Ecosystem service values from sustainable farming practices: Application of ecosystem service model and choice modelling valuation approach in estimating residents' "willingness-to-pay" for the improvement of ecosystem services

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Introduction

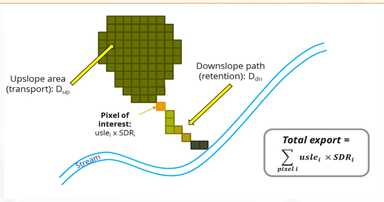
Economic activities shape ecosystems and consequently affect ecosystem services. Oftentimes, the profit and loss statements focus more on the monetary benefits and less on non-pecuniary benefits of their activities. This can potentially lead to undervaluation of ecosystem services, and often produce damaging impacts. One of the major industries that drive such change is agriculture. Although agriculture delivers significant benefits to the society, it is also not without challenges, particularly on its impact to ecosystem services. For example, common agricultural issues to ecosystem services include water quality issues through sediment and nutrient runoff. Furthermore, since farms are being converted to urban areas, agricultural land competes with other land covers such as with forested land. This results to detrimental effects to the ecosystem and ecosystem services such as decline in wildlife habitat and effect to water supply.

Due to these issues, best management practices, commonly referred to as sustainable farming practices, have been explored to maintain a balance between the economic gain while considering the quality of the ecosystem and ecosystem services. However, these practices also entail costs and strategic planning. One way to address this is to solicit support from stakeholders by estimating their value towards an improved ecosystem service. Valuation of ecosystem services (ES) has become significant and plays an important role in natural resource management. The goal of this study is to assess the value of the ES within the Santee River Basin Network (SRBN) by estimating the willingness-to-pay (WTP) of its residents to support the implementation of these best management practices.

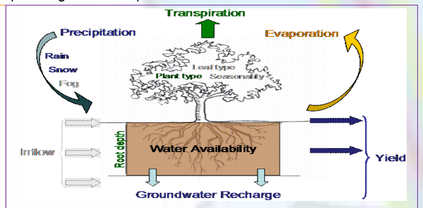
Methodology

➢Ecosystem service-based models for quantifying the ES in SRBN

- We used the Integrated Valuation of Ecosystem Services and Tradeoff (InVEST) model to quantify the ES across the landscape
- A modified Crop Data Layer of 2018 was used to account for seasonality change in the land cover for agriculture. Off-season crops were treated as idle cropland.
- We simulated the sustainable farming practice scenario by assuming that off-season crops will be vegetated across the whole year through planting cover crops.



Sediment Delivery Ratio (SDR) model estimates the amount of sediment contributed by an area to the stream, hence quantifying the sediment retention capacity per pixel of landcover



Water Yield (WY) model estimates the amount of water that is captured by an area which can potentially runoff, hence quantifying the potential surface runoff contribution per pixel of landcover

➢Estimating the WTP:

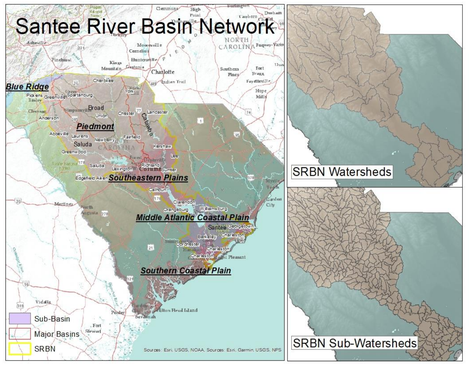
- We surveyed 1560 respondents through the Qualtrics platform
- The sampled respondents were split into 2 groups representing the proposed types of sustainable farming intervention
  - Cover crop application
  - Agroforestry implementation
- We used mixed logit model (Hole, 2013) to analyze the respondents' choices

$$P_{ni} = \int \frac{\exp(x'_{ni}\beta)}{\sum_{j=1}^{J}\exp(x'_{nj}\beta)} f(\beta|\theta)d\beta$$

- We estimated the willingness-to-pay (Hole, 2013) from the mixed logit model

$$E(WTP^k) = -\frac{E(\beta^k)}{\beta^{price}}$$

Study site



- Santee River Basin Network (SRBN)
  - 7.54 million acres
  - Consists of four major basins: Broad, Catawba, Saluda, Santee
  - Can be subdivided into:
    - 12 sub-basins
    - 70 watersheds
  - Transcends across ecoregions: Blue Ridge, Piedmont, Southeastern Plains, Middle Atlantic Coastal Plain, and Southern Coastal Plain
  - Hosts 79% of the total population of SC across 30 counties.

Results: Estimating Mean WTP

Mixed Logit regression of choice responses

	Cover Crop		Agroforestry	
	coef	pval	coef	pval
Water Supply	-0.002	0.879	0.037	0.001
Water Quality	0.230	0.000	0.204	0.000
Wildlife	0.225	0.001	0.517	0.000
Price	-0.093	0.000	-0.123	0.000

The mixed logit regression result shows that residents are willing to pay for improvement of ecosystem services, particularly for water quality and wildlife. However, for water supply, residents are willing to pay only if the improvement is substantial, such as if it comes from Agroforestry intervention.

Mean Willingness-to-pay

	Cover Crop	Agroforestry
Water Supply	NA	$0.30
Water Quality	$2.48	$1.66
Wildlife	$2.43	$4.21

Residents are willing to pay $2.48 per month for a 1% worth of improvement to water quality in streams and $2.43 per month if the intervention can increase wildlife occurrence, using cover crop as the best management practice to be implemented.

Residents are willing to pay $0.30 per month for a 1% worth of improvement to water supply, while $1.66 per month for a 1% worth of improvement to water quality, and $4.21 per month if the intervention can increase wildlife occurrence, using agroforestry as the best management practice to be implemented.

In terms of water quality, since residents in SC are more familiar to cover crops and its association to the improvement of water quality, we see that their WTP is higher than for agroforestry. While for wildlife values, since agroforestry has "forestry" in its name, forest are more attributed to improvement of wildlife habitat, hence stakeholders have higher WTP to agroforestry than cover crops.

Considering the number of household in SC as of 2018, overall if we compute for the potentially revenue that can be collected using this WTP. This could amount to $11million to $14million per month which is substantial to support conservation programs.

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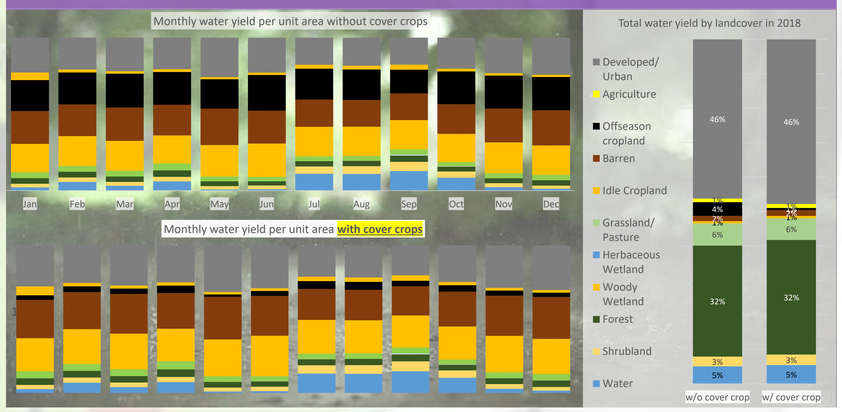
Results: Quantifying Ecosystem Services

Sediment retained (tons/acre) per month

Results show that the cover crops improved the agricultural land by increasing from 0.5 tons per acre to 2.71 tons per acre retention capacity. That is 1% to 4% retention capacity improvement. Since sediments hold not just particles but also nutrients, we can assume that improvement of this aspect will directly contribute to the improvement of water quality.

Water yield (m/sqm) per month



There is a significant decline in the amount of potential runoff from the offseason areas when simulated with sustainable farming intervention. Note that low runoff means high soil organic matter is retained, and hence implies an improvement to soil quality and more infiltration for ground water recharge. Furthermore, low runoff could also reduce potential flooding.

Therefore, implementation of sustainable farming practices, such as cover crops, improves ecosystem service provision.

Conclusion

Vegetated areas provide the most ecosystem services, therefore, implementation of sustainable farming practices, such as cover crops, could be highly beneficial.

Residents are also willing to pay for the improvement of ecosystem services, particularly if it improves water quality and wildlife habitat.

The potential total revenue from the stakeholders' WTP can substantially generate sustainable financing for conservation programs

The information indicates a favorable circumstance for developing a sustainable financing program and a conservation plan.

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