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Evaluating Sustainability in the Rio Grande Basin with an Ecological Footprint Analysis

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INTRODUCTION

- Sustainability indicators have been acknowledged as useful measures to help track progress towards sustainable development and support design of policy measures (Heberling and Hopton, 2014, Hopton and Berland, 2015, Hopton and White, 2012)
- Existing sustainability indicators do not always provide a comprehensive picture of the ability or likelihood of a current system state to be maintained or improved over time (Milman and Short, 2008).
- These indicators do not always represent changes as a result of shocks, e.g. extreme weather events (heat and drought, heavy precipitation, snow and flooding), which could directly impact sustainability.

METHODS

Ecological Footprint Analysis includes supply (biocapacity - BC) and demand (ecological footprint - EF) of environmental resources

Sustainability index = demand - supply

$$BC = N \times bc = N \times (1-12\%) \times \sum \gamma_i y_i a_i$$

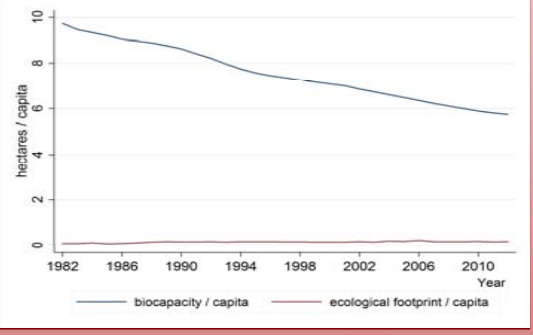
$$EF = N \times ef = N \times \sum \gamma_i (a_i) = N \times \sum \gamma_i (c_i / p_i)$$

Estimation of weather impacts on biocapacity and ecological footprint:

$$Z_{ct} = \alpha_0 + \sum_{k=1} \alpha_{ctk} w_{ct} + u_{ct}$$

i - type of the resources; *bc* and *ef* - per capita biocapacity and ecological footprint; *N* - total population; γ_i - equivalence factor describing productivity of land types; y_i - yield factor (supply-existing national biocapacity per capita; a_i - ecologically productive area of land; p_i - average resource productivity.

RESULTS: SUSTAINABILITY INDEX



RESEARCH OBJECTIVES

This research has three main objectives:

1. Apply the Ecological Footprint Analysis (EFA) to evaluate sustainability levels in the Rio Grande Basin
2. Investigate how weather conditions can affect the demand and supply of environmental resources
3. Predict future sustainability developments under different scenarios of potential extreme weather events

To the best of our knowledge, this research is the first study to:

a) Examine impacts of future extreme weather on the demand and supply of environmental resources and

b) Investigate a regional scale of ecosystem sustainability

RESULTS: WEATHER VARIABLES

Variables	Biocapacity/capita	Ecological footprint/capita
Mean temperature	-5.9399**	-4.5956***
	(2.4600)	(1.1372)
Mean temperature, squared	0.2942*	0.1766***
	(0.1635)	(0.0384)
Annual precipitation	0.6971	-0.0314
	(0.5379)	(0.0691)
Annual precipitation, squared	-0.0038	0.0009
	(0.0032)	(0.0005)
Drought index	1.9200	-2.9081***
	(1.7586)	(1.0280)
Variation of mean temperature	0.4918	-0.5560
	(1.4418)	(0.6708)
Precipitation intensity index	-9.0688*	-1.7899
	(5.4048)	(2.1571)
Time trend	0.3618	0.0833
	(0.3423)	(0.0621)
Constant	63.3475	34.6203***
	(40.0929)	(10.7057)
R^2	0.0139	0.0630
N	1710	1710

Note: Standard errors in parentheses; * p<0.1, ** p<0.05, *** p<0.01

CONCLUSIONS

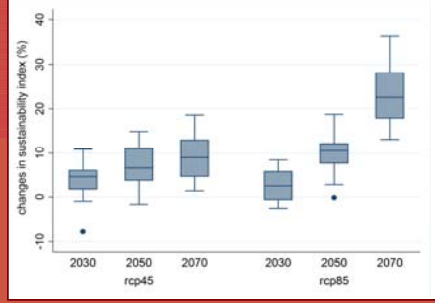
- Resource supply (biocapacity) had a decreasing trend in the past 31 years, with a mean biocapacity ~8 ha/capita.
- Resource demand (ecological footprint) had a stable trend, with a mean ~0.2 ha/capita.
- Resource use in the Rio Grande Basin is currently sustainable.
- Resource supply and demand can be affected by the mean temperature and extreme weather events.
- Projections show that resource use and application in the Rio Grande Basin will be more sustainable in the future subject to weather variations.

DATA

County-level data from 1982 to 2012 were used from the following sources:

- National Resource Inventory (land use data), USDA National Agricultural Statistics Services (NASS) (crop production and consumption data), U.S. Bureau of Economic Analysis (BEA) (population), U.S. Energy Information Administration (EIA) (energy consumption and production data)
- Historical weather observations were obtained from Aatzoglou (2013)
- For the future scenarios, weather data from 2010 to 2099 was used based on statistically downscaled climate model simulations in the Coupled Model Intercomparison Project Phase 5.

RESULTS: SUSTAINABILITY INDEX UNDER EXTREME WEATHER



- Baseline for resource demand and supply: 1976 -2005
- Projections of future periods: period 2030 (2010- 2039) period 2050 (2040- 2069) period 2070 (2070 -2099)
- Sustainability index calculated as a percent change from the baseline

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