Ecosystem Services in the Anthropocene: Future scenarios for Latin America and the Caribbean

Marcello Hernández-Blanco, Robert Costanza, Sharolyn Anderson, Ida Kubiszewski, Paul Sutton

Australian National University
CRAWFORD SCHOOL OF PUBLIC POLICY

CINPE
CENTRO INTERNACIONAL DE POLÍTICA ECONÓMICA PARA EL DESARROLLO SOSTENIBLE

Introduction

- LAC holds 60% of global terrestrial biodiversity as well as a diverse marine and freshwater flora and fauna
- 6 of the most biodiverse countries
- Highly diverse in terms of economy, geography and policy, which determines the route of development that the region has followed

Introduction

- Development characterized by examples of success in sustainability as well as by social and economic challenges.
- Between 1990 and 2014 the total terrestrial area of LAC under protection increased from 8.8 % to 23.4 %
- Urban areas have been growing

Introduction

- Between 1997 and 2011, the global value of ecosystem services has decreased by an estimated $20 trillion/yr due to land use change

1/3 of global GDP in 2011

Introduction

Biome	Area (e6 ha)			Unit values 2007$/ha/yr			A. Original: Aggregate Global Flow Value e12 2007$/yr	B. Change unit values only	C. Change area only	D. Change both unit values and area	E. Column C - Column A	F. Column D - Column B
							Assuming 1997 area and 1997 unit values	Assuming 1997 area and 2011 unit values	Assuming 2011 area and 1997 unit values	Assuming 2011 area and 2011 unit values	2011-1997 Change in Value e12 2007$/yr	
	1997	2011	Change 2011-1997	1997	2011	Change 2011-1997	1997	2011	2011	2011	1997 unit values	2011 unit values
Marine	**36,302**	**36,302**	0	796	1,368	572	**28.9**	**60.5**	**29.5**	**49.7**	0.6	(10.9)
Open Ocean	**33,200**	**33,200**	0	348	660	312	11.6	21.9	11.6	21.9	-	-
Coastal	**3,102**	**3,102**	0	5,592	8,944	3,352	17.3	38.6	18.0	27.7	0.6	(10.9)
Estuaries	180	**180**	0	31,509	28,916	-2,593	5.7	5.2	5.7	5.2	-	-
Seagrass/Algae Beds	200	**234**	34	26,226	28,916	2,690	5.2	5.8	6.1	6.8	0.9	1.0
Coral Reefs	62	**28**	-34	8,384	352,249	343,865	0.5	21.7	0.2	9.9	(0.3)	(11.9)
Shelf	2,660	**2,660**	0	2,222	2,222	0	5.9	5.9	5.9	5.9	-	-
Terrestrial	**15,323**	**15,323**	0	1,109	4,901	3,792	**17.0**	**84.5**	**12.1**	**75.1**	(4.9)	(9.4)
Forest	**4,855**	**4,261**	-594	1,338	3,800	2,462	6.5	19.5	4.7	16.2	(1.8)	(3.3)
Tropical	1,900	**1,258**	-642	2,769	5,382	2,613	5.3	10.2	3.5	6.8	(1.8)	(3.5)
Temperate/Boreal	2,955	**3,003**	48	417	3,137	2,720	1.2	9.3	1.3	9.4	0.0	0.2
Grass/Rangelands	**3,898**	**4,418**	520	321	4,166	3,845	1.2	16.2	1.4	18.4	0.2	2.2
Wetlands	**330**	**188**	-142	20,404	140,174	119,770	6.7	36.2	3.4	26.4	(3.3)	(9.9)
Tidal Marsh/Mangroves	165	**128**	-37	13,786	193,843	180,057	2.3	32.0	1.8	24.8	(0.5)	(7.2)
Swamps/Floodplains	165	**60**	-105	27,021	25,681	-1,340	4.5	4.2	1.6	1.5	(2.8)	(2.7)
Lakes/Rivers	**200**	**200**	0	11,727	12,512	785	2.3	2.5	2.3	2.5	-	-
Desert	**1,925**	**2,159**	234	-	-	0	-	-	-	-	-	-
Tundra	**743**	**433**	-310	-	-	0	-	-	-	-	-	-
Ice/Rock	**1,640**	**1,640**	0	-	-	0	-	-	-	-	-	-
Cropland	**1,400**	**1,672**	272	126	5,567	5,441	0.2	7.8	0.2	9.3	0.0	1.5
Urban	**332**	**352**	20	-	6,661	6,661	-	2.3	-	2.3	-	0.1
Total	**51,625**	**51,625**	0				**45.9**	**145.0**	**41.6**	**124.8**	**(4.3)**	**(20.2)**

Costanza et al, 2014

Methods

Scenario planning

- Goal: to present potential futures based on policy decisions around influential and uncertain drivers
- Plausible rather than probable futures

Scenarios

- 3 existing sets of global scenarios were used to develop and evaluate the future value of global ecosystem services under four alternative land-use scenarios

Bringing Ecosystem Servic
Economic Decision-Making
Use in the United Kingdom

Ian J. Bateman,[1*] Amii R. Harwood,[1] Georgina M. Mace,[2] Robert T.
Barnaby Andrews,[3] Amy Binner,[3] Andrew Crowe,[4] Brett H. Day,[1] S
Jo Foden,[7] David Hadley,[7,8] Roy Haines-Young,[9] Mark Hulme,[10] A
Andrew A. Lovett,[1] Paul Munday,[3] Unai Pascual,[11,12] James Pater
Antara Sen,[1] Gavin Siriwardena,[10] Daan van Soest,[15] Mette Term

Landscapes generate a wide range of valuable ecosystem services, yet lan
value of these services. Using the example of the United Kingdom, we sh
change not only for agricultural production but also for emissions and seq
open-access recreational visits, urban green space, and wild-species dive
models in conjunction with valuation methods to estimate comparable ec
taking account of climate change impacts. We show that, although decis
agriculture reduce overall ecosystem service values, highly significant va
from targeted planning by incorporating all potential services and their va
conserves wild-species diversity.

The Millennium Ecosystem Assessment (*1*) provided important evidence of the ongoing global degradation of ecosystem services and highlighted the need to incorporate their value into the economic analyses that underpin real-world decision-making. Previous studies have shown that the overall values of unconverted natural habitats can exceed the private benefits after conversion (*2*, *3*); that knowledge of landscape heterogeneity and ecological processes can support cost-effective land planning (*4*–*7*); that trade-offs in land-u
ecosystem service
level (*8*, *9*); and t
able to the impact
the UK National
(*12*), a comprehen
Kingdom's ecosys
atic environmental
benefits they gener
account of multipl
ronment (including

Table 1. Summary of the ecosystem service related goods considered in

Ecosystem service–related good	Metrics (in year specified)	Main dat and sourc
Agricultural production	Proportion and output of land use in each 2-km grid square	Land use, soils and environment, cli digital mapping, (*31*–*33*)
Greenhouse gases	Net metric tons of CO_2, CH_4, and N_2O per 2-km grid square	Land-use prediction GHG responses (
Recreation	Visitors per 2-km grid square	National survey of households, cens
Urban green-space amenity	Distance to green space from each 2-km grid square	Digital mapping census (*32*, *41*)
Wild bird–species diversity	Wild bird diversity (*20*) per 2-km grid square	*Breeding Bird Survey* (*42*)

Scenarios for Australia in 2050:
A Synthesis and Proposed Surve

Robert Costanza
Australian National University
Australia

Ida Kubiszewski
Australian National University
Australia

Steve Cork
Australian National University
Australia

Paul W. B. Atkins
Australian National University
Australia

Alexandra Bean
Australian National University
Australia

Alexis Diamond
Australian National University
Australia

Nicola Grigg
CSIRO Land and
Australia

Emily Korb
Australian Nation
Australia

Jasmin Logg-Sca
Australian Natio
Australia

Rajkumari Navis
Australian Natio
Australia

Kimberley Patri
Australian Natio
Australia

Abstract

We reviewed a broad range of scenarios of the future developed globally and developed a synthesis for Australia. Our four synthes structured around two axes: (1) individual vs. community orientatio biophysical limits are binding on continued GDP growth or could technology. While global scenarios have explored transformational

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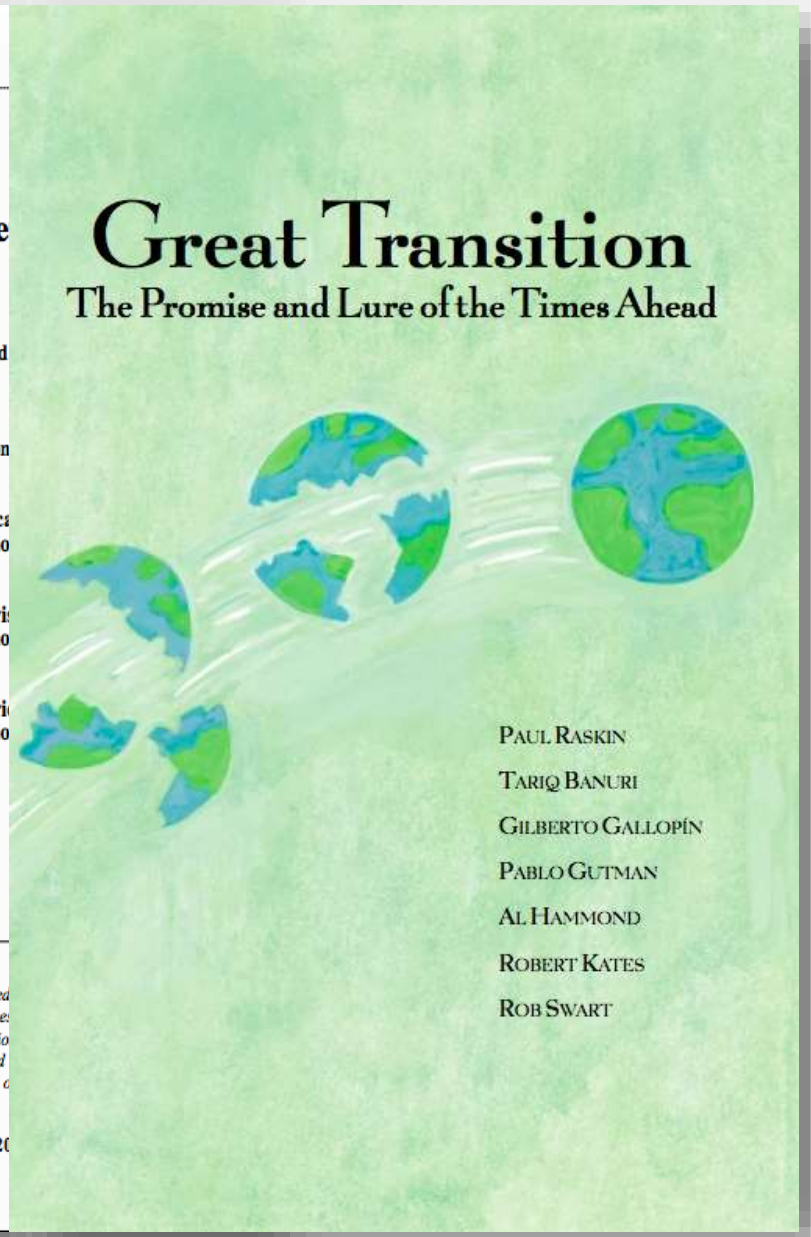
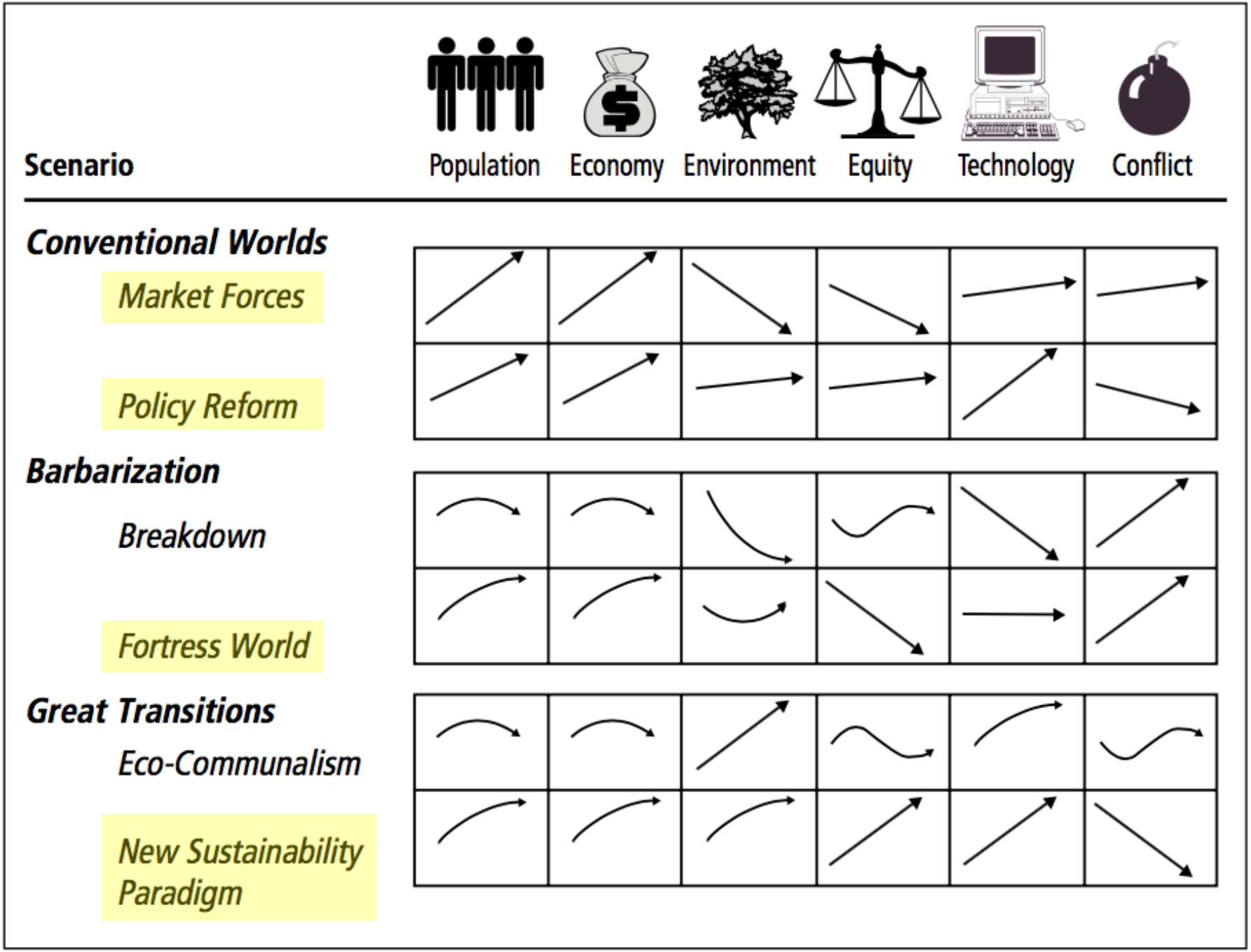


Scenarios

- The scenarios are a synthesis of prior scenario studies, but are based around the four ‘Great Transition Initiative’ (GTI) archetypes created by Raskin et al

- We estimated the implications of these scenarios for the value of 55 ecosystem services to 2050



Source: Gallopín et al. (1997)

Scenarios

Market Forces (MF): an economic and population growth archetype based on neoliberal free market assumptions

Fortress World (FW): an archetype in which nations and the world become more fragmented, inequitable, and head towards temporary or permanent social collapse

Policy Reform (PR): a continuing economic growth archetype, but with discipline/restraint/regulation based on assumptions about the need for government intervention and effective policy; and

Great Transition (GT): a transformation archetype based on assumptions about limits to conventional GDP growth and more focus on environmental and social well-being and sustainability

Market Forces

Policy reform

Fortress Worlds

New Sustainability Paradigm –Great Transition

Value changes in the scenarios

Changes in EESS value due to 2 factors

- Change in area covered by each ecosystem type
- Change in “unit value” due to degradation and restoration

Scenarios

Market Forces (MF): *10% reduction in unit values* from their 2011 levels

Fortress World (FW) *20 % reduction in unit values* from their 2011 levels

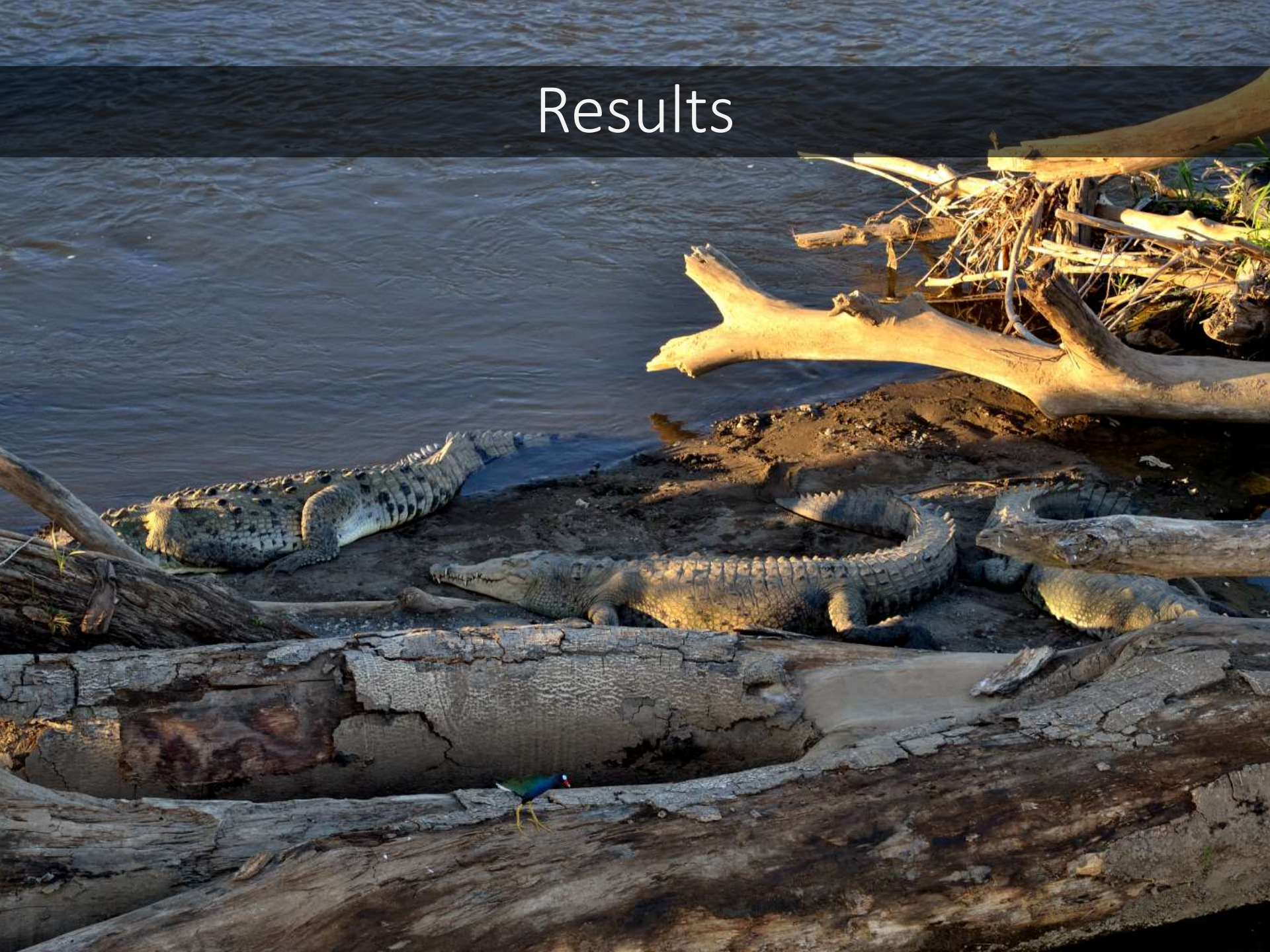
Policy Reform (PR): *no significant change in unit values* from their 2011 estimates

Great Transition (GT): *20% increase in unit values* from their 2011 levels

Mapping

- Global land use data layers (1km^2 res.) for 2011 and the 4 scenarios using an algorithm that distributed the percentage changes in land-cover
- Modified version of the GlobCov data as base data for 2011
- For each scenario, each 2011 land-cover extent grew or shrank based on the percentage changes of that land-cover in that scenario's projection.
- Precedence of land-cover transitions: urban, wetland, cropland, forest, rangeland/grassland, and desert.

Results



ELD Scenarios	1997	2011	1. MF	2. FW	3. PR	4. GT
Great Transition Initiative (GTI)			Market Forces	Fortress World	Policy Reform	Great Transition
Costanza et al. 2014			Free Enterprise	Strong Individualism	Coordinated Action	Community Well Being
Bateman et al 2013			Focus on Market Growth	Maintain Current Practices	Green and Pleasant Land	Conservation Fully Implemented
Population (e9)	5.9	7	9.08	9.53	8.68	8.08
— Urban pop (e9)	2.75	3.5	6.25	6.57	5.99	5.57
— Rural pop (e9)	3.15	3.5	2.83	2.96	2.69	2.51
Global GDP (e12 $2007)	53	87	188	162	180	170
Inequality (Richest 10%/Poorest 10%)		16	29.4	53	14.9	7.1
Urban land (e6 ha)	332	350	554	675	490	397
Cropland (e6 ha)	1400	1672	1757	1782	1733	1676
Forest (e6 ha)	4855	4261	3450	3541	3989	4313
Grass/Rangeland (e6 ha)	3898	4418	3991	3696	4219	4483
Desert (e6 ha)	1925	2159	3396	3494	2427	1924

Biome	Area (e6 ha)					% Change	-0.1	-0.2	0	0.2	Total Annual Flow of Eco-Services Values (e12 2007$/yr)				
						Unit Values ($2007/ha/yr)									
	Scenarios to 2050					($/ha)	Scenarios to 2050				Scenarios to 2050				
	2011	1. MF	2. FW	3. PR	4. GT	2011	1. MF	2. FW	3. PR	4. GT	2011	1. MF	2. FW	3. PR	4. GT
Marine	**36,302**	**36,302**	**36,302**	**36,302**	**36,302**	**1,368**	**1,231**	**1,094**	**1,368**	**1,642**	**49.7**	**38.0**	**32.5**	**49.7**	**62.3**
Open Ocean	33,200	33,200	33,200	33,200	33,200	660	594	528	660	792	21.9	19.7	17.5	21.9	26.3
Coastal	3,102	3,102	3,102	3,102	3,102	8,944	8,050	7,155	8,944	10,733	27.7	18.3	15.0	27.7	36.0
Estuaries	180	180	180	180	180	28,916	26,024	23,133	28,916	34,699	5.2	4.7	4.2	5.2	6.2
Algae Beds/Seagras	234	257	262	234	227	28,916	26,024	23,133	28,916	34,699	6.8	6.7	6.1	6.8	7.9
Coral Reefs	28	5	0	28	35	352,249	317,024	281,799	352,249	422,699	9.9	1.6	0.0	9.9	14.8
Shelf	2,660	2,660	2,660	2,660	2,660	2,222	2,000	1,777	2,222	2,666	5.9	5.3	4.7	5.9	7.1
Terrestrial	**14,822**	**14,822**	**14,823**	**14,822**	**14,822**	**4,901**	**4,411**	**3,921**	**4,901**	**5,881**	**72.0**	**49.3**	**38.8**	**72.3**	**90.0**
Forest	4,225	3,426	3,574	4,037	4,269	3,800	3,420	3,040	3,800	4,560	16.1	11.8	11.0	15.4	19.3
Tropical	1,255	1,070	1,106	1,206	1,211	5,382	4,844	4,306	5,382	6,458	6.8	5.2	4.8	6.5	7.8
Temperate/Boreal	2,970	2,356	2,468	2,831	3,058	3,137	2,823	2,510	3,137	3,764	9.3	6.7	6.2	8.9	11.5
Grass/Rangelands	4,414	3,986	3,695	4,201	4,478	4,166	3,749	3,333	4,166	4,999	18.4	14.9	12.3	17.5	22.4
Wetlands	189	76	24	226	289	140,174	126,157	112,139	140,174	168,209	23.2	8.0	1.8	24.0	30.7
Tidal Marsh/Mangro	109	41	10	108	108	193,843	174,459	155,074	193,843	232,612	21.1	7.2	1.6	20.9	25.1
Swamps/Floodplains	80	35	14	118	181	25,681	23,113	20,545	25,681	30,817	2.1	0.8	0.3	3.0	5.6
Lakes/Rivers	220	220	220	220	220	12,512	11,261	10,010	12,512	15,014	2.8	2.5	2.2	2.8	3.3
Desert	1,690	2,737	2,791	1,871	1,436	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Tundra	433	433	433	431	424	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Ice/Rock	1,640	1,640	1,640	1,640	1,640	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Cropland	1,664	1,749	1,777	1,710	1,670	5,567	5,010	4,454	5,567	6,680	9.3	8.8	7.9	9.5	11.2
Urban	347	555	669	486	396	6,661	5,995	5,329	6,661	7,993	2.3	3.3	3.6	3.2	3.2
Total	**51,124**	**51,124**	**51,125**	**51,124**	**51,124**						**121.6**	**87.3**	**71.3**	**122.0**	**152.3**


Coral Reefs
Tidal Marsh/Mangrove
Swamps/Floodplains
Urban
Lakes/Rivers
Cropland
Temperate/Boral Forest
Tropical Forest
Desert
Grass/Rangelands
Tundra
Ice/Rock
Marine Shelf
Open Ocean

Base 2011

Market Forces

Fortress world

Policy reform

Great transition

Values in 2011

- The total terrestrial ecosystem service values (ESV) in 2011 in LAC was $15.3 trillion/year.

- Brazil had the largest ESV of USD $6.8 trillion/year due to its size and extensive rain forest cover.

- Argentina and Bolivia with USD $2.2 and $1.3 trillion/year, respectively.

Values in 2011

- The Caribbean has the highest per hectare values in the region
  - Bahamas: $23,000/ha/year
  - Saint Vincent and the Grenadines: $20,000/ha/year
  - Antigua and Barbuda: $18,000/ha/year

- In South America:
  - Paraguay: $12,000/ha/yr
  - Bolivia: $11,800/ha/yr.

Values in 2011

- In Mesoamerica, Costa Rica has the highest ESV per hectare at USD $8,000/ha/yr.

- The differences in per hectare values is due to varying land use management practices and policies in the countries and heterogeneity distribution of ecosystem services across the region

Values in 2011

- In 2011 LAC represented 15.1% of the global terrestrial area, 8.3% of GWP, and 21.4% of the world's ecosystem services value.

- The majority of ESV comes from South America, which makes up 19% of world's ESV

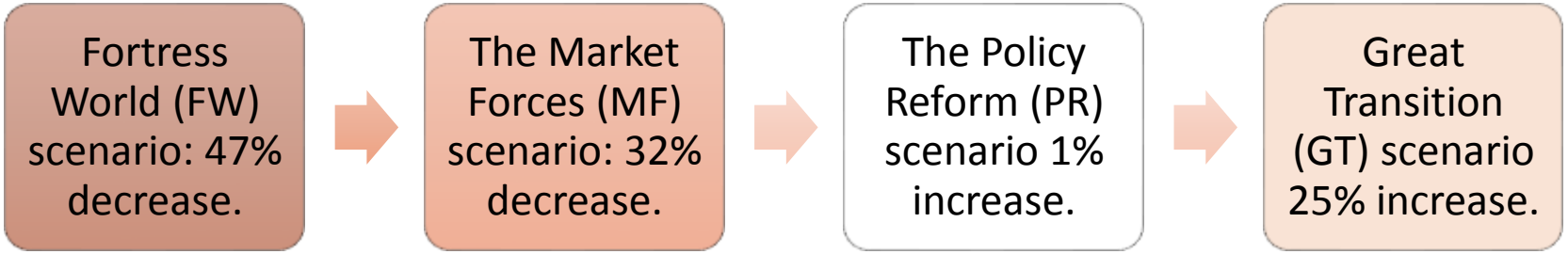
- Brazil represents 49% of the total area of South America (6.3% of the world's), 60% of its GDP (3% of the world's), and 49% its ESV (9.4% of the world's).

Values in 2011

- In Mesoamerica:
  - Mexico: 72% of the ESV of Mesoamerica
  - Nicaragua: 7.4%
  - Honduras: 5.7%

- In the Caribbean
  - Guyana: 38% of this region's ESV
  - Suriname: 30%.

Future values of ecosystem services (region)



Future values of ecosystem services (subregion)

- The Caribbean will experience the most change in ESV in the future under three of the four scenarios
  - FW: 35% decrease
  - PR: 3% increase
  - GT: 30% increase

- Under the FW, the ESV of South America is going to decrease the most at 49%.

Future values of ecosystem services (country)

- Saint Vincent and the Grenadines show the greatest potential ESV loss among the countries in the FW scenario with a decrease of 79%.

- In Mesoamerica, Costa Rica is the country most affected under the MF and FW scenarios with a decrease in the ESV of 28% and 48% respectively

- In South America, Bolivia is the country with the highest decrease of ESV also under MF and FW, with a loss of 50% and 69% respectively.

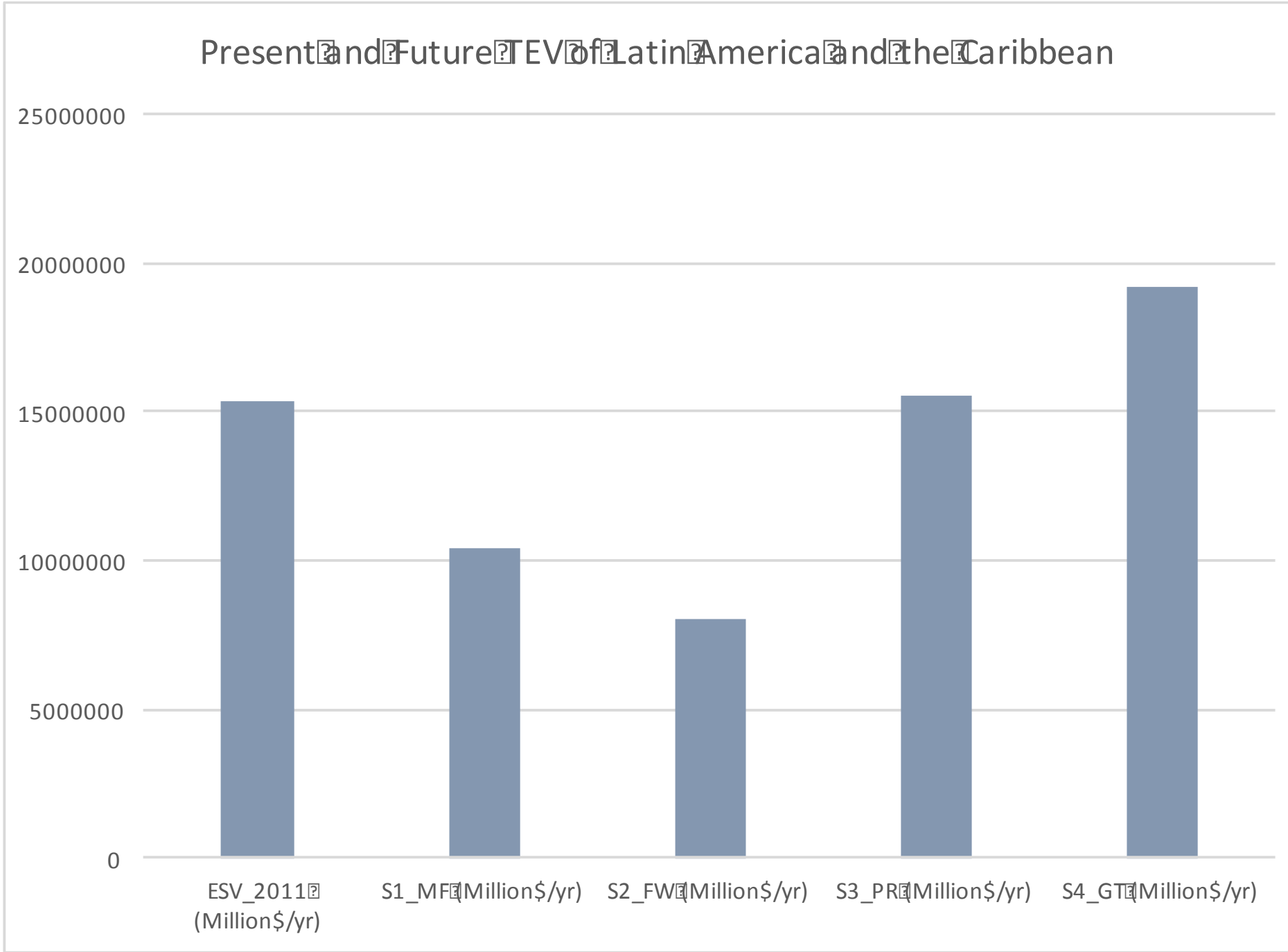
Future values of ecosystem services (country)

- Under the PR scenario, the majority of the countries show little change in their ESV except for Saint Kitts and Nevis which experiences a 16% decline.

- The GT scenario shows a similar increase of ESV among Mesoamerican countries (between 19% and 22%), and the highest increase occurs in the Caribbean with an improvement of 37% in Guyana.

- The Caribbean is the region that will experience the greatest volatility.

Country	Area (km2)	ESV_2011 (Million$/yr)	S1_MF (Million$/yr)	MF % change from 2011	S2_FW (Million$/yr)	FW % change from 2011	S3_PR (Million$/yr)	PR % change from 2011	S4_GT (Million$/yr)	GT % change from 2011
Mesoamerica										
Belize	22,211	11,647	10,352	-11%	9,268	-20%	11,618	0%	13,840	19%
Costa Rica	51,410	42,444	30,740	-28%	22,144	-48%	42,672	1%	51,343	21%
El Salvador	20,680	14,953	11,058	-26%	8,850	-41%	15,061	1%	18,217	22%
Guatemala	109,691	58,364	51,519	-12%	45,974	-21%	58,853	1%	70,241	20%
Honduras	112,866	66,954	54,006	-19%	46,800	-30%	66,974	0%	80,364	20%
Mexico	1,965,721	848,935	763,625	-10%	676,614	-20%	859,273	1%	1,019,572	20%
Nicaragua	128,867	87,309	71,065	-19%	59,578	-32%	87,279	0%	104,884	20%
Panama	74,595	51,622	38,148	-26%	31,843	-38%	51,673	0%	62,196	20%
Total Mesoamerica	2,486,041	1,182,227.8	1,030,513.4	-13%	901,070.6	-24%	1,193,404.9	1%	1,420,657	20%
Percent of world	1.84	1.65	2.09		2.32		1.66		1.58	
South America										
Argentina	2,787,501	2,212,877	1,418,025	-36%	935,071	-58%	2,194,339	-1%	2,698,339	22%
Bolivia	1,092,700	1,294,751	652,015	-50%	405,007	-69%	1,310,242	1%	1,639,570	27%
Brazil	8,523,524	6,768,369	4,726,633	-30%	3,717,035	-45%	6,868,298	1%	8,461,479	25%
Chile	745,770	298,938	177,484	-41%	158,005	-47%	284,881	-5%	390,255	31%
Colombia	1,142,733	717,015	538,452	-25%	468,230	-35%	740,988	3%	934,161	30%
Ecuador	257,031	160,915	120,877	-25%	105,843	-34%	163,455	2%	201,541	25%
Paraguay	400,675	496,869	380,381	-23%	251,496	-49%	497,670	0%	599,140	21%
Peru	1,299,044	922,717	556,076	-40%	448,138	-51%	942,175	2%	1,202,038	30%
Uruguay	178,378	125,929	88,071	-30%	67,292	-47%	126,284	0%	152,939	21%
Venezuela	916,774	691,372	460,285	-33%	371,038	-46%	715,163	3%	902,459	31%
Total South America	17,344,130	13,689,752.6	9,118,300.1	-33%	6,927,154.6	-49%	13,843,494.6	1%	17,181,922	26%
Percent of world	12.87	19.1	18.5		17.8		19.2		19	
Caribbean										
Antigua and Barbuda	537	984.6	810.7	-18%	669.9	-32%	990.6	1%	1,144	16%
Bahamas, The	12,204	28,623	13,698	-52%	10,216	-64%	28,647	0%	35,302	23%
Barbados	448	322.3	298.7	-7%	215.7	-33%	328.8	2%	388.9	21%
Cuba	109,710	68,757	55,242	-20%	46,182	-33%	69,358	1%	82,987	21%
Dominica	778	586.1	428.4	-27%	357.0	-39%	562.8	-4%	716.6	22%
Dominican Republic	48,634	26,451	23,842	-10%	21,450	-19%	26,686	1%	31,803	20%
Grenada	349	288.8	264.2	-9%	237.0	-18%	293.5	2%	347.8	20%
Guyana	211,967	182,562	110,337	-40%	88,824	-51%	191,707	5%	250,956	37%
Haiti	27,322	15,837	14,189	-10%	12,662	-20%	16,025	1%	19,111	21%
Jamaica	11,094	6,156	5,498	-11%	4,989	-19%	6,247	1%	7,396	20%
Saint Kitts and Nevis	198	201.1	153.5	-24%	138.5	-31%	169.8	-16%	243.4	21%
Saint Lucia	637	537.4	486.3	-10%	437.9	-19%	543.5	1%	606.1	13%
Saint Vincent and the	343	692.5	197.0	-72%	147.6	-79%	677.9	-2%	852.2	23%
Suriname	145,973	141,562	83,839	-41%	64,152	-55%	145,858	3%	185,120	31%
Trinidad and Tobago	5,038	6,016	3,377	-44%	2,286	-62%	6,246	4%	7,995	33%
Total Caribbean	575,232	479,577.5	312,660.9	-35%	252,964.5	-47%	494,339.8	3%	624,968	30%

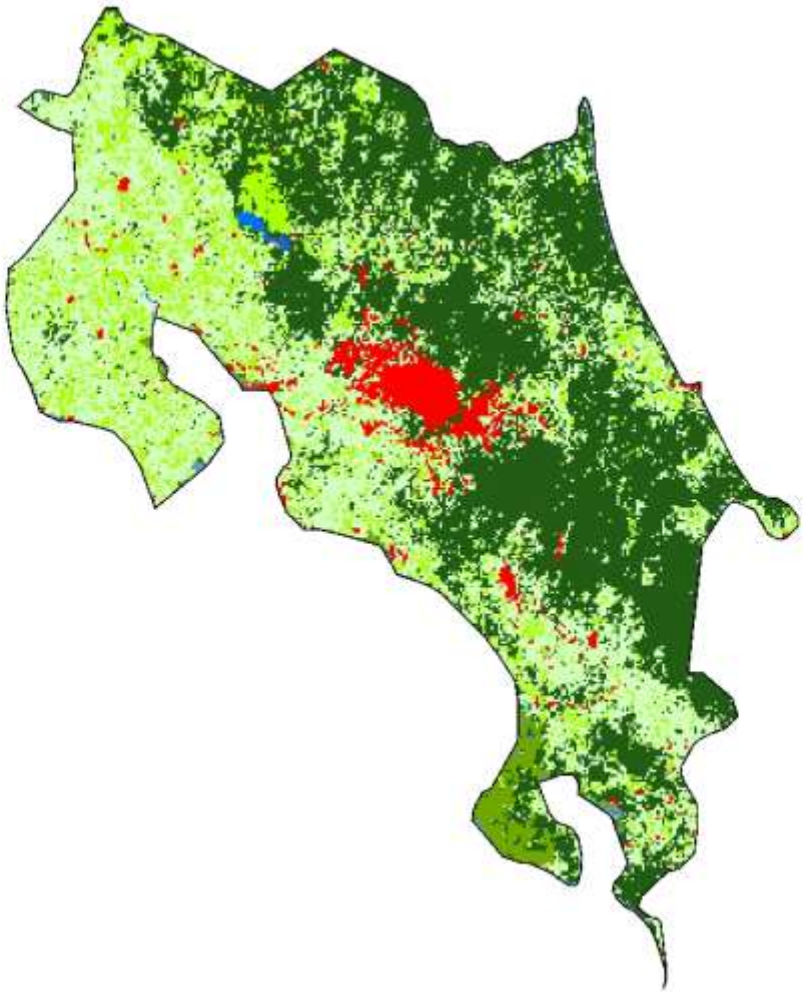

Present and Future TEV of Latin America and the Caribbean
25000000
20000000
15000000
10000000
5000000
0
ESV_2011 (Million$/yr)
S1_MF (Million$/yr)
S2_FW (Million$/yr)
S3_PR (Million$/yr)
S4_GT (Million$/yr)

Future values of ecosystem services in detail

- Brazil
- Colombia
- Costa Rica
- Dominican Republic
- Guyana
- Haiti
- Mexico
- Nicaragua
- Saint Vincent and the Grenadines

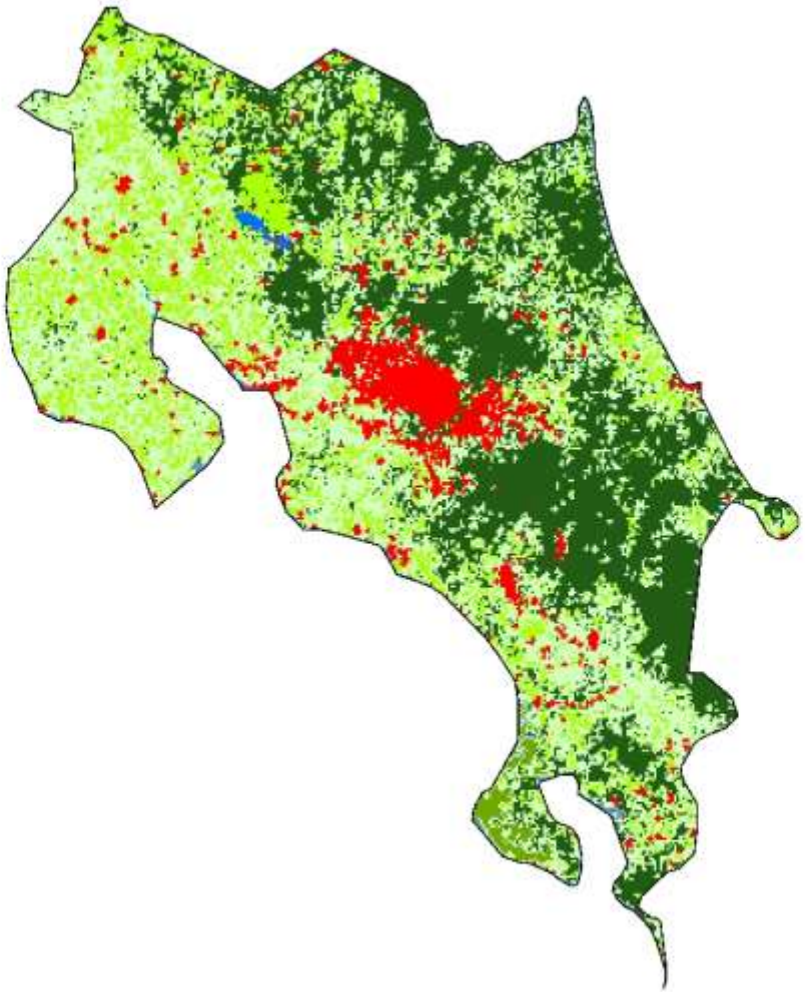
Future values of ecosystem services in detail

Costa Rica					
Code	Count pxl (km2)	Hectares	Value/ha (2007 US$)	Biome	Total Ecosystem Value
1	13	1300	352249	**Coral Reefs**	457923700
2	904	90400	193843	Tidal Marsh/Mangrove	17523407200
4	2220	222000	6661	Urban	1478742000
5	153	15300	12512	Lakes/Rivers	191433600
6	7262	726200	5567	Cropland	4042755400
7	269	26900	3137	Temperate/Boral Forest	84385300
8	21842	2184200	5382	Tropical Forest	11755364400
10	18195	1819500	4166	Grass/Rangelands	7580037000
13	646	64600	2222	Marine Shelf	143541200
14	39	3900	660	Open Ocean	2574000
				Total	43,260,163,800



- Coral Reefs
- Tidal Marsh/Mangrove
- Swamps/Floodplains
- Urban
- Lakes/Rivers
- Cropland
- Temperate/Boral Forest
- Tropical Forest
- Desert
- Grass/Rangelands
- Tundra
- Ice/Rock
- Marine Shelf
- Open Ocean

Base 2011



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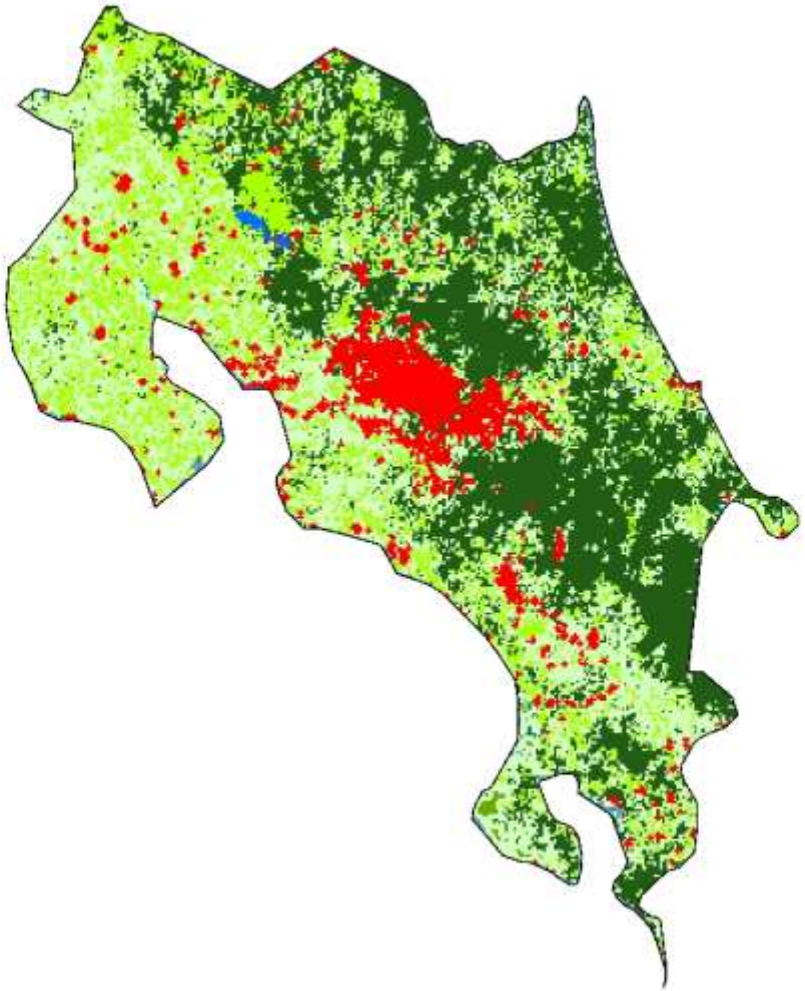
Market Forces



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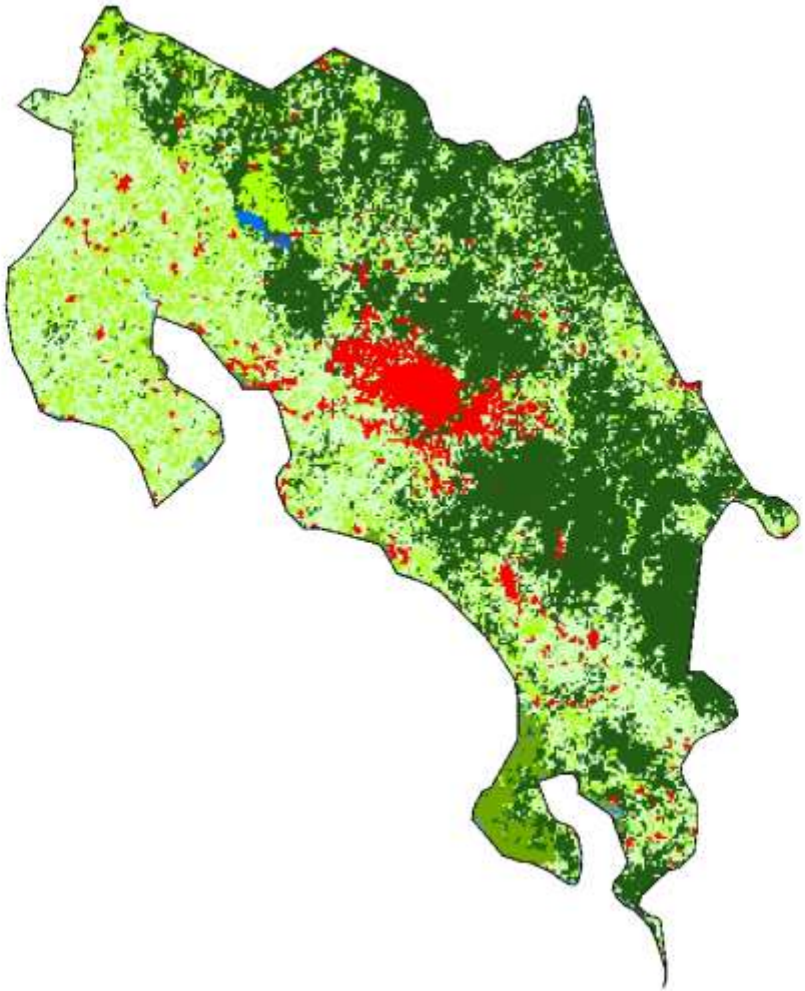
Fortress world



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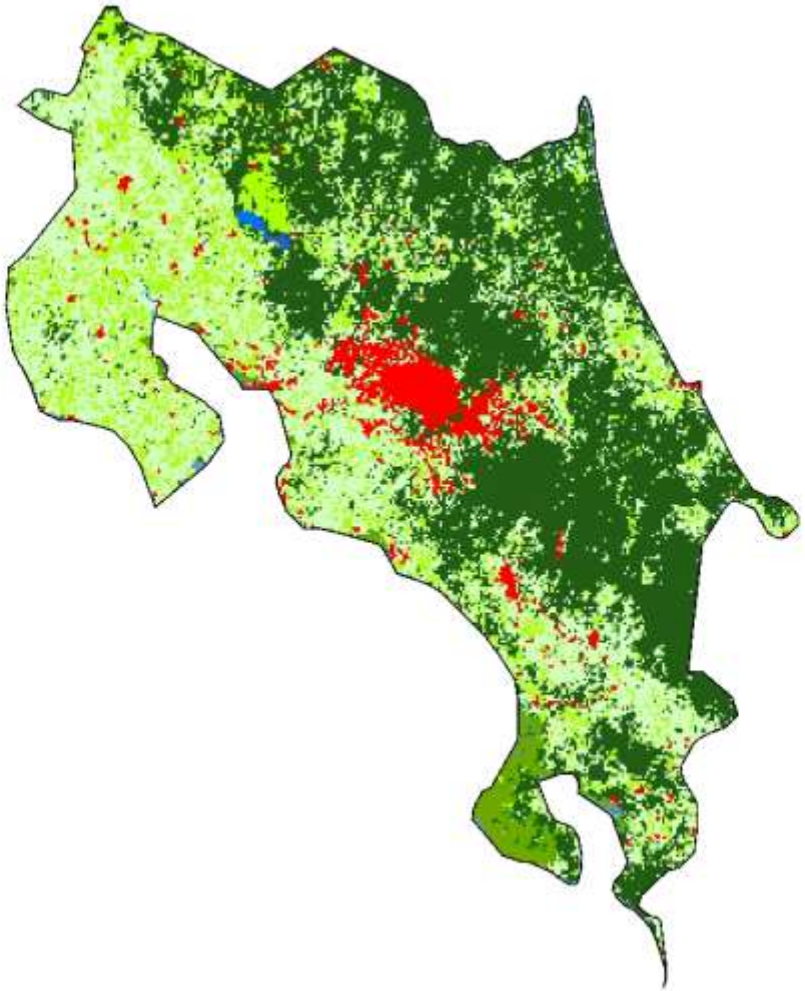
Policy reform



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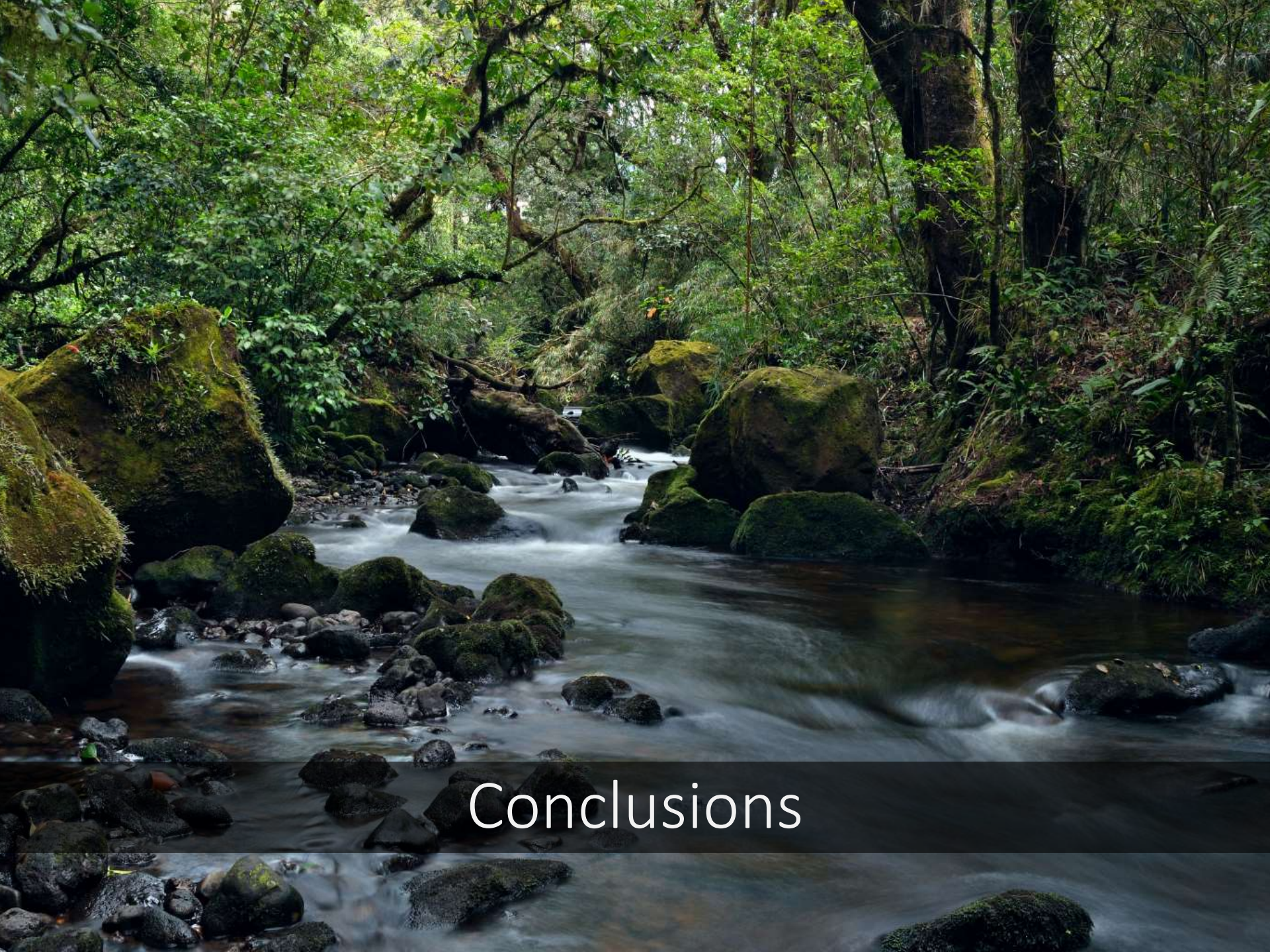
Great transition



Conclusions

Conclusions

- Results are *estimates* and *scenarios*, not measurements and predictions.
- Estimates are intended to help inform choices by making the connection clearer between future human wellbeing and the wellbeing of the rest of nature in quantitative terms
- Our scenarios can help decision makers deal with uncertainty and design policies to improve the chances of better futures actually occurring.
- They can also be used to engage the larger public in thinking about the kind of future they really want.

Conclusions

- The approach in this study is simple and straightforward.
- However, the simplifying assumptions most likely lead to underestimates of the true value of ecosystem services
- Scarcity and change in incomes

Special thanks to

Ecosystem Services in the Anthropocene: Future scenarios for Latin America and the Caribbean

marcello.hernandez@anu.edu.au

Australian National University

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CINPE

CENTRO INTERNACIONAL DE POLÍTICA ECONÓMICA PARA EL DESARROLLO SOSTENIBLE