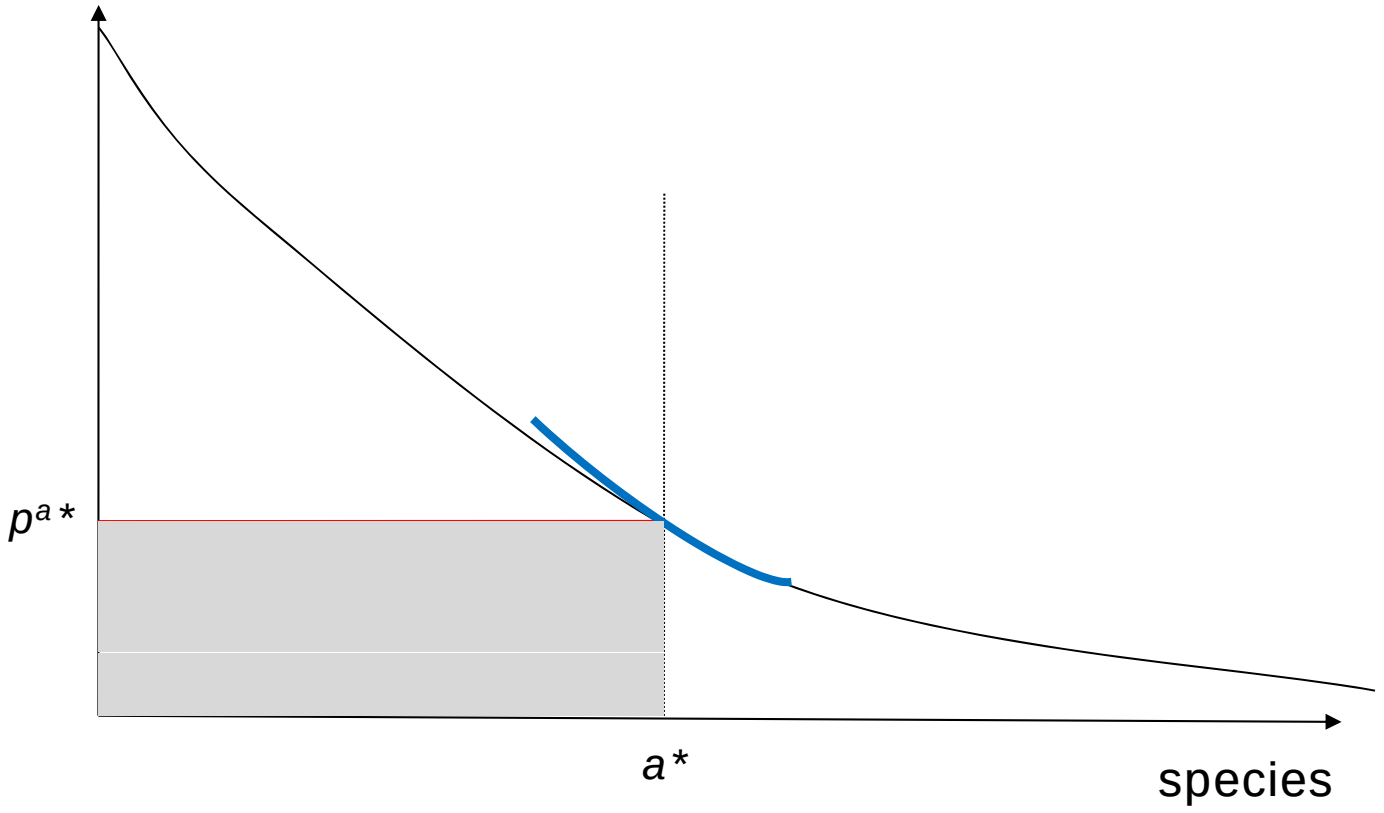


Long-term

Monopolistic competition in the short run (a) and in the long run (b). The demand is the thick solid line, marginal revenue the thin solid line, average cost the thick dashed line and marginal cost the thin dashed line.

Endangered species

- Choice experiment or CV
- General plan to protect threatened species
- Voluntary payment for one particular species



Endangered species, ecosystems, etc.

- But even “marginal” accounting prices we have a very large number:
  - For endangered species
  - For iconic endangered species
  - For oak ecosystem
  - For pine ecosystem
  - For pastureland
  - ….
- Thus, to ensure that the budget constraint is respected, we need to specify a relevant set of ecosystems and/or endangered species and investigate them **simultaneously**.

- Choice experiments and then simulate the payment for the ecosystem service

Carbon sequestration

- Not all the carbon sequestered could be internalyzed
- Distinguish Kyoto carbon from non-Kyoto
- Value using reduced EU-ETS prices (to take into account the impact that including sequestration would have on the price)

Applications:
Case studies and RECAMAN

Case studies

Class	Guadarrama pines				Monfragüe cork-oaks			
	ESA 95		Public environmental	AAS	ESA 95		Public environmental	AAS
	EAF 97	Omitted			EAF 97	Omitted		
	1	2	3	4=1+2+3	1	2	3	4=1+2+3
Total output (TO)	**235**	**394**	**235**	**864**	**538**	**138**	**17**	**693**
Intermediate output (IO)		12		12		16		16
Livestock-grazing (GR)		*12*		*12*		*16*		*16*
Final output (FO)	235	382	235	852	538	122	17	677
Timber (TH)	*235*			*235*				
Cork (CS)					*462*			*462*
Firewood (FH)					*76*			*76*
Hunting (HR)		*3*		*3*		*37*		*37*
Mushrooms (MC)			*24*	*24*				
Owners' self-consumption (SC)		*379*		*379*		*85*		*85*
Min		*199*		*199*		n.a.		
Max		*379*		*379*		*85*		*85*
Public access recreation (VR)			*178*	*178*			*8*	*8*
Min			*38*	*38*			*3*	*3*
Max			*178*	*178*			*8*	*8*
Conservation, visitors (VC)			*33*	*33*			*9*	*9*
Total cost (TC)	**100**	**62**		**162**	**192**	**6**		**198**
Intermediate consumption (IC)	45	48		93	48	6		54
Private (PIC)	*45*			*45*	*48*			*48*
Governmental[a] (GIC)		*48*		*48*		*6*		*6*
Labour (L)	47	14		61	142			142
Private (PL)	*47*			*47*	*142*			*142*
Governmental[a] (GL)		*14*		*14*		n.a.		
Fixed capital consumption (FCC)	8			8	2			2
Net operating margin (NOM)	**135**	**332**	**235**	**702**	**346**	**132**	**17**	**495**
Gross value added at market prices (GVA)	**190**	**346**	**235**	**771**	**490**	**132**	**17**	**639**
Net value added at market prices (NVA)	**182**	**346**	**235**	**763**	**488**	**132**	**17**	**637**

Source: Campos, P. and Caparrós, A. (2006). Social and private total Hicksian incomes of multiple use forests in Spain. *Ecological Economics* 57: 545-557.

RECAMAN: Mediterranean *Monte* Ecosystems Total Income Green Accounting

- *Andalusian montes* cover 4.7 million hectares, or 54% of Andalusia (61% forest, 21% shrubland, 10% grassland, 8% other)

- They provide many ecosystem services and are part of one of the bio-diversity hotspots of the world (Mediterranean forests)

- Ownership:
  - 72% private
  - 28% public.

Source: Campos: P. and Caparrós, A. (2011). *Forest* income and capital accounting: RECAMAN Project. London Group on Environmental and Economic Accounting, 17th Meeting Statistics, Sweden, Stockholm 12-15 September. http://unstats.un.org/unsd/envaccounting/londongroup/meeting17/LG17_13.pdf

Commercial and environmental values

- **Accounting for**
  - Flows: price x quantity
  - Capital: future discounted capital income flows

Main commercial values:

- Timber growth and felling (age structure)
- Cork growth and stripping
- Natural grass and acorn fodder
- Hunting (age structure)
- Mushrooms

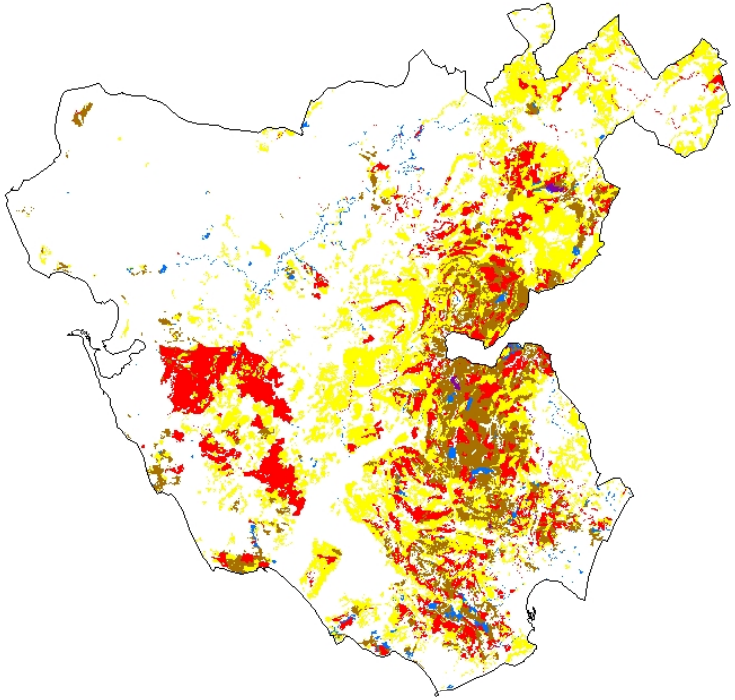
Main environmental values:

- Public recreation
- Owner amenity self-consumption
- Selected landscapes
- Threatened biodiversity
- Carbon sequestration
- Water

RECAMAM: Primary Data

- Forest National Inventory (age structure)
- Land cover and land use data GIS
- Prices of over 4,000 transactions per year on forest products
- 57 revenues and costs in depth analysis of *montes* estates
- Face to face interviews:
  - 800 interviews to *montes* non-industrial landowners
  - 4,000 interviews to free access visitors (CV and choice experiments)
  - 4,000 interviews to households (CV and choice experiments)
  - 800 interviews to hunters
  - 800 interviews to *montes* hunting estates
- 4,000 telephone interviews to mushroom gatherers
- 1,600 internet interviews to households in Portugal, France, Italy, Germany and England.
- Public expenditures on *montes* disaggregated by activities

Results are GIS based



Thanks!

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