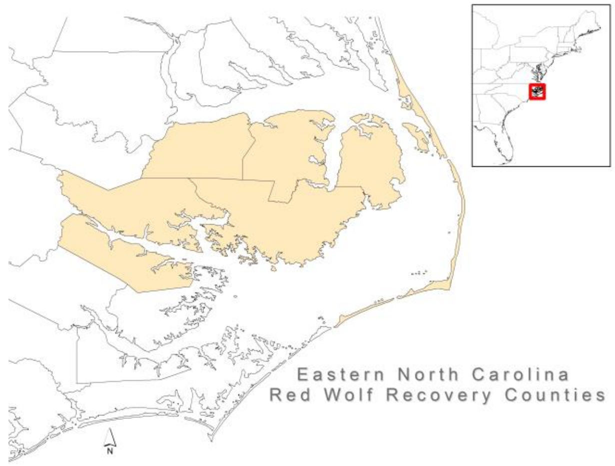
Research Statement

Motivation:

The red wolf (*Canis rufus*), a gray wolf-coyote hybrid species, was declared endangered in 1967 and extinct in the wild in 1980 (USFWS, 2015). Captive populations were reintroduced in 1987 launching a long-standing recovery effort. Today, approximately 50 to 75 wild red wolves populate five counties in eastern North Carolina (USFWS, 2015) constituting the world's only wild red wolf population. Habitat loss spurred a westward migration of the population onto private agricultural lands without which population recovery would be infeasible. Successful recovery is also threatened by interbreeding, or hybridization, with local coyote populations, which jeopardizes the species' genetic distinctiveness and will remain a concern until recovery is complete. Hybridization is prevented by sterilizing a "placeholder" coyote population that defends a buffer territory between fertile coyotes and red wolves accounting for a significant portion of the recovery budget (Williams et al. 2014). The spatial pattern of red wolf recolonization, arising from private agricultural land retirement choices, therefore influences species recovery and recovery costs. The policy problem is to incentivize private agricultural landholders to voluntarily modify their land to accommodate the growing population while financing an anti-hybridization program that is increasingly costly in habitat fragmentation.[1]



A recent independent evaluation of the Red Wolf Recovery program concluded

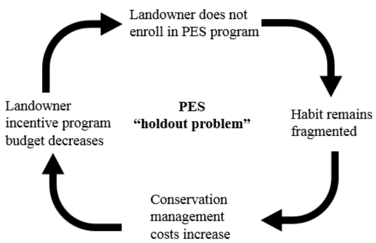
> *"More intensive monitoring of wolves will be required in order to respond to the public concerns about their movement and habitat use. Alternatively, expenses could decrease if the FWS would adopt a different management strategy that would allow wolves to disperse throughout the restoration area. This action would likely be tolerated only if the FWS developed a landowner incentive program that would provide compensation for the presence of red wolves on private property within the restoration areas. Funding levels must consider the red wolf/coyote hybridization issue that is likely to occur in any selected reintroduction site…" (Williams et al. 2014).*

Landowner incentive programs are common, often voluntary and pay a fixed rental rate on retired parcels of land. The fixed payment structure does not reward the added benefit that accompanies interconnected habitat. The agglomeration bonus is an incentive program that rewards the added value of contiguous habitat with a one-time bonus on adjacent retired parcels (Parkhurst et al. 2002). The agglomeration design is vulnerable to overcompensating "green" landholders and undercompensating "brown" landholders because rental rates and bonus payments are fixed. An alternative and potentially cost-effective approach is to target landholders spatially using payments realized through a reverse auction that ensures contiguity is achieved (Fooks et al. 2015). Both the agglomeration and spatial targeting mechanisms attempt to provide least-cost contiguous habitat. We expand this line of work by recognizing wildlife agencies choose between (i) reuniting fragmented habitat for species recovery and (ii) implementing costly conservation methods to foster species recovery in fragmented areas.

[1] Agricultural land modification, in the case of red wolf recovery, comes in the form of (i) not killing red wolves on private property – i.e., "pay for presence" schemes - and/or (ii) granting federal wildlife officials access to conduct routine operations.

Relevance:

The proposed payment for ecosystem services (PES) mechanism is distinctly in line with the Center for Behavioral & Experimental Agri-Environmental Research (CBEAR) mission of "applying behavioral insights and experimental designs to improve programs related to agriculture and the environment." Recent work finds mixed support for the Red Wolf Recovery Program among private agricultural landholders in eastern North Carolina (Kramer and Jenkins 2009). This polarized support inhibits recovery efforts by limiting the total area and contiguity of habitat reconstruction. Smaller and fragmented recovery areas are less supportive of species recovery and more expensive to manage, which reinforces the program's inability to incentive new landholders. The classic agglomeration bonus framework breaks down if the fixed rental and agglomeration payments cannot satisfy a given landholder's participation constraint. A potentially field-implementable mechanism must be able to (i) adjust rental payments based on landowners' private preferences for the recovery program, (ii) pool conservation management funds with PES scheme funds and (iii) let the revelation of private landholders' preferences determine whether red wolf recovery is better suited by investing in the mitigation of habitat fragmentation or investing in conservation management that fosters species recovery in the presence of fragmented habitat (CBEAR Mission: Objective 3).



Consistent with CBEAR's mission to "improve farmers' and landowners' participation and smooth the application processes and the implementation of good conservation practices," this proposal will examine in a laboratory setting a mechanism designed to support the conservation of the world's most endangered wolf by eliciting the voluntary support of local farmers who control the resources vital for its recovery (CBEAR Mission: Objective 2). Laboratory results will form the platform for a collaborative Agriculture and Food Research Initiative (AFRI) Foundational Program proposal to field test this mechanism using a pilot experiment in eastern North Carolina (CBEAR Mission: Objective 1). The prospect of pursuing federal funds and field-testing this mechanism has been discussed with potential collaborators in the USFWS Red Wolf Recovery Program, the North Carolina Wildlife Resource Commission (NCWRC) and the Red Wolf Coalition, Inc. (CBEAR Mission: Objective 4).

Contribution:

The agglomeration mechanism is designed to improve the provisioning of ecosystem services by reuniting fragmented habitat of varying quality (Parkhurst et al. 2002) and has been examined under conditions of high and low information on parcel retirement (Banerjee et al. 2014), costless (Parkhurst et al. 2002) and costly (Banerjee et al. 2015) communication between players and when combined with a spatial targeting mechanism (Fooks et al. 2015). Employing an agglomeration payment scheme has been shown to yield up to 70% cost-savings compared to a fixed payment scheme on land retirement (Drechsler et al. 2010). The agglomeration bonus has not been tested to incentivize landholders with polarized preferences for habitat reconstruction. A landowner that is particularly averse to a conservation program may "block" contiguous habitat reconstruction because of a strong private disincentive to support the program.

Integrating the PES budget with the conservation management budget will highlight a key tradeoff between *using increasingly costly incentive payments to preserve least-cost contiguity* and *foregoing least-cost habitat contiguity in favor of increasingly costly conservation management*. That is, private information unknown to the policymaker will guide the mechanism to the social optimum, which may invest heavily in mitigating habitat fragmentation (e.g. pay higher rates to "brown" landholders with a strong aversion to species recovery and incur low conservation management costs), invest heavily in adapting to habitat fragmentation (e.g. pay lower rates only to "green" landholders with a weak aversion to species recovery, forgo habitat contiguity and incur higher conservation management costs) or combine mitigation and adaptation techniques.

Consider the case of two landholders who are asked to participate in a payment for ecosystem services (PES) scheme. Landholders are compensated for enrolling any two of their parcels of land and participation is voluntary. Parcels A and B are owned by Player 1 and parcels C, D and E are owned by Player 2. The opportunity cost of land retirement varies across parcels and players. These opportunity costs are usually based on land quality and known to private landowners and policymakers (Parkhurst et al. 2002, Fooks et al. 2015). We assume the opportunity cost of land retirement is driven by landowner sentiments, which are unknown to the government.

	Player 1	Player 2	
	A = 5	C = 140	
	B = 55	D = 10	
		E = 110	

Player 1 is empathetic to the species recovery effort and player 2 is averse to the species recovery effort. Player 1's opportunity costs of retiring parcels A and B are 5 units and 55 units. Player 2's opportunity cost of retiring parcels C, D and E are 140, 10 and 110. The government pays a fixed amount *r* for every parcel of retired land and a fixed amount *b* of agglomeration bonus for every shared border. Player 1 chooses between strategies AB or 0 and Player 2 between strategies DE, CD and 0.[2] In the case where the government can observe the cost of retiring each parcel of land perfectly, the lowest-budget offer to landholders is to offer r=0 to both players, while offering player 1 an agglomeration bonus of 20 per shared border and offering player 2 an agglomeration bonus of 50 per shared border. Player 1 receives agglomeration payments for three shared borders that perfectly offset her opportunity cost of land retirement making her indifferent to retiring AB and not participating. Player 2 receives agglomeration payments for three shared borders that perfectly offset her opportunity cost of land retirement making her indifferent to retiring CD and not participating. Player 2 would only receive two agglomeration payments for retiring DE, which would not offset the 120 unit opportunity cost of retiring those parcels. A government is able to incentivize construction of ABCD with a total budget of 210. If the government's budget is smaller than 210, the area ABCD cannot be achieved.

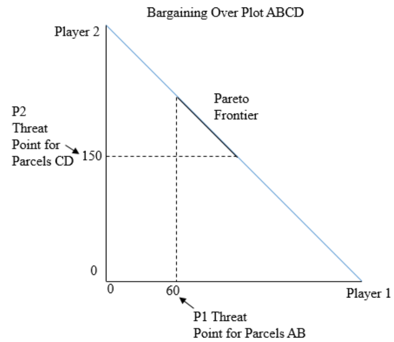
If the government cannot observe landholders' preferences to make discriminatory offers, it needs to offer both players a 50 unit agglomeration bonus requiring a total budget of 300 units. A more realistic case is when land retirement costs are unobserved by the government. A policymaker risks setting incentive payments that overcompensate those landholders who are less averse to species recovery and undercompensate those landholders who are more averse to species recovery. The former case risks misusing scarce recovery funds while the latter case risks not meeting the landholder's participation constraint.[3] Our design moves beyond examining the problem of habitat reconstruction as one that encourages the least-cost, including ex post management cost, construction of contiguous habitat. We recognize that (i) landowner incentive programs attempt to mitigate habitat fragmentation *and* (ii) governments manage conservation efforts to support species recovery in the presence of fragmented habitat. We propose an application of the simultaneous and repeated two-player Nash bargaining problem to incentivize the voluntary construction of habitat for species recovery.

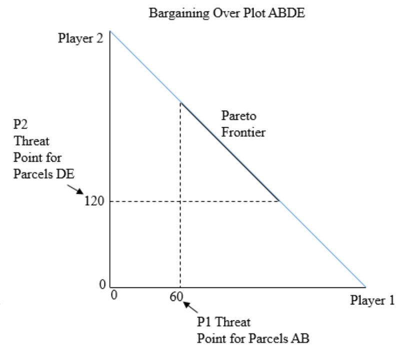
<u>Approach:</u>
In this program, players are not offered predetermined agglomeration or rental payments on their land. Instead, the government's species recovery budget constitutes a "pie" that is bargained over between both

[2] We eliminate the possibility of player 2 playing strategy CE for exposition.

[3] It is also possible for the policymaker to overcompensate both the "green" and "brown" landholders, which represents a particularly severe case of misappropriating recovery funds.

players. Player "threat points" are determined by private opportunity costs of parcel retirement. Player 1 requests a buyout payment to play strategy AB while player 2 requests buyout payments to play each strategy CD and DE. The round ends and players are uncompensated if the conjointly requested funds are in excess of the budget - i.e., beyond the Pareto frontier. If only one of the {AB, CD} and {AB, DE} strategies are viable, players receive payouts for those strategies for the round. If both the {AB, CD} and {AB, DE} strategies are financially viable, the government honors the most equitable outcome - i.e., the outcome that minimizes the difference between the two players' payouts. The game is repeated for twenty rounds.





Treatment	Cost	Incurred By
1	Low-High	Government
2	Low	Landowners
3	High	Landowners

The experiment will have three treatments each with two sessions of 40 students. In treatment 1, players engage in Nash bargaining without regard to conservation management expenses that the government *ex post* incurs. That is, outcome {AB, CD} would require 12 perimeter cells to be filled with "placeholder" coyotes while outcome {AB, DE} would require an additional two cells to be filled.[4] Here, the spatial pattern of land retirement creates a negative management externality that the government incurs, which serves as a baseline where landowners incur no cost. In treatment 2, players engage in Nash bargaining where the negative management externality associated with each retired parcel is low cost and deducted from player payouts. Management fees are only shared if the buffer parcel is adjacent to or diagonal from both players.[5] Internalizing the spatial externality associated with land retirement patterns into a Nash bargaining framework enables those *ex post* costs associated with adaptation to fragmented habitat *to regulate* the level of *ex ante* investment in mitigation of habitat fragmentation. In treatment 3, players engage in Nash bargaining where the negative management externality associated with each retired parcel is high cost and deducted from player payouts.

Players are bargaining over a pie of size Y-210 when constructing plot ABCD and a pie of size Y-180 when constructing plot ABDE. This result holds because player 2 has a lower threat point for parcels DE as compared to parcels CD. In treatment 1, where management costs are separated from landowner payments, the contiguous outcome ABCD is not theoretically achievable. In treatment 2, internalizing management costs, c, transforms each player's threat point, i.e., – *ex post* management costs are incurred by landholders out of their payments. When bargaining over plot ABCD, player 1 has a threat point of $60\text{-}6c$ and player 2 has a threat point of $150\text{-}6c$. When bargaining over plot ABDE, player 1 has a threat point of $60\text{-}5.5c$ and player 2 has a threat point of $120\text{-}8.5c$. Here, the spatial pattern of land retirement influences *both* players' threat points by way of incurring privately conservation management costs resulting from species recovery on their land.

Hypothesis 1: Privatizing conservation management costs creates the voluntary construction of contiguous habitat.

Internalizing a negative externality associated with the spatial pattern of land retirement incentivizes the voluntary construction of habitat. This hypothesis would be supported by players constructing habitat

[4] Plot ABDE is still contiguous in our example. In the experiment, the spatial patterns of land retirement will be more complex where equilibria may support completely fragmented land with more intensive buffering. We have simplified the example for the purpose of this proposal.

[5] For example, {AB, CD} results in management fees on 6 buffer parcels charged to each player whereas {AB, CE} results in a management fee on 5.5 parcels charged to player 1 and a management fee on 8.5 parcels charged to player 2.

randomly in the baseline treatment and by constructing habitat that is contiguous in the low and high cost treatments.[6]

Hypothesis 2: The bargaining mechanism will lead to perfectly contiguous (fragmented) habitat construction when conservation management costs (landowner reservation costs) are high.

Internalized conservation management costs shrink the bargaining pies associated with both plots but management costs associated with ABCD are less sensitive because the plot's spatial pattern minimizes the required conservation management. Mitigating habitat fragmentation reduces the need to support a recovering species in fragmented habitat. In theory, if management costs are low, $c<15$, landowners will bargain over plot ABDE and pass up perfectly contiguous habitat whereas if management costs are high, $c>15$, landowners will choose to bargain over plot ABCD and choose to support the perfectly contiguous habitat. Internalizing management costs can support partially fragmented habitat or contiguous habitat. The outcome that is preferred depends upon landowner sentiments and how costly adaptation to fragmented habitat is. This hypothesis would be supported by players adopting strategies AB and DE in treatment 1 and strategies AB and CD in treatment 2. In the latter case, the construction of ABCD is evidence that the bargaining framework is able to overcome the "hold out" problem that exists when using an agglomeration mechanism.

<u>Researcher/Team Qualifications & Available Resources:</u>
Jacob Hochard earned his Ph.D. in Economics from the University of Wyoming in 2015 and is an Assistant Professor of Economics and Assistant Research Scientist in the Institute for Coastal Science and Policy (ICSP) at East Carolina University in Greenville, North Carolina. Hochard brings to the research team an expertise in the management of ecosystem services from a recovering gray wolf population (Hochard and Finnoff 2014; Hochard and Finnoff 2015), informing listing and delisting decisions for species protection under the endangered species act (Sims et al. 2015) and modeling the spatial intersection between livestock grazing on public land and wolf-caused livestock depredation (Aadland et al. 2015). Hochard also has experience running laboratory experiments (Hochard et al. 2015) and has worked closely with the World Bank's Development Impact Evaluation (DIME) Initiative and the Vietnamese government to design and plan a sequence of randomized control trials in Hanoi, Vietnam. Yuanhao Li earned his Ph.D. in Economics from the University of Wyoming in 2015 and is a Postdoctoral Research Fellow in the Department of Economics at Norwegian School of Economics. Li brings to the research team an expertise in the design of laboratory economic experiments (Li, Thunstrom, van 't Veld 2015) and behavioral modeling (Li and van 't Veld 2015).

<u>Collaborator:</u>
This work will be conducted in collaboration with Jason Shogren and David Finnoff at the University of Wyoming. East Carolina University facilities will be used to run experiments in the spring 2016. In addition to CBEAR support, Dr. Hochard is currently in discussion with the following non-profit, state and federal stakeholders

- Pete Benjamin, Field Supervisor, USFWS Raleigh Ecological Services Field Office
- Brandon Sherrill, Mammologist & Associate Wildlife Biologist, NCWCR
- Kim Dawson, Executive Director, Red Wolf Coalition, Inc.

Laboratory results are expected to motivate and support a collaborative spring 2016 field implementation proposal to the United States Department of Agriculture's (USDA) Agriculture and Food Research Initiative (AFRI) Foundational Program on Natural Resources and the Environment.

[6] Notice that our running example only offers options to construct plots ABCD and ABDE. This simplification was made for the purpose of this proposal. In the experiment, the spatial pattern will be slightly more complex allowing players to construct completely fragmented parcels.