Economic Instruments for Ecosystem Management and Biodiversity Conservation

Nick Hanley

University of St Andrews

Scotland

- Please feel free to ask questions at any time

Objectives of this lecture

- Provide some background on ecosystem services approach, value of ecosystem services
- Analyse what the “policy problem” is that has to be solved here
- Review the policy options
- Look in detail at economic instruments as a policy option
- Analysis of 2 important aspects of such instruments: spatial targetting and spatial coordination
- Leeds on to PES sessions tomorrow afternoon.

Ecosystem services framework

- According to the Millennium Ecosystem Assessment (2005), ecosystems such as forests and wetlands provide society with a number of valuable *ecosystem services*
- These are supporting, regulating, provisioning and cultural services
- Each of these benefit people, either directly or indirectly.

Ecosystem Services:
an example for forests

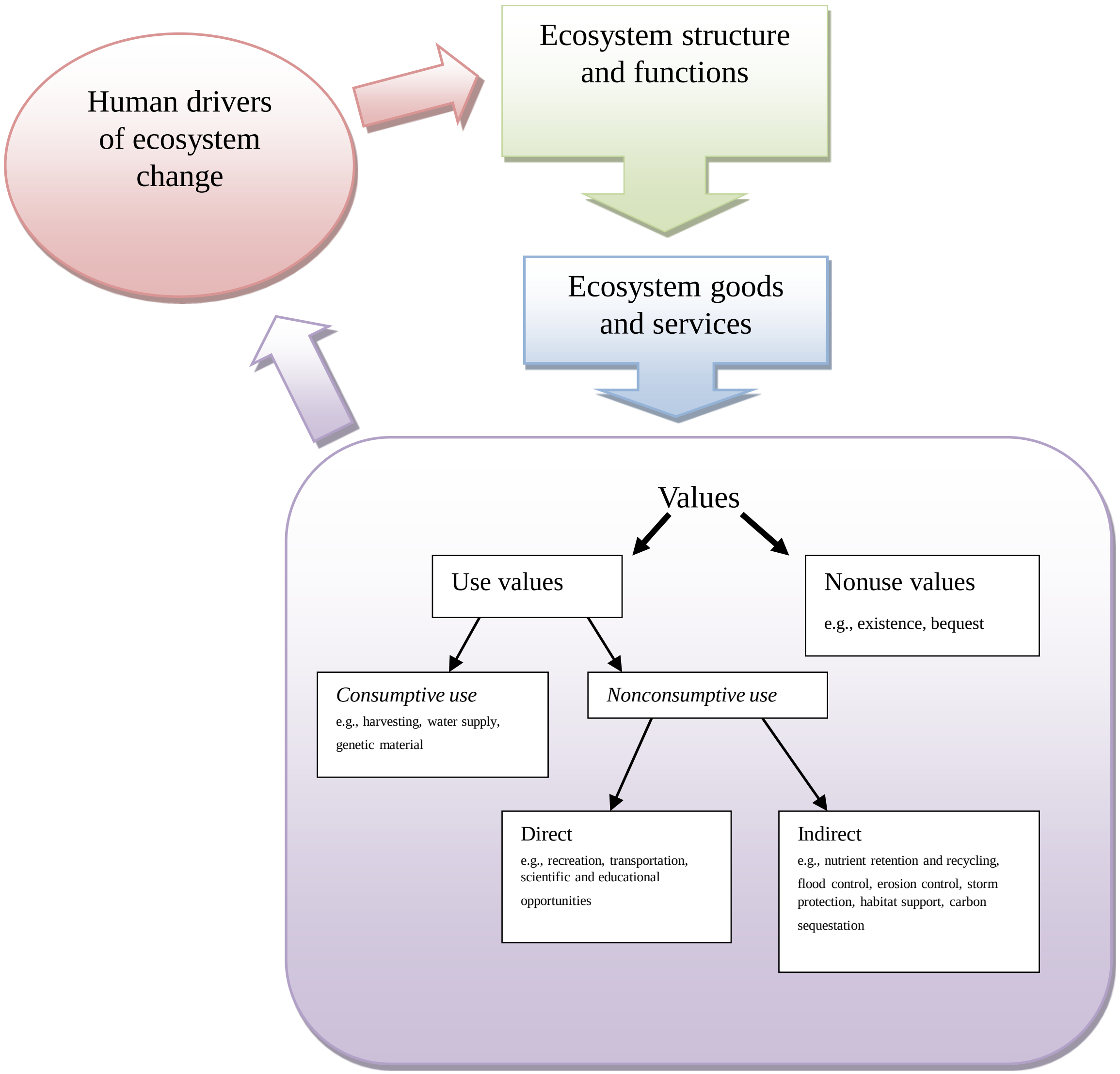
- Supporting (intermediate) services: providing habitats for wildlife
- Regulating services: storing carbon, regulating water quality, preventing soil erosion
- Provisioning services: wood production, non-timber forest products, deer
- Cultural services: opportunities for forest recreation, educational values of forests, forests’ contribution to landscape.

Another example: Beaumont et al (*Marine Pollution Bulletin*, 2007), ecosystem services "delivered" by marine ecosystems.

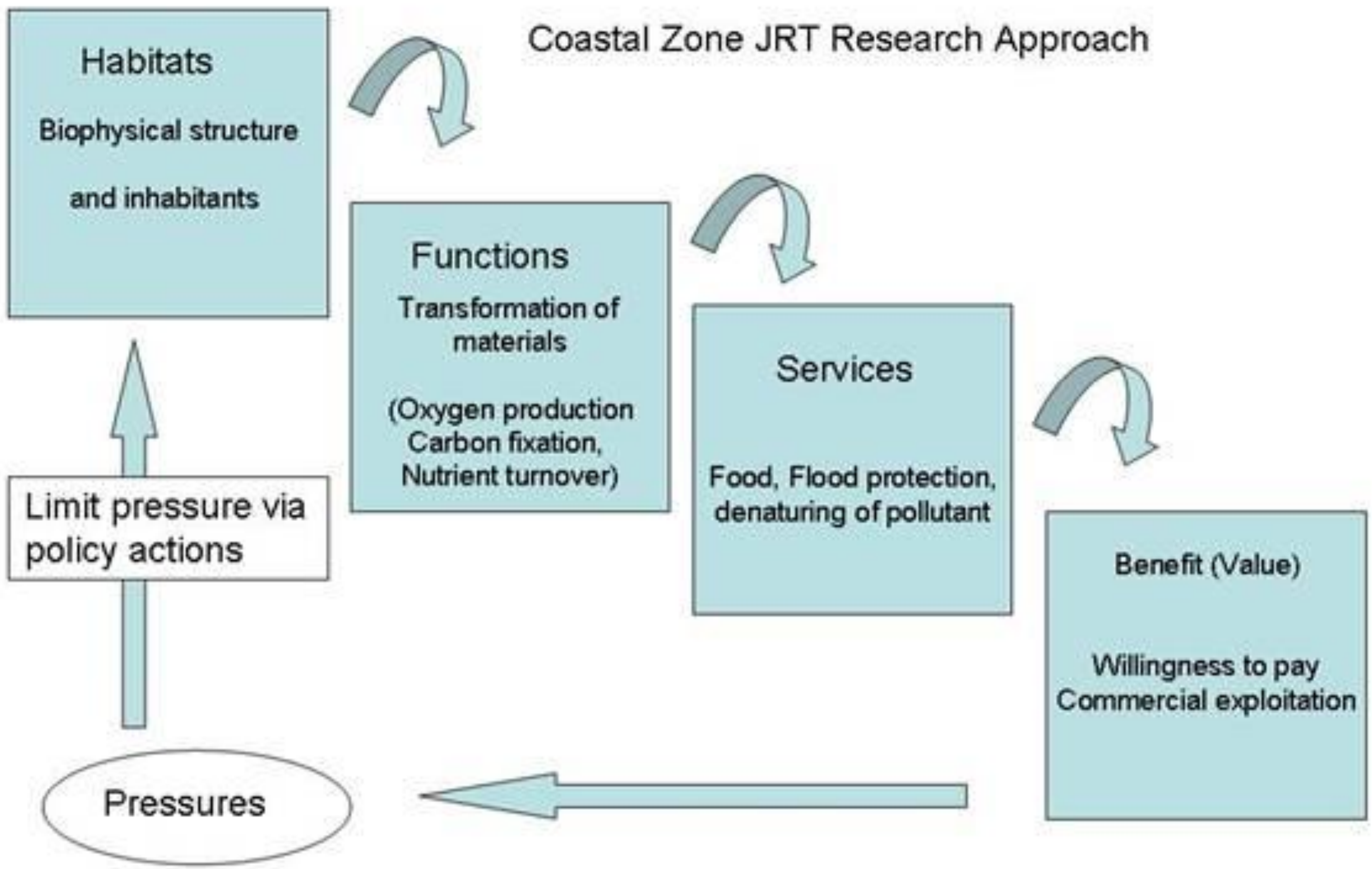
- Supporting services
  - Resilience
  - Nutrient cycling
- Provisioning Services
  - Food products (eg fish)
  - Non-food products (eg seaweed for fertiliser)
- Regulation Services
  - Climatic regulation (eg role in C sequestration)
  - Storm protection (eg coastal mangroves)
  - Bio-remediation of wastes
- Cultural services
  - Cultural heritage
  - Recreation
  - Non-use benefits

- Biodiversity supports the "production" of all of these ecosystem services, but is also a feature of ecosystems that is important to people.
- Components of biodiversity also directly responsible for some ecosystem service supply eg pollination
- Mace et al, *TREE*, 2012.

The Ecosystem Valuation Framework



Source: Barbier, 2012


Coastal Zone JRT Research Approach
Habitats
Biophysical structure
and inhabitants
Functions
Transformation of materials
(Oxygen production Carbon fixation, Nutrient turnover)
Services
Food, Flood protection, denaturing of pollutant
Benefit (Value)
Willingness to pay Commercial exploitation
Limit pressure via policy actions
Pressures

Do ecosystem services and biodiversity really have economic value?

- Yes, so long as they add to people's well-being ("utility"), for example because, for example, people enjoy walking in the forest
- Or because they provide inputs to production (eg wild pollinators)
- Or because they reduce the costs to people of climate change or extreme weather events (for example, by reducing soil erosion, providing defence against storms)
- Or because they provide us with a service which would be expensive to replace (eg pollution assimilation)
- Banzhaf and Boyd (2007) – we need to distinguish between ecosystem services as inputs, and <u>economic benefits</u> which are produced with additional inputs, such as labour.

Economic values for ecosystem services come through two routes:

- Service flows which contribute directly to peoples' well-being (utility)
- Service flows which contribute to the production of other goods or services which are then bought and sold (indirect values)

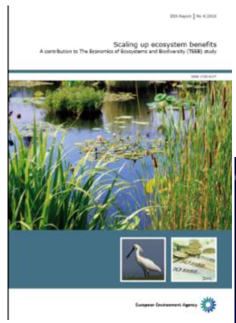
➔ In both cases, market prices do not reveal the full economic value of ES due to the problem of "missing markets".

Economists mainly want to value *changes* in these service flows; for example, the effects of draining peatlands, or protecting a forest, or conserving a mangrove swamp.

There is an increasing body of evidence on the economic value of ecosystems and the services they provide...

Thanks to Helen Dunn

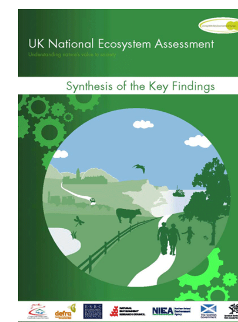
natural capital PROJECT



Natural Capital Initiative
Linking Environment & Policy

GLOBE INTERNATIONAL
The Global Legislators Organisation

VALUING NATURE NETWORK



2005 2010 2011

What is the policy problem?

- many ecosystem services deliver benefits which are PUBLIC GOODS: they are *non-rival* and / or *non-excludable* in production
- Missing markets
- Lack of financial reward for producing these ES and for conserving biodiversity
- Lack of financial penalty for actions which deplete ES or which reduce biodiversity

➔ market failure, need for action to correct this.

- From now on, I am going to focus on policy design for biodiversity conservation and ecosystem service supply from privately-owned land
- Landowner as the producer of the ecosystem service or biodiversity output
- Providing ES/biodiversity is *costly* for the landowner, and they often receive no reward for this, or a reward less than the social value.
- Those who benefit from habitat protection are not those who incur the (opportunity) costs
- So we get market failure: not enough ES/biodiversity “produced” by market forces.

Important messages:

- **the market system, left to its own devices, does not deliver “enough” ecosystem services or biodiversity conservations.**
- **But designing policy to correct this market failure in the best way is difficult.**

- What to do?
- Actions are possible at three levels:

1. Voluntary actions by landowner – but these are costly, and rely on good will or green premium
2. Actions by groups of citizens eg through conservation charities, or through common property management. Now, some of those who benefit pay for the goods. But still a problem due to the *public good* nature of conservation – many other people benefit, even if they do not pay
3. Actions by the government

Options for government action

- Create /encourage/ facilitate schemes to encourage *voluntary actions* between supplier and beneficiaries.
  - ➔One example of this is Payment for Ecosystem Service schemes – which we discuss tomorrow
- Use *regulation* eg land use restrictions, protected areas, national parks ….but these can be ineffective and also impose costs on land owners/land users
- Use *economic instruments*

Economic instruments (1)

- Create a price for an environmental action or consequence
- Can be positive (eg reward provision of environmental goods ➔ subsidies)
- Or negative (eg tax negative environmental impacts such as pollution)
- Can create these prices by setting up tradeable permit markets (eg carbon trading)
- Or simply by offering subsidies and imposing taxes

Economic instruments (2)

- General insight from environmental economics is that *economic instruments can often achieve environmental targets at a lower overall cost than regulation*.
- This is possible because they allow for flexibility in how firms, farmers, landowners…respond – people choose their best response, given the economic incentives, rather than being told what to do
- Lots of evidence of such costs savings in the context of pollution control, for example
- Also encourage “green” innovation, since they reward the production of environmental goods, and penalise the production of environmental bads, at the margin.

policy design options for managing ecosystems and biodiversity

- Subsidies (voluntary contracts offered at standard/variable payments per hectare)
  - Could be differentiated across regions or farm/forest types
  - Could include a bonus for spatial coordination
  - Most likely a contract for management actions
  - But could be related to outcomes, or indeed a mixture of actions and outcomes

Policy options (continued)

- Facilitate PES schemes which involve voluntary contacts between private parties
- Conservation auctions
- Biodiversity Offset schemes / tradeable conservation credits
- Conservation easements
- Pollution or input taxes (for example where nutrient pollution is a problem)

more insight on the economics of the policy design problem.

- Consider the case where we have a biodiversity conservation target in an area where the actions of many farmers will determine whether we achieve this target.
- Each farmer faces a trade-off between more intensive production, which gives higher income; and producing more of the biodiversity target (eg an endangered bird species) through setting land aside
- So, for each farmer, actions which promote biodiversity conservation on his land are *costly* in terms of foregone income:


Trade-off between income and
conservation outcomes.
Conservation outcome (eg
number of birds conserved)
Farmer's income

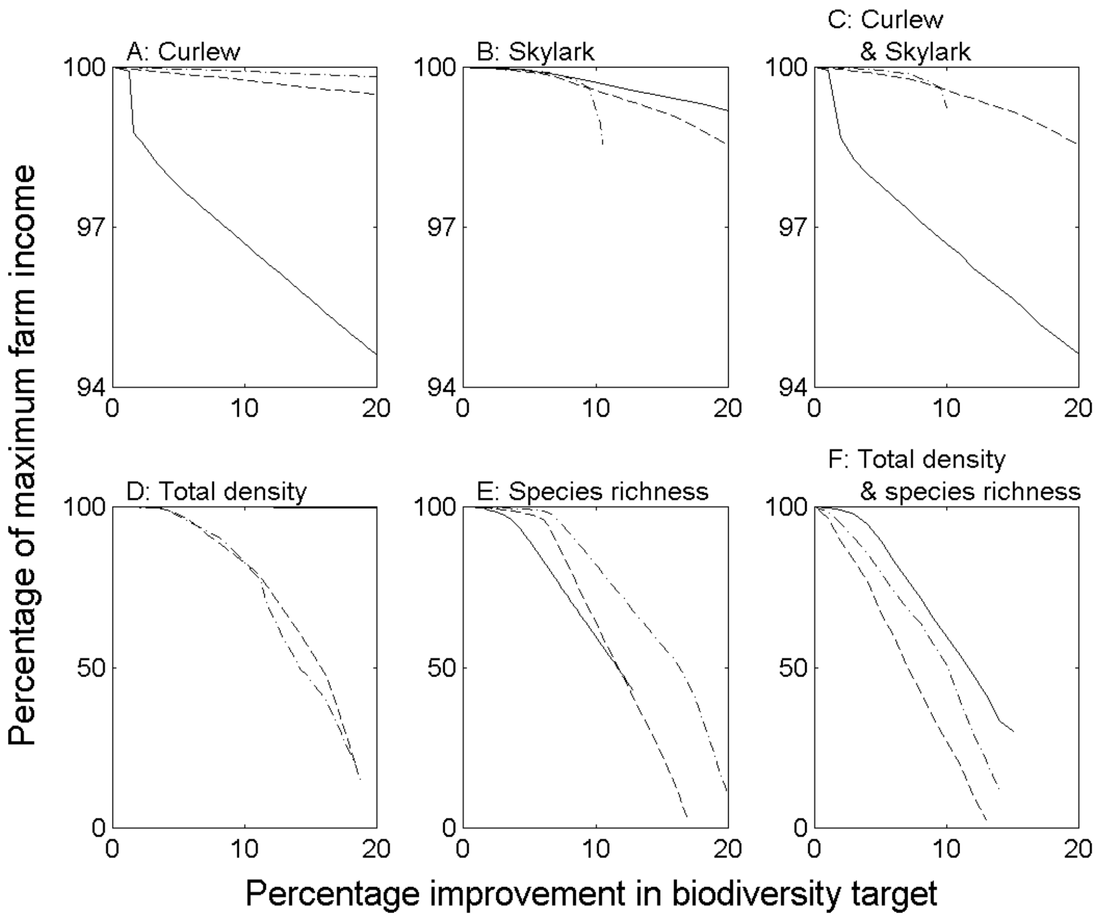


Figure 1: Trade-off curves relating the percentage reduction in maximum farm income that results from requiring a given percentage increase in a focal biodiversity target. Examples of trade-off curves shown for (AB) single species targets; (C) two species at the same time; (DE) community-level targets; and (F) two community level targets at the same time. Three curves illustrate representative farm types in three study regions (solid – Dark Peak, dashed – E Moors, dot-dashed SW Peak).

Nature of the design problem: conservation subsidies as the baseline.

(1a) Payments are typically uniform across producers, despite fact that true supply price varies a lot

- *Therefore, many producers are over-compensated*
- *Means policy is usually less cost-effective than it could be, given a fixed budget*
- *Implies need for differentiated payments*

(1b) For a given producer, marginal supply price is not a constant

- *Farmers earn rent on infra-marginal actions*

(2) spatial variability in “biodiversity productivity” of land

– *everyone gets same payment irrespective of potential ecological gains (not true in **all** schemes, since some spatial targeting does exist)*

- *Yet we know ecological productivity varies with condition of site, site history, landscape characteristics.*

(3) little recognition of need for spatial co-ordination in sign-ups.

important spatial considerations include minimum viable habitat size; multiple land-cover needs of some species; re-colonization issues; hydrological connectivity.

➔ Agglomeration bonus, spatially-coordinated auctions.

So what policy design issues does this raise?

- True supply prices (opportunity costs) not observable from the perspective of the government
- Nor is the “ecological potential” of individual management actions

➔ *Likelihood of “adverse selection”*

- Actions of landowners (compliance with contract) are very costly to monitor

➔ *Likelihood of “moral hazard”*

3 possible improvements in PES design?

- Differentiated payments across suppliers
- Agglomeration Bonus (spatial coordination)
- Paying for outputs not inputs

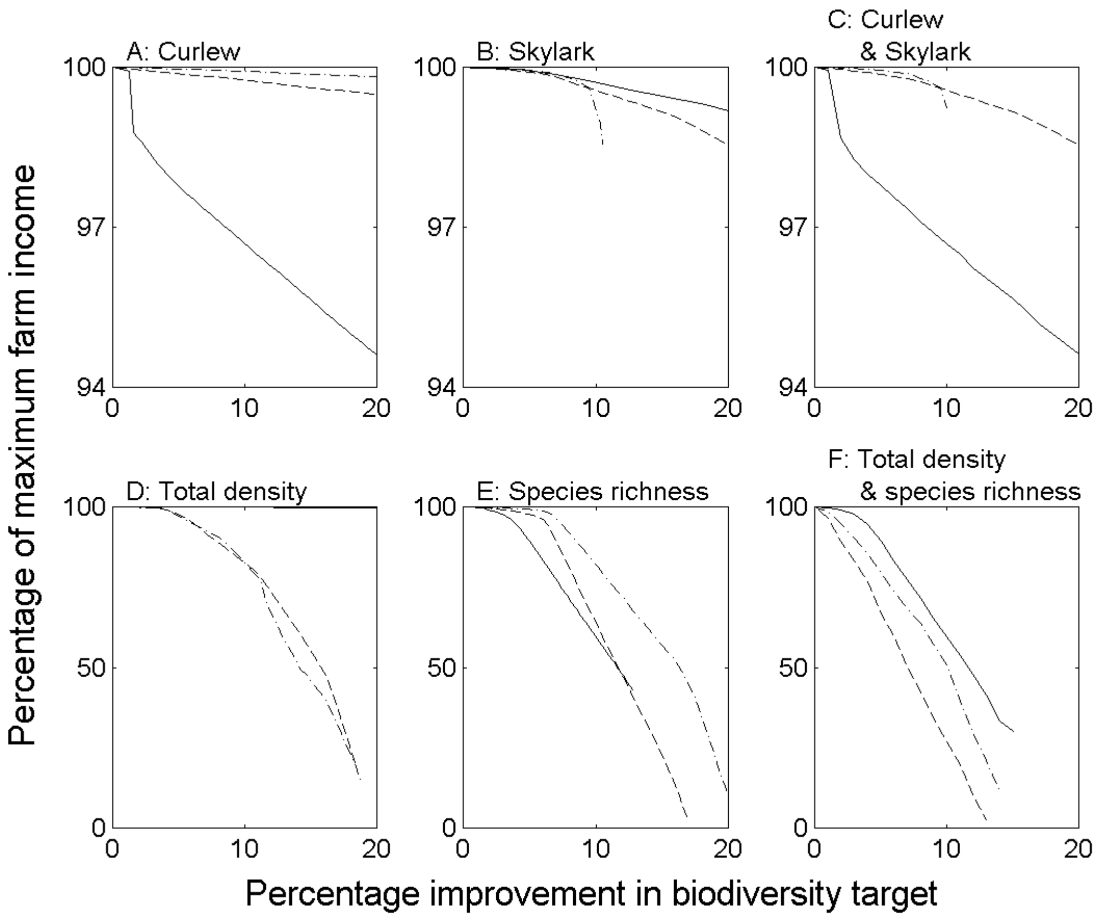
1.The benefits of differentiated payments:

Armsworth et al, 2012, Ecol. Letters.

- This study quantifies the costs of different “simplifications” for policy, since optimal policy may have high transactions costs and be politically infeasible
- an ecological-economic model of relationship between upland farming and birds in the Peak District, England
- Spatial variation in “ecological production functions”
- Model enables us to compute optimal policy for a range of biodiversity targets, by computing true supply price.
- Land use related to biodiversity outcomes using parameters from ecological regression models.

Minimising the costs of supplying biodiversity

- Run model with increasing strict biodiversity constraints for individual species density, then for total density and total richness.
- Model shows optimal adjustment by farmers in three regions of study area
- Traces out <u>production possibility frontier</u> between *biodiversity* and *farm income*
- Shows where increases of biodiversity can be "purchased" at low cost
- Shows us the range of shadow prices of different biodiversity constraints in different regions as a function of quantity produced ➔ optimal subsidy.



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Costs of non-optimal policy

- Minimising costs of hitting a given biodiversity target thus requires:-
  - Payment which varies across farmers
  - Varies for individual farmers according to quantity of biodiversity produced
  - Allocating optimal share of budget in each region
- For a given conservation budget, we investigate how much **less** biodiversity can be “bought” if each of these complications are ignored.

- Failure to exploit low-cost gains made possible by spatial variation in payments across regions are particularly costly.
- Setting regionally varying payment rates is a crucial element to scheme design that cannot be sacrificed without fundamentally undermining conservation outcomes.
- **Can achieve a 70% increase in biodiversity outputs from a fixed budget if differentiate payments spatially**

2. Spatial coordination in PES schemes

There are many examples where spatial coordination of landowner actions can improve biodiversity outcomes:

- Corridors for wildlife movement
- Minimum viable habitat size
- Creation of options for re-colonisation
- Species with demands on multiple habitats:

The Agglomeration Bonus (AB)

- ..is a **Two-part** PES scheme with participation component & a bonus (*Parkhurst and Shogren 2007*)
- The AB is a **coordination game**
- This game has multiple strategies and multiple N**ash Equilibria**
- Nash equilibria can be **Pareto Ranked**
- **AB** not likely to be cost-minimizing as farmers can be over-compensated for opportunity costs of participation.

AB formally

$$u(\sigma_i\ ) = r(\sigma_i) + s(\sigma_i) + n_{i\sigma}b(\sigma_i) \qquad\qquad \sigma_i = N, G$$

N: land set aside for nature (land sparing)

G: land employed for agricultural production (land sharing)

Both land management options thus provide conservation services, but the *N* type more so than *G*

$r(\sigma_i)$: (net) agricultural revenue

$s(\sigma_i)$: participation component

$b(\sigma_i)$: bonus component

$n_{i\sigma}$: number of neighbours choosing land option σ_i

$r(N) = 0$	$s(N) = 10$	$b(N) = 40$
$r(G) = 55$	$s(G) = 5$	$b(G) = 10$

- Experimental evidence suggests that spatial coordination can be incentivized through:

  (i) Repeated interactions (Parkhurst & Shogren 2007)

  (ii) simple spatial targets to which participants can coordinate with relative ease, and

  (iii) non-binding pre-play communication prior to making a choice.

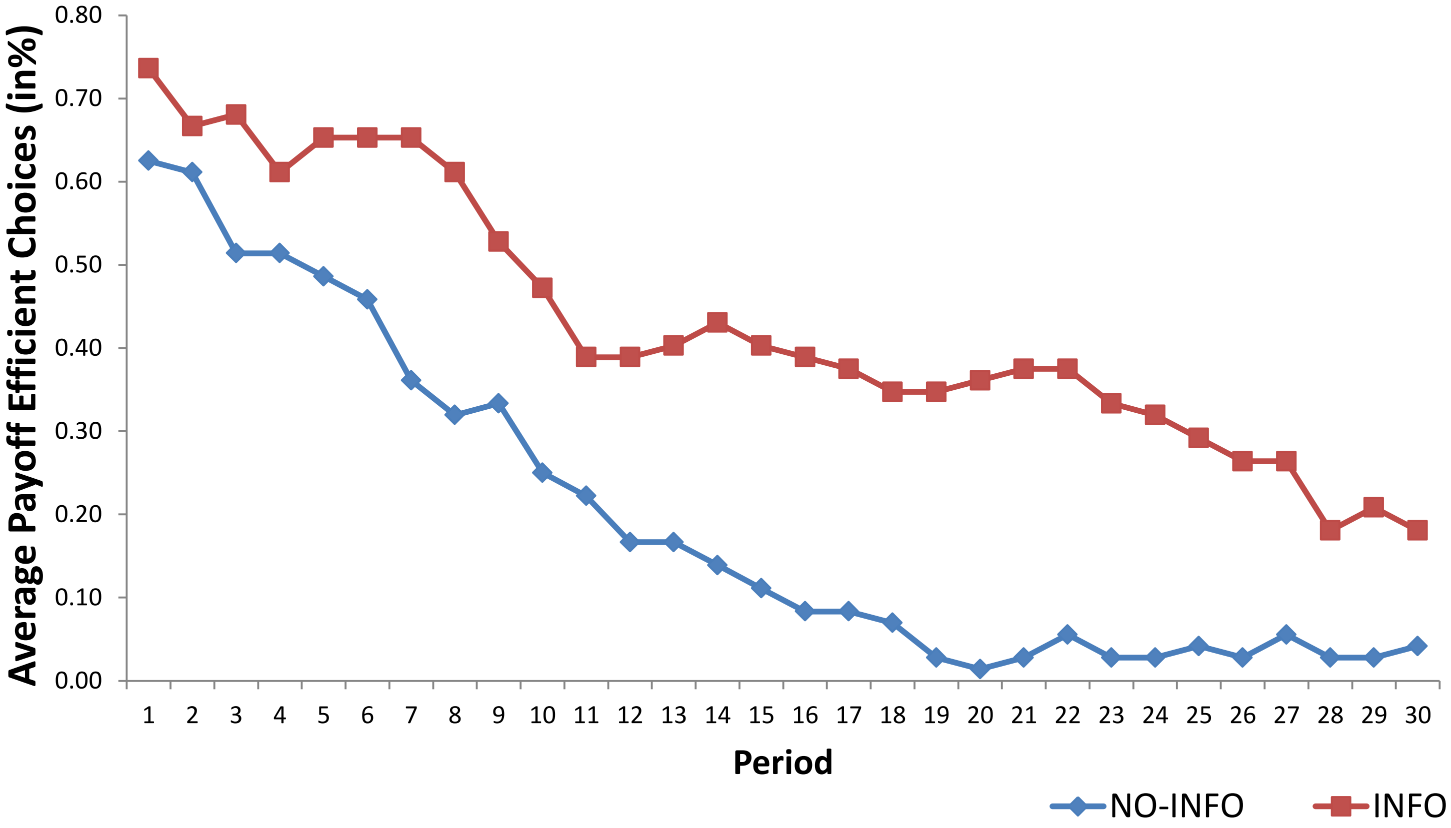
  (iv) Successful coordination is also more likely on landscapes with fewer participants owing to the difficulty of coordination in larger groups (Banerjee et al. 2012).

Banerjee et al, AJAE, forthcoming

- Objectives
  - Analyse ability of AB to achieve spatial coordination in environments with different amounts of information about others' land management actions.
  - Identify factors (precedence, learning/experience, neighbours choices) which influence coordination and individual behaviour on local networks.
  - Derive lessons for supply of ecosystem services and biodiversity conservation

- Main results
  - Spatial coordination incentivized with AB.
  - Information produces significant differences in behaviour and Nash Equilibrium obtained between treatments.
  - More information delays the convergence to risk dominant outcome, but does not prevent it.

Individual *N* choices



Policy implications?

- AB provides incentives for spatially coordinated land management
- All AB configurations correspond to ecologically superior outcomes
  - Under both global and local coordination
- Producing socially optimal outcomes will require more information about other farmers/participants, or some other mechanism to reduce strategic uncertainty

3.Outcome-based or action-based contracts?

- Increased interest in outcome-based schemes
- But limited evidence of efficiency
- Mainly analysed using principle-agent models

An example: White and Hanley, IRERE, forthcoming.

Case for and against outcome-based contracts

- For
  - Can induce farmer innovation - dynamic efficiency
  - Reduced cost of monitoring inputs
  - Incentivise unobserved or unobservable inputs such as effort
- Against
  - Hard to measure the output
  - Pushes risk of non-delivery onto risk averse farmers – participation falls .

➔Theoretical predictions are limited (Khalil and Lawaree, *JET*, 1995)

Conclusions: pay for outcomes or inputs?

- Outcome-based contracts have potential as they incentivise un-observed effort
- Land-based contracts are likely to be ineffective as they do not incentivise effort
- Input-based contracts gets closest to first best *in our model*
- Mixed contracts (land and outcome) are equivalent (but only because they uniquely determine effort in this case)
- Key factor determining which contract we prefer is the "degree of observability" of outcomes versus effort.

thanks

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ndh3@st-andrews.ac.uk