Value Detection of Species through Payment for Ecosystem Services and Landscape Management

Integrating Willingness to Pay for ESS and Nature Provision in Approaches of Biodiversity Management

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PES for Bio-Diversity?

Issues in Pure Monetarization of Bio-Diversity

- Economic values are still considered as price labels.
- Monetary values of ESS are trusted as shields against land conversion?
- User Values and accounting are most relevant for trading.
- “Pricing in” or valorization for providers means to get profits from selling a product; not to conserve!
- Prices are a mean to allocate resources; prices are variables: see grain prices at stock exchanges
- The diamond-water problem: what is scarcity and what is a valuable commodity?

Can There be a Role of Ecologists in PES?

- How can one use the knowledge of a concept of ecosystem function of species in a food-web for service qualification
  > Which species are needed: complementarities of species?
  > protection as much as possible?
- Concept of economics as choice and substitution of inputs to reach an objective
  > substitution of species in ecology and economy
  > selective extinction of species with “low value” possible?
- Management of ecosystems vs. resource management
  > values are derived from objectives
  > management needs specific values how the inclusion or abandonment of elements (species) change the function (here objective: “well-being”)

Concept

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- Linear programming is used to get objective functions and behavioral equations of farmers (providers) citizens (users) of ESS and eco-system managers.
- An ecosystem manager pursues the idea of a depiction of functional importance of species.
- He is a mediator of the PES as he extracts money from citizens
- Habitat designs are translated into species prevalence
- Eco managers use compensation payments (for providers) and tax (from users) to establish an PES actively for Biodiversity.
- Flexible shadow prices are derived from optimization and equating of quasi demand and supply functions including the service of management. They are the “new prices for species”.
- The eco manager pursues an ecological valuation. He has discretionary and maneuverable options for “nature design”.
- The equilibrium gives optimal shadow prices (values) in a simulated equilibrium. They are substitutes for “market” values.

Idea for a Price Analysis build on Shadow Prices

- Primal: linear programming and shadow prices:
- Min {c e} (1)

  $A\ e \geq \mathbf{s}$
- with

  e : = activities

  c : = unit costs

  s : = target, i.e. species vectors

ecologists knowledge

- Dual: (2)
- Max {s'λ }

  $A'\lambda + r \leq c$
- with:

  λ : = shadow prices

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Objective Function

Calibrating a quadratic cost approach to provision
(by Maximum Entropy for Matrices Q_i)

$$E = [c-p]' e - 0.5\, e' Q_1 e + e' Q_2 \lambda - 0.5\, \lambda' Q_3 \lambda \qquad (3)$$

with:

$e = A^{-1} s$ and $\lambda = A' [c-p]$

a description of the expenditures emerges to get a species vector

$$E = [c-p]' A^{-1} s - .05\, s' A^{-1\prime} Q_1 A^{-1} s + s' A^{-1\prime} Q_2 \lambda - 0.5\, \lambda' Q_3 \lambda \qquad (4)$$

Equation 4 prevails for a desired species vector '**S**' given by ecologists.

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Fig. 1a: Traditional land use structure

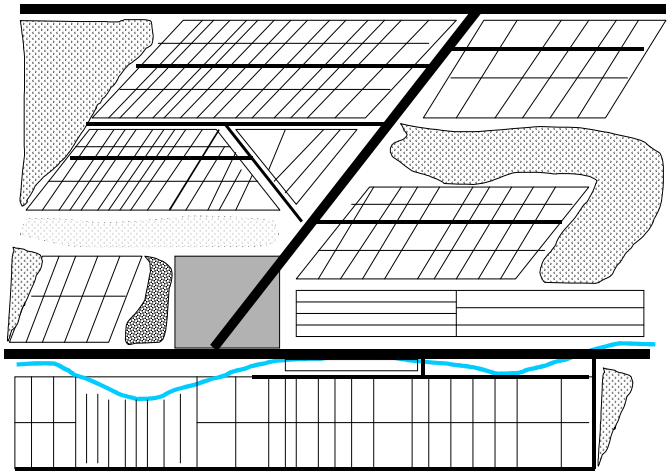
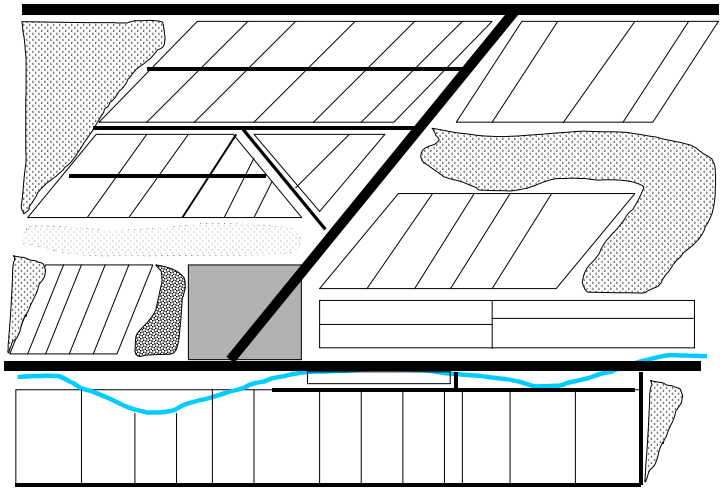


Fig. 1b: Modern land use structure



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tools for landscape modeling

$$s \geq \Xi_I \, e + X_{II} \, x \qquad (5)$$

$$e = \begin{bmatrix} a - a_0 \\ b - b_0 \\ y - y_0 \\ c \\ u \end{bmatrix}$$

change in farm size
change in field size
change in yields
buffer strips
additional labor

Ξ_I : can be retrieved

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depiction of farmers (providers) objective function

$$P(p,g,a,b,i,\Delta b,\Delta u,\Delta i) =$$

$$p \cdot q + g \cdot e - \pi_1' q - .5[q-e]' \Pi_1 [q-e] - \pi_2' e + e' \Pi_2 e + z' \Omega [q-e] \quad (6)$$

where:

e : = efforts or activities

q : = crops

g : = compensation payments corresponds to c: request as in PES of providers

A supply system q, e is obtained from differentiation

$$g - \pi_2 - \Pi_1 [q-e] + - \Pi_2 e + \Omega z' = 0 \quad (7a)$$

$$p - \pi_1 - \Pi_1 [q-e] + \Omega z' = 0 \quad (7b)$$

Farmers offer "e" given a compensation payment "g"

$$e = \Pi_{f,1} g + \Pi_{f,2} z \quad (8)$$

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willingness to pay of citizens (users)

general frame of depicting the user benefits by linear programming

Min {p'z} (minimization of expenditures given an aim a)

s.t. $\Theta_{c,z}\, z \geq a - \Theta_{c,s}\, S - \Theta_{c,x}\, q$ (9)

$z \geq \underline{z}$

where additionally>

z: purchased good for amenities
a: amenity index of satisfaction
p: price of z good
S: species vector as characterizing biodiversity
q: by-product land use

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The corresponding dual problem is

Max { $[a - \Theta_{c,s}\, s - \Theta_{c,x}\, q]' \tau + \Theta' z$} (10)

s.t. $\Theta'_{c,z}\, \tau \leq p$

Where additionally>

τ : shadow price for ESS received (vector of species): WTP

Comment on flexibility and application for different PES cases of biodiversity as ESS

- The above linear programming approach on willingness to pay can be used for indirect benefits of biodiversity as ESS.
- For example, if a poor person wants to minimize his efforts in food production, an ESS (as service vector of species) is valuable in terms of the shadow price.
- It can be also be a commercial farm operator who minimizes is minimizing his costs given that he wants to produce a certain amount of topical products based on ESS.
- The willingness to pay derivation is based on coefficients which describe technologies or technologies to meet preferences.

indirect utility function and willingness to pay

$$V(z,\tau) = .5\,\tau' S_v\,\tau + \tau'\,\chi_v' z + .5\,z'\,Q_v\,z \qquad (11)$$

Where:

τ : shadow price for amenity: willingness to pay for species

To derive optimal behavior we take

$$\delta V(z,\tau)/\,\delta z = \chi_v'\,\tau + Q_v\;z \;=\; p\,z \qquad (12)$$

$$\delta V(z,\tau)/\,\delta \tau = Q_v\,\tau + \chi\;\; z \quad = a - \Theta_{c,\,s}\,\mathbf{s}_{c^*} - \Theta_{c,x} q$$

demand of citizens/consumers:

$$\Psi_{c,1}\,\tau \;= \Psi_{c,2}\,a + \Psi_{c,1}\,\mathbf{s}_c^{*} + \Psi_{c,3}\,q + \Psi_{c,3}\,x_z \qquad (13)$$

This derived demand function is artificial, though gives WTP as shadow price for PES simulation

ecologist as managers

$\mathbf{S}_n = \mathbf{S}_c^* + s_d$

Where:

S_n := choice of ecologist

S_c^* := choice of consumer

s_d := deviation

objective of the ecologist as manager

$$N(S_n) = - s_d' \Phi_{b,1} [s_n - s_d] - [s_n - s_d] \Phi_{b,2}' c - .5\, c' \Phi_{b,3}\, c$$
$$+ \lambda_e' [s_n - s_d] - C(\iota, l) + s_d' \Phi_{b,4}\, x^e + c' \Phi_{b,5}\, x^e$$

where additionally:

$C(\iota, l)$:= cost to pursue the ecologically desired species composition (14)

l := labor

ι := shadow price of labor of the manager

This objective function of the manager is given by

- own preferences
- cash balances and
- labor costs

A demand of ecologist as manager of an ecosystem is:

$$\delta N / \delta s_d = - \Phi_{b.1} [s_n - s_d] + \Phi_{b.2}' g + \lambda_e + \Phi_{b.4}\, x^e = 0$$

equilibrium

- The derived provision (farmer) and request (users for species and ecologists for ecologically preferred species) functions can be used to simulate an equilibrium of

$[\ \lambda\ ,\ g\ ,\tau\ ]$ and S. i.e. S_N and S_C

- We receive shadow prices for species that depict a social optimum.
- The shadow prices are given by budget incidences (WTP).
- Ecologist (eco-manager) are mediators with a planning competence, they are managers with a budget and employees with an income as well as interests.
- Eco-Managers can (must) pursue detailed planning based on ecological concepts of functionality which imply recognition of species beyond WTP for profound PES.
- There is a compromise between ecology and economy

Conclusion

- Valuation in PES, based on biodiversity, might include species or nature products explicitly.
- The presented biodiversity valuation in a PES framework needs and an be solved by modeling.
- Valuation has to be translated into functions and material flows which capture beneficiary and provider optimization.
- Valuation can be done by management.
- It is grounded in an equlibrium of shadow prices