Policy Instruments, Strategic Interactions, and Incentives for Habitat Conservation for Imperiled Species

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Objective: We use economic experiments to compare the performance of (i) land use restrictions, (ii) subsidies, and (iii) voluntary conservation agreements with assurances (VCAAs) when multiple landowners must coordinate their conservation efforts to protect an imperiled species (IS).

Background

- **Nearly 50% of species listed under the US Endangered Species Act (ESA) have >80% of their habitat on private land [1].**
  - The presence of listed animals on one's land can result in costly land use restrictions under the ESA, generating incentives to degrade habitat to preempt colonization by IS.
- **Designing conservation incentives for IS is complicated: habitat quality is influenced by landscape size and connectivity, and hence may depend on coordinating conservation activities across multiple landowners.**
  - This is true for species like the lesser prairie chicken, a grassland bird that was listed as threatened under the ESA from 2014–15 [2].

(a) 

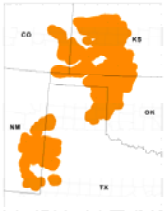
(b) 

Fig. 1 (a) Lesser prairie chicken (LPC); (b) primary LPC habitat in the U.S.

- **Landowners face a coordination game when making conservation choices, with multiple equilibria including:**
  1. **Full conservation:** Landowners expect their neighbors to conserve and hence have incentives to conserve too, incurring costs but avoiding harm to IS—the Pareto-dominant outcome; and
  2. **No conservation:** Landowners expect their neighbors to shirk and hence have incentives to shirk too, avoiding costs but potentially harming the IS—an outcome called "coordination failure."
- **Two types of voluntary policy instruments have been used to incentivize habitat conservation on private lands:**
  1. **Subsidies** that offset conservation costs; these may lessen—but do not eliminate—the possibility of coordination failure [3]; and
  2. **VCAAs** that indemnify landowners from land use restrictions if they conserve a certain amount of their land [4]; these eliminate the possibility of coordination failure, but their relative performance has never been assessed empirically.

Experimental Design

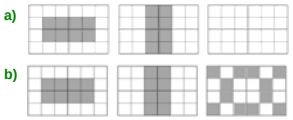
- **Student subjects act as farmers managing 6 parcels on a symmetric landscape (Fig. 2), with 4 farmers per landscape.**
- **In each of 5 rounds, farmers simultaneously decide whether to conserve one or more of their parcels to protect the IS from listing.**
  - Each farmer earns 900 experimental dollars ($E) in income before conservation; conservation reduces earnings by the amount listed in each parcel in Fig. 2.
- **The IS requires an 8-parcel area of conserved habitat (Fig. 3); the species will become listed unless landowners conserve enough habitat in the required arrangement.**
- **We test 3 instruments over 3 treatments (Box 1) to determine their effects on:**
  - Conservation success (i.e., whether the IS is listed or not);
  - The number of parcels conserved; and
  - Total costs of conservation.
- **There are 3 Nash equilibria for each treatment (Fig. 4), shown in order of decreasing net benefits to society.**
- **Subjects' earnings depend on net income in each treatment and a Holt-Laury lottery, used to elicit risk preferences [5].**

Fig. 2 The experimental landscape with conservation costs; each color represents a different farmer's land

200	300	200	200	300	200
400	250	300	300	250	400
400	250	300	300	250	400
200	300	200	200	300	200

Fig. 3 Habitat arrangements that prevent listing

Fig. 4 Nash equilibria under (a) land use restrictions, subsidies and (b) VCAAs



Box 1 Experimental treatments *(within-subject design)*

C1. No policy (control)
- Net farm income does not depend on conservation success.

T2. Land use restrictions
- If the IS is listed, then all farmers in the group face land use restrictions and lose $E 900, plus any conservation costs.

T3. Conservation subsidy & land use restriction
- Farmers earn a cost-share subsidy for each conserved parcel equal to:
  - 20% if the parcel does not border a parcel conserved by a neighbor;
  - 30% if the parcel borders 1 parcel conserved by a neighbor; or
  - 40% if the parcel borders 2 parcels conserved by neighbors.
- Listing results in the land use restrictions and losses from T2.

T4. VCAA & land use restriction
- Listing results in the land use restriction described in T2.
- Each farmer can avoid the penalty by conserving 3 or more parcels, regardless of conservation success.

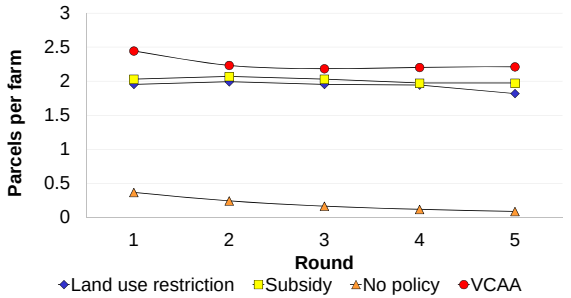
Results

Table 1. Mean outcomes for control and three policy treatments

	No Policy (C1)	Land Use Restriction (T2)	Subsidy & Land Use Restriction (T3)	VCAA & Land Use Restriction (T4)
Percent species protected	**0**[a]	**0.82**[b,c]	**0.87**[c]	**0.76**[b]
	[0, 0]	[0.78, 0.85]	[0.84, 0.90]	[0.73,0.80]
Parcels conserved per farmer	**0.19**[a]	**1.93**[b]	**2.01**[c]	**2.25**[d]
	[0.15, 0.24]	[1.89, 1.97]	[1.98, 2.04]	[2.22, 2.29]
Unsubsidized cost per farmer when listing is avoided	—	**503.7**[a]	**510.0**[a]	**522.2**[b]
	—	[497.3, 510.0]	[504.8, 515.1]	[515.7, 528.8]
Efficiency	**186.2**[a]	**590.4**[b]	**498.7**[b]	**417.7**[b]
	[126.6, 245.7]	[376.3, 804.5]	[287.0, 710.4]	[290.2, 545.1]
Efficiency when listing is avoided	—	**14.62**[a]	**39.82**[a,b]	**88.89**[b]
	—	[0.31, 28.93]	[13.67, 65.98]	[49.99, 127.8]

95% confidence intervals shown in brackets. Common superscripts denote estimates that are not statistically significantly different from one another at a 5% level. Efficiency is the difference between total group costs and the minimum cost required to prevent listing.

Figure 5. Mean conservation for each treatment by round



Discussion and Conclusion

- **VCAAs incentivize greater per-capita conservation relative to subsidies and reduce landowners' losses in the presence of IS.**
- **However, conservation outcomes are worse under VCAAs than under subsidies, and are not significantly different than those under simple land-use restrictions.**
  - This is despite eliminating the possibility of coordination failure.
- **Free-riding generates excessively large conservation costs for landowners who conserve habitat under VCAAs, even when listing is avoided.**

Acknowledgements

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