



THE UNIVERSITY OF  
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RESOURCE ECONOMICS

# Impacts of population and income growth rates on threatened species

Ram Pandit, *The University of Western Australia*  
David N Laband, *Auburn University, USA*

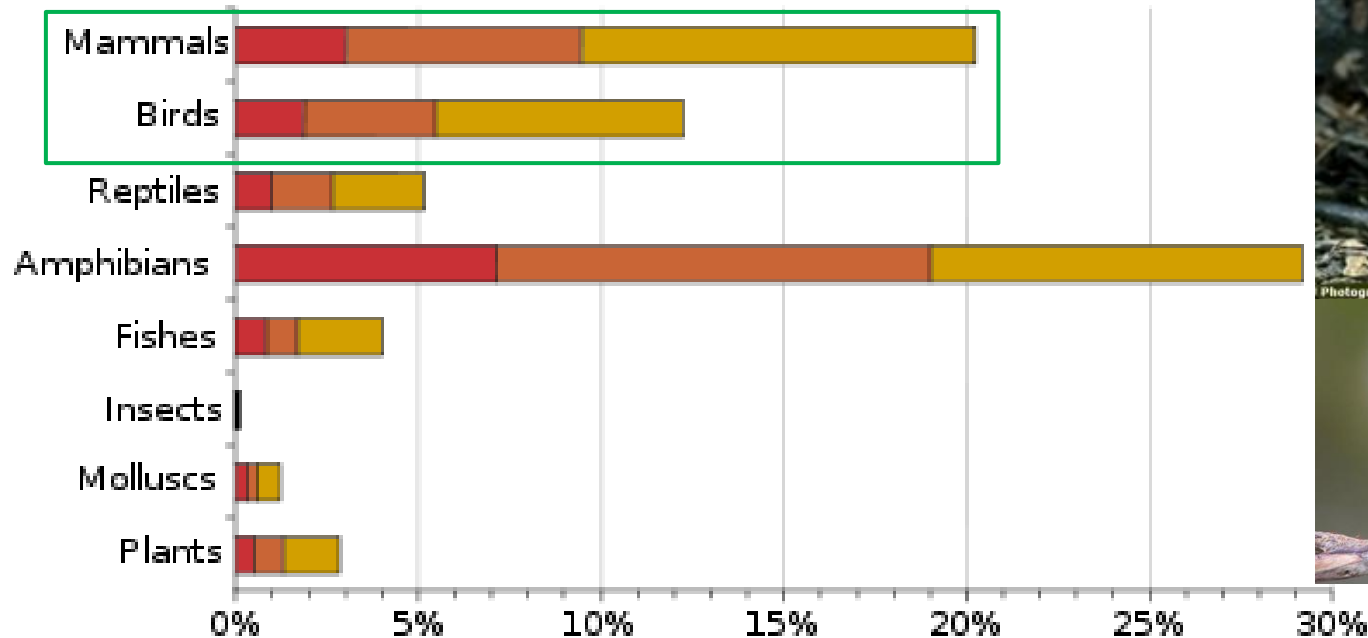
9-11 February 2011, 55<sup>th</sup> AARES Conference, Melbourne

# Context

- 1 in 5 vertebrate species are on the verge of mass extinction (Hoffmann, Hilton-Taylor et al. 2010, *Science*)



The Nagoya CoP10 logo - Life in harmony, into the future



Photograph Courtesy of Dick Walker



The percentage of species in several groups which are listed as ■ critically endangered, ■ endangered, or ■ vulnerable on the 2007 IUCN Red List.



# Drivers of threatened species

- Direct drivers
- Indirect drivers
- Ecological - Endemism, succession
- Anthropogenic - Human population and associated activities
- Cross-sectional models are used (Kerr and Currie 1995, Naidoo and Adamowicz 2001; Asafu-Adjaye 2003)



# A closer look on drivers

<u>Country</u>	<u>1970</u>	<u>2007</u>	<u>%Change</u>
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- Population (in million):

Ghana	8.7	22.8	162
Greece	8.7	11.2	28
South Africa	22.1	~48.2	118
South Korea	31.9	~48.2	51

- Per Capita Income (int. \$):

Guyana	567	2604	360
Thailand	560	10302	1740
Lebanon	2871	8228	287
China	195	8271	4137



# Research questions

- Is there a lagged effect of the **level of** human population and per capita income?
- Does the **rate of** population and per capita income growth have any effects?
- Does space matter?



# Data and Analysis

- Data sources
  - ❖ The World Conservation Union
  - ❖ World Bank
  - ❖ Penn World Table
- Modeling approach
  - ❖ 113 continental countries
  - ❖ Linear model (double logged form)
  - ❖ Spatial weight matrix
  - ❖ Test for spatial dependency
  - ❖ Spatial models



# Linear Model

$$y = X\beta + \varepsilon$$

$y$  =  $n \times 1$  vector of observations on # of threatened species

$X$  =  $n \times k$  matrix of observations on explanatory variables

$\beta$  =  $k \times 1$  vector of regression coefficients

$\varepsilon$  =  $n \times 1$  vector of random error terms

- # of threatened species in 2007  
=  $f$  (# of endemic species, land area, population size 1970, population growth rate 1970-2007, per capita income 1970, income growth rate 1970-2007)



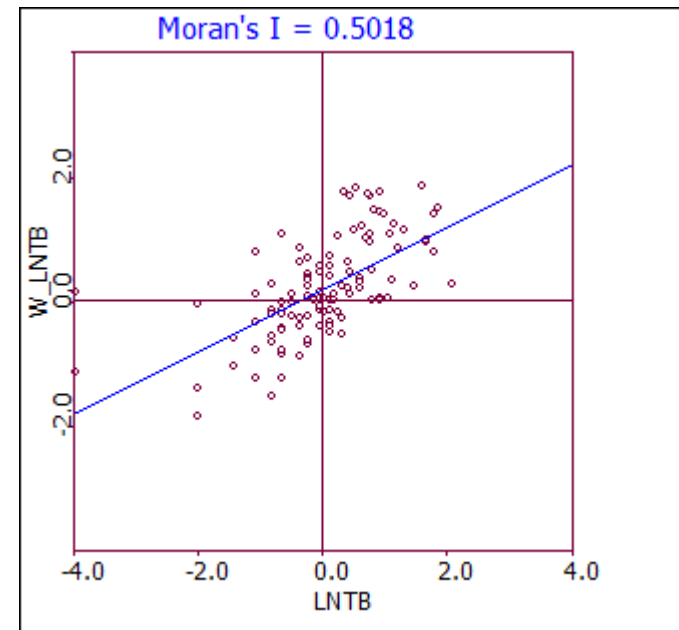
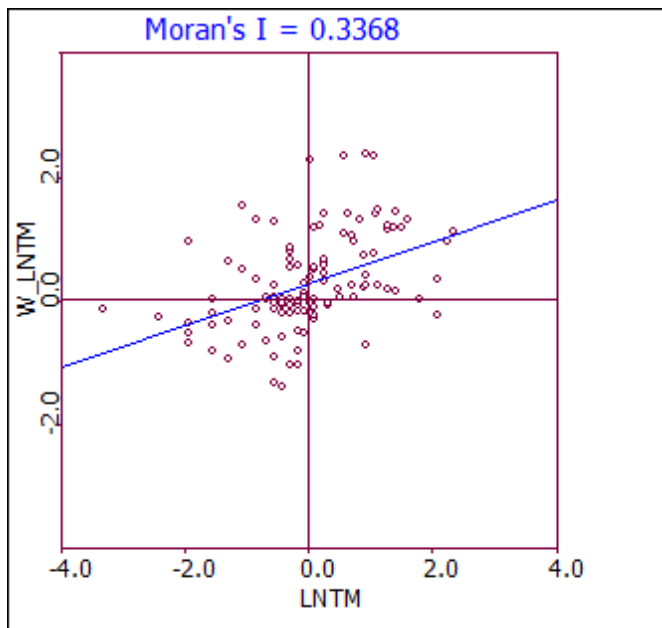
# Check for spatial dependency

- How to weigh neighbors (weight matrix  $W$ )?
  - ❖ Simple contiguity (0, 1)
  - ❖ Ecuador: Peru, Columbia
  - ❖  $W_{Ecu} = (0.5 + 0.5)$
- Check for spill-over effect?  
(Spatial autocorrelation)
  - ❖ Dependent variable
  - ❖ Linear model residual



# Spatial dependency test

Models	Dependent variable		Linear model residual	
	Moran's I	P-value	Moran's I	P-value
Ln Threatened Mammals	0.34	8.88E-06	0.228	0.0004
Ln Threatened Birds	0.50	6.39E-11	0.210	0.0009



# Spatial models

- Spatial **lag** model  
(based on dependent variable)

$$y = \rho W y + X \beta + \varepsilon$$

$$y_{\text{Ecu}} = \rho[0.5y_{\text{Per}} + 0.5y_{\text{Col}}] + X \beta + \varepsilon$$

- Spatial **error** model  
(based on autoregressive error)

$$y = X \beta + \lambda W \varepsilon + v$$

$$y_{\text{Ecu}} = X \beta + \lambda[0.5\varepsilon_{\text{Per}} + 0.5\varepsilon_{\text{Col}}] + v$$



# Spatial model results: Mammals

Double log model, N=113 continental countries

Dependent variable: # of threatened species in 2007

Variable	Lag model	Error model
Intercept	-3.124 (1.965)	-4.190** (1.821)
Number of <b>endemic spp</b>	0.143*** (0.026)	0.152*** (0.027)
Land <b>area</b>	0.030 (0.035)	0.070* (0.038)
Human <b>population 1970</b>	0.173*** (0.035)	0.122*** (0.035)
Population <b>growth rate</b> 1970-2007	0.080 (0.050)	0.115* (0.059)
Per capita <b>Income 1970</b>	0.803 (0.526)	1.266** (0.518)
Per capita <b>income 1970<sup>2</sup></b>	-0.071* (0.037)	-0.099*** (0.037)
Income <b>growth rate</b> 1970-2007	0.083* (0.049)	0.042 (0.048)
<b>Spatial control</b> variable	0.134** (0.052) $\rho$	0.527*** (0.084) $\lambda$
AIC (LL)	144.94 (-62.47)	135.64 (-57.82)

# Spatial model results: Birds

Variable	Lag model	Error model
Intercept	-10.252*** (2.651)	-6.602** (2.595)
Number of <b>endemic spp</b>	0.211*** (0.034)	0.205*** (0.042)
Land area	0.049 (0.045)	0.050 (0.050)
Human <b>population 1970</b>	0.285*** (0.051)	0.251*** (0.052)
Population <b>growth rate</b> 1970-2007	0.437*** (0.070)	0.315*** (0.088)
Per capita <b>Income 1970</b>	1.982*** (0.738)	1.291* (0.751)
Per capita <b>income 1970<sup>2</sup></b>	-0.146*** (0.053)	-0.095* (0.054)
Income growth rate 1970-2007	0.090 (0.072)	-0.011 (0.070)
<b>Spatial control</b> variable	0.238*** (0.059) $\rho$	0.613*** (0.073) $\lambda$
AIC (LL)	226.43 (-103.21)	223.20 (-101.60)



# Concluding remarks

- There are lagged effects of population and income **levels**
- There exists an EKC between lagged income and # of threatened birds and mammals
- The **rate** of population growth has impacts on threatened mammals and birds, however income growth rate does indicate strong effects on threatened mammals and birds



# Concluding ...

- Spatial dependency needs to be explored in modeling spatially distributed phenomena, i.e. threatened mammals and birds
- Results have implications for cross-boundary conservation initiatives among continental countries



# **Thank you!**

## **Questions and suggestions!!!**

