Designing cost-effective compensation payments for conservation measures:

Agglomeration payment, agglomeration bonus or homogeneous payment?

(work in progress)

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Motivation

Biodiversity conservation often depends on a particular type of land use which may, however, be costly for land owners in terms of foregone economic benefits.

Payments to compensate land users for these foregone benefits have become one of the most important instruments for biodiversity conservation worldwide.

One key challenge when designing compensation schemes for conservation measures is to account for the spatial arrangement of habitats.

Why?

Motivation

In spatially structured landscapes, species populations exist as metapopulations, which consist of subpopulations each of which inhabits a habitat patch

If individual members of species can move between patches, this is beneficial for survival of metapopulation because it allows recolonization of patches

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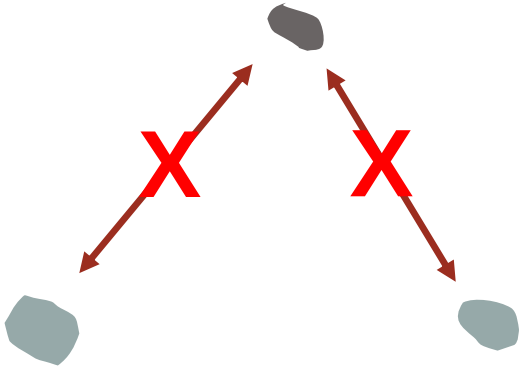

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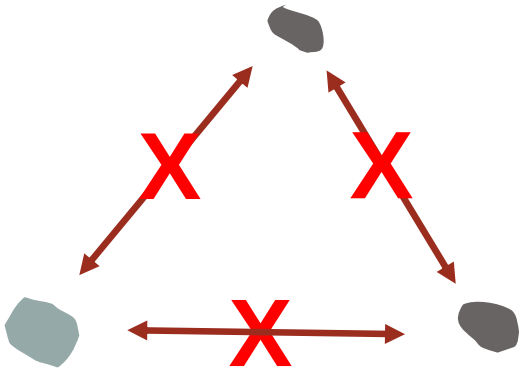

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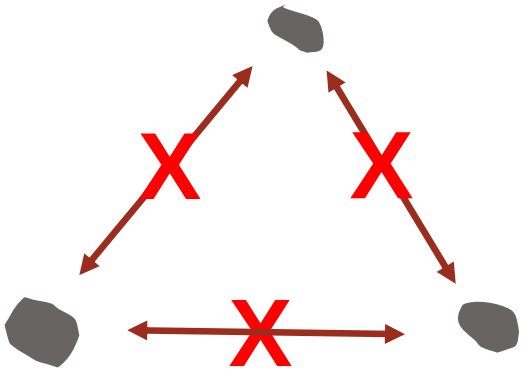

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General rule: for given total habitat area connected habitats are ecologically more valuable than isolated habitats

Motivation

Given voluntary nature of payment schemes: How to induce land-owners to select land for conservation so that habitats are connected?

Suggestion by *Parkhurst et al. (2002) Ecological Economics:* agglomeration bonus

Idea of agglomeration bonus is that a bonus is paid on top of a standard payment for conservation measures if managed patches are arranged in a specific spatial configuration

Idea of agglomeration bonus has become popular – one can distinguish three strands of discussion:

1. The agglomeration bonus idea requires cooperation among land owners and some research has focussed on cooperation problem (e.g. *Parkhurst/Shogren (2007) Ecological Economics, Parkhurst/Shogren (2008) American Journal of Agricultural Economics*)

Motivation

2. Some authors have proposed an agglomeration bonus to improve the design of conservation policies (e.g. *Schulte et al. (2008) Landscape Ecology, Juutinen et al. (2009) Ecological Economics, Smits et al. (2008) Environment and Planning C - Goverment and Policy, Khanna and Ando (2009) Journal of Environmental Planning and Management*)

In Switzerland, a scheme actually shows features of the agglomeration bonus. Farmers are paid a homogeneous payment for certain biodiversity-enhancing farming practices on (parts of) their land. In addition, they receive, a ‘network bonus’, if this land is part of a contiguous habitat network.

3. Other authors discussed the cost-effectiveness/budget efficiency of the agglomeration bonus/payment idea (*Drechsler et al. (2010) Resource and Energy Economics, Lewis et al. (2011) Resource and Energy Economics*).

Motivation

Drechsler et al. (2010) found that an agglomeration payment (a payment that farmers only receive if they generate a certain spatial configuration) is always better than a homogeneous payment in terms of budget efficiency.

This is due to the interplay of three effects:

I. *connectivity effect*; it arises because of the higher ecological benefits of spatially connected habitats => higher efficiency of agglomeration payment in comparison to homogeneous payment

II. *patch restriction effect*; it captures that for spatially connected habitats more costly habitat patches may need to be selected than if habitat patches could be chosen from the entire landscape => higher efficiency of homogeneous payment in comparison to agglomeration payment

III. *surplus transfer effect*; it arises because some land owners may need to be compensated for loss due to participation through side-payments from other land-owners => higher efficiency of agglomeration payment in comparison to homogeneous payment

Motivation

Aim of research is to go beyond Drechsler et al. (2010) in several ways:

- Drechsler et al. only compare an agglomeration payment and a homogeneous payment whereas we include the agglomeration bonus idea
- We also compare not only the budget efficiency of the three policy design alternatives but also their cost-effectiveness
- We analyse how different landscape and species parameters (cost differences, spatial correlation of costs, dispersal capability of species) influence results
- We investigate the relevance of the ‘surplus transfer effect’ in ranking the three options to assess the impact of side payments

Overall goal: to identify under what ecological and economic conditions which of the three design options is best in terms of cost-effectiveness/budget efficiency to enable better policy design

Model

- We select a landscape with 100 patches of size a_i on a square regular grid
- On each patch a land owner may carry out conservation measures (x_i=1) or not (x_i=0)
- The opportunity cost of conserving patch *i* is c_i. The c_i are normally distributed random numbers with mean 1 and standard deviation σ.
- Costs are spatially correlated with α being a correlation measure (a value of α = 0 represents no correlation and a value of α close to 1 high correlation).

The ecological benefit of a certain landscape pattern is given by

$$V(\mathbf{x}) = \sum_{i=1}^{N} x_i \sum_{j=i+1}^{N} y_j \exp(-d_{ij} / D)$$

where d_{ij} is distance between patches and *D* dispersal distance of the species

Model

A practical way to increase V is to increase the density of green patches ρ in part of the landscape

$$\rho = \frac{\sum_{i \in I_R} x_i}{N_R} \geq \rho_{\min}$$

with I_R containing the indices of all patches in R and N_R being the no. of patches

- A payment λp is offered to every landowner who carries out conservation measures (x_i=1).

- A payment p-λp is offered to every landowner whose patch is located within some rectangle R, given the density threshold $\rho_{\min}$ in that rectangle is fulfilled

The land owners decide on the size and location of the rectangle themselves.

Model

- Landowner *i* conserves a patch (x_i=1) if the profit π_i from this activity is positive

$$\pi_i = \lambda p - c_i + \varphi_i(R)(p - \lambda p) + \sum_{\substack{j=1 \\ (j \neq i)}}^{N} s_{ji}$$

where s_{ji} represents possible side payments and φ_i equals 1 if patch *i* is located within *R* and 0 otherwise.

The land owners select a landscape pattern where their aggregated profit is maximised (note we assume zero transaction costs).

Model

- Comparison of cost-effectiveness/budget efficiency of three design options for different scenarios, which differ in terms of dispersal distance *D*, standard variation of costs σ, and cost correlation α.
- Systematic variation of *p*, ρ_{min} and λ.
- We determine for each ρ_{min}, *p* and λ *combination* the related budget, costs and ecological benefit
- Because costs *c* for the different patches are drawn randomly, we sample the costs c_i for all patches 100 times and calculate mean values for budgets, costs and ecological benefits.
- Comparison of cost-effectiveness/budget efficiency of different scenarios

Results

Agglomeration bonus vs agglomeration payment vs homogeneous payment

For all scenarios budget efficiency/cost-effectiveness of agglomeration bonus is always in between agglomeration payment and homogeneous payment and never the single best option

Budget efficiency: Consider a case where the agglomeration payment is the better option compared to homogeneous payment which implies that surplus transfer effect and connectivity effect dominate patch restriction effect.

Moving from agglomeration payment to bonus means that the connectivity and surplus transfer effect is reduced, but, on the other hand, the patch restriction effect also decreases.

For an agglomeration bonus to be the superior option it would be necessary for changes in the patch restriction effect to dominate changes in the other two effects. This is not possible as long as changes in the three effects are ‘well-behaved’.

Cost-effectiveness: Basically, the same reasoning, just that the surplus transfer effect is not relevant here.

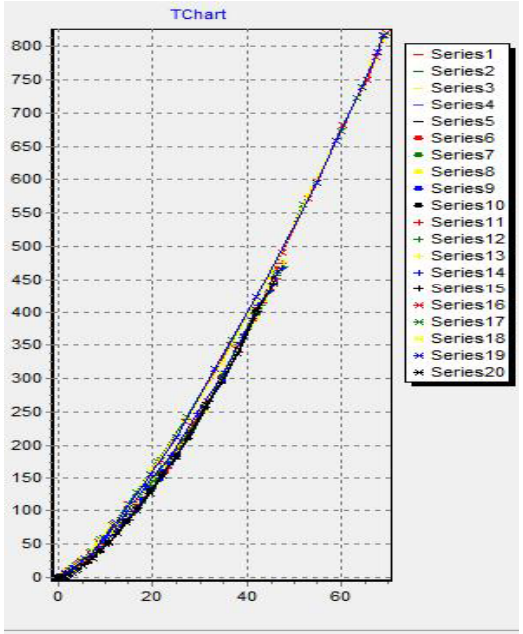
Results

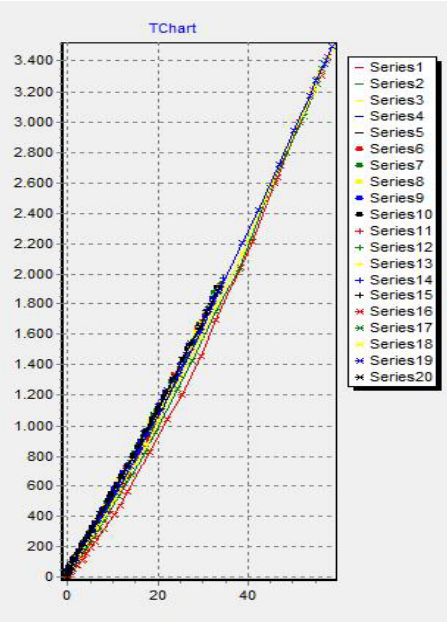
Budget efficiency vs cost-effectiveness

Agglomeration payment is always better in terms of budget efficiency (though the degree varies with differences in the ecological and economic parameters)

Result is known from Drechsler et al. (2010) and can be explained with dominance of surplus transfer effect and connectivity effect over patch restriction effect

Depending on parameters both homogeneous and agglomeration payments may be more cost-effective. Differences between budget efficiency and cost-effectiveness arise because surplus transfer effect is relevant for budget efficiency but not cost-effectiveness.





Left:
D=2
σ= 0.3
α= 0.7

Right:
D=8
σ= 0.6
α= 0.7

Results

Effects of side payments

Budget efficiency: Agglomeration payments lead to reduction of producer surpluses due to side payments. Without side payments surplus transfer effect does not occur which reduces budget efficiency advantage of agglomeration payment

Cost-effectiveness: Without side-payments the agglomeration payment does marginally (?) better in terms of cost-effectiveness than with side payments

Reason: for a certain network of connected habitat patches to be supported by a scheme the payment must exceed the costs of each patch without side payments but not with side payments => less costly habitat patches may be included in the network

Results

Effects of ecological and economic parameters

Dispersal ability: For bad dispersers the budget efficiency/cost-effectiveness of the agglomeration payment relatively increases compared to good dispersers

Cost differences: Regarding budget efficiency there is little effect for smaller budgets but for medium sized budgets higher cost differences increase advantage of agglomeration payment.

Reason: with increasing budget patch restriction effect decreases and surplus transfer effect increases

Cost-effectiveness: With increasing cost differences the performance of the homogeneous payment compared to the agglomeration payment increases because the patch restriction effect becomes stronger

Results

Effects of ecological and economic parameters

Cost correlation: the cost-effectiveness performance of agglomeration payments and homogeneous payments is roughly equal for low and high cost correlations.

Reason: connectivity effect decreases with increasing cost correlation but also patch restriction effect. By and large, these effects cancel each other out.

Budget efficiency: advantage of agglomeration payment is higher in landscapes with low cost correlations due to the fact that the surplus transfer effect is higher in such landscapes

Impact of budget: in general, relative differences between the two payment schemes are highest for small budgets; decrease with increasing budgets and disappears after a certain budget size. This is because all three effects decrease with increasing budget size.

Summary and discussion

An agglomeration bonus scheme has been implemented in Switzerland and in many articles an agglomeration bonus has been suggested – our results show that this is an inferieur (or at least not better) solution to either homogeneous or agglomeration payments.

Agglomeration bonus/payment has often been suggested for ecological reasons – our analysis shows that economic factors are (at least) equally important (perhaps not too surprising for this audience)

The agglomeration payment loses some of its charm if side payments do not occur – it may be important for policy makers to be able to assess whether side payments (in whatever forms) occur.

Thank you for your attention!