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Offsetting cumulative impacts of multiple developments: sequential vs strategic approaches

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The problem

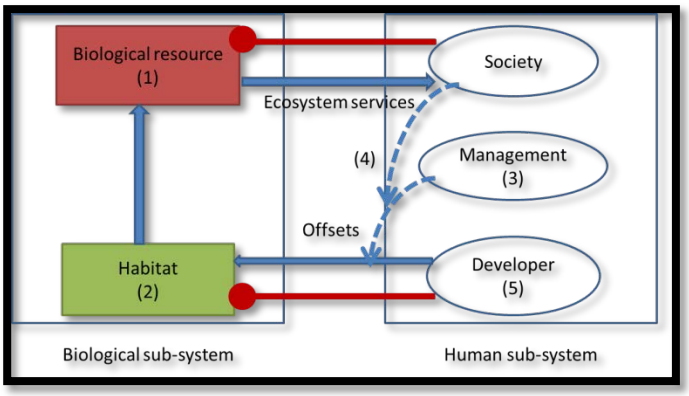
This work explores different approaches to offsetting in the context of the cumulative impacts of multiple developments over time. It looks at the effects of two types of delays. The first is delay in the recovery of ecological systems and associated ecosystem services following implementation of an offset. The second is delays in management action to restore impacted habitats after development. We compare four different offset strategies using a simplified model of a human/environmental system.

Our approach

We develop a simplified model of a hypothetical marine system to explore how a biological resource (protected matter) which is damaged by development responds to offsetting under different scenarios. The model has four main elements:

1. A biological resource that provides ecosystem services (in our case, harvest from a commercial fishery)
2. A habitat that supports the resource and is degraded by development
3. A management body that assesses the requirement for offsets for a development proposal
4. A social process that determines the allowed extent of ecosystem service loss before offsets are required
5. A series of developments that degrade the habitat.

We describe by equations key processes and relationships for each of these elements and predict the time paths of key variables, notably: size of offset required of developers, level of habitat and of biological resource, and level of human utility from consumption of ecosystem services.



We explore the effects of four different scenarios. Each scenario simulates the effects of five identical development projects occurring annually over five consecutive years under different offsetting strategies.

	Management approach	
Offset objective	***Project-by-project***	***Strategic***
Replace equivalent habitat	Sequential myopic	
Replace equivalent value (in final year)	Sequential correcting	
Replace cumulative value (over 20 years)	Sequential compensating	Strategic assessment

Results

Habitat restoration and resource recovery

- Total area of habitat was restored after 25 years in all offsetting strategies
- The total area of habitat available after 25 years increased under offset strategies focusing on replacing equivalent value rather than equivalent area
- Under the project-by-project approach (sequential myopic), the resource does not regain pre-development abundance
- Replacing cumulative ecosystem services (the sequential compensating and strategic assessment strategies) results in an increase in resource abundance.

Influence of initial area available for habitat

- The larger the initial area available for habitat, the faster the recovery, regardless of the offset strategy. If the initial area is used as a surrogate for degradation, this result makes a case for early restoration action before habitats become damaged.

Influence of social response

- If the requirement for an offset was only triggered after the third development the habitat had already become degraded due to the cumulative impacts of the first three developments.
- None of our offset strategies allowed recovery of pre-development habitat, resource or services during the simulation period.

Cost to developers

- The sequential compensating strategy delivers similar levels of utility after 20 years to the strategic assessment approach but costs more for later developments, resulting in inequitable costs to developers.

Strategy	Cost of offset year 1-5					Total cost	Utility loss in year 20	Cumulative utility loss at year 20
Sequential myopic	1.00	1.00	1.00	1.00	1.00	5	0.06	4.60
Sequential correcting	1.12	1.13	1.15	1.18	1.22	5.80	0	3.89
Sequential compensating	1.82	1.97	2.12	2.29	2.52	10.72	-0.41	-0.12
Strategic assessment	2.10	2.10	2.10	2.10	2.10	10.50	-0.40	-0.11

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