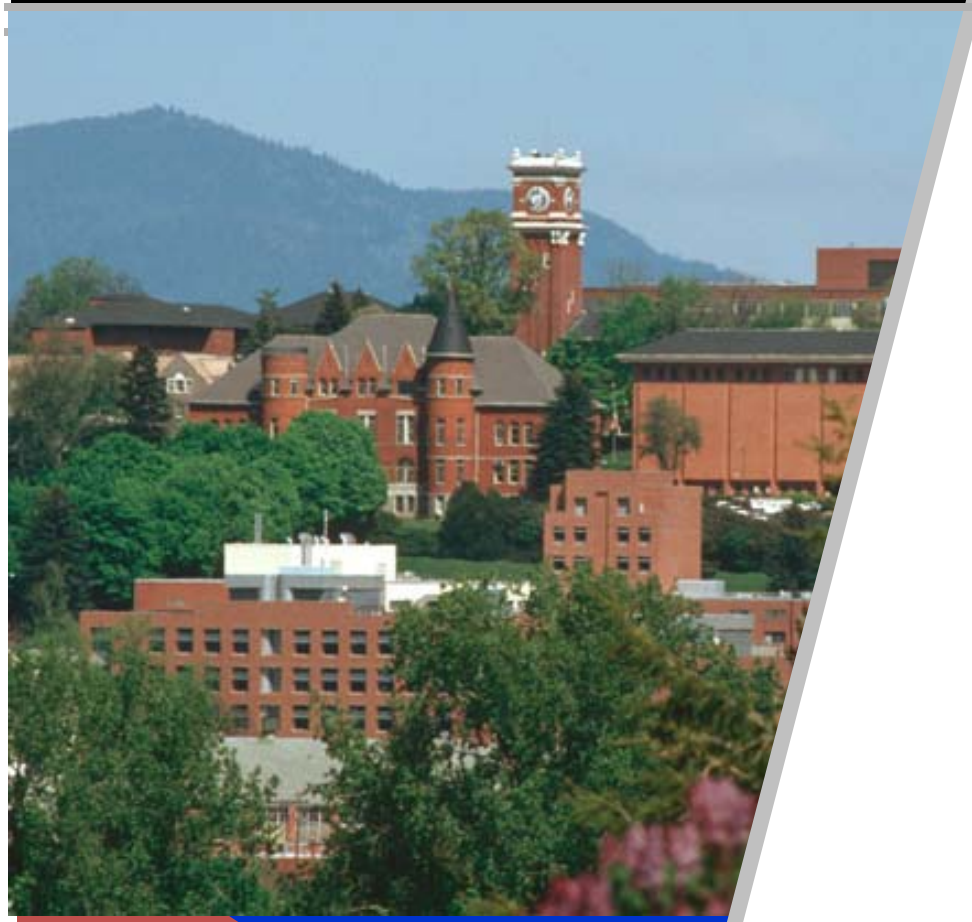
WASHINGTON STATE UNIVERSITY

World Class. Face to Face.



Social Science and Global Environmental Change: Broad and Narrow Looks

Eugene A. Rosa

Edward R. Meyer Professor Professor of Natural Resources & Environmental Policy

Thomas F. Foley Institute for Public Policy and Public Service

Professor of Sociology

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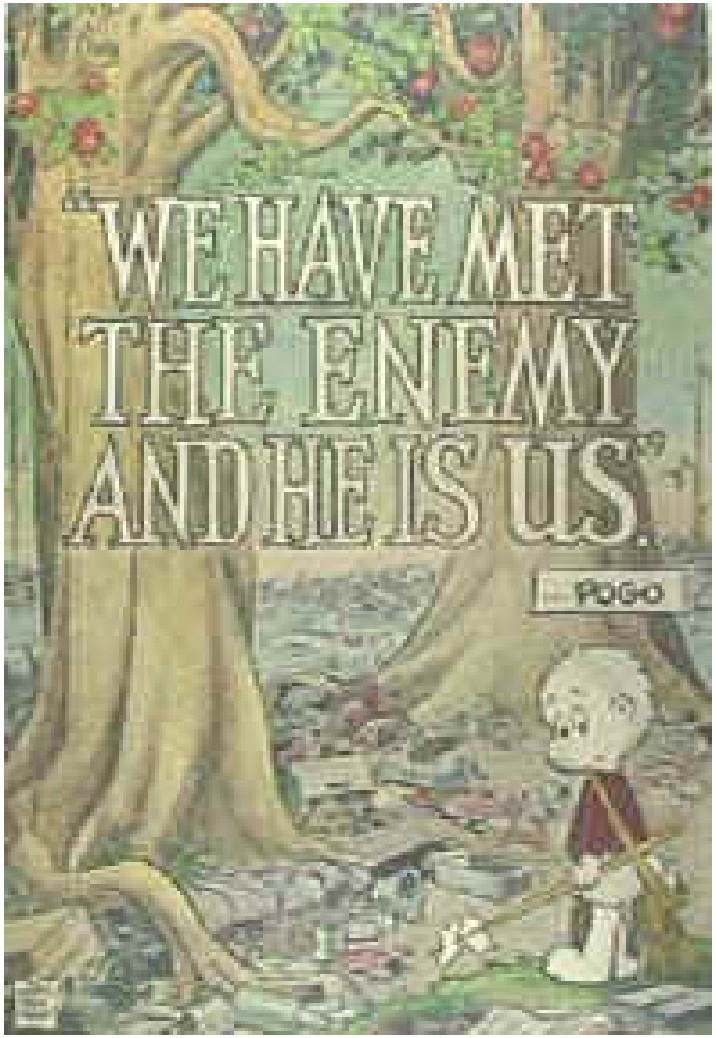
SEMINAR GOALS:

1. **PROVIDE HISTORICAL CONTEXT AND A BRIEF OVERVIEW OF ADVANCES IN SELECTED CORE SOCIAL SCIENCE RESEARCH PROGRAMS (EXCEPT FOR ECONOMICS) IN UNDERSTANDING THE HUMAN (ANTHROPOGENIC) DIMENSIONS OF GLOBAL ENVIRONMENTAL CHANGE.**

2. **ILLUSTRATE ONE OF THE CONTINUING, CUMULATIVE RESEARCH PROGRAMS: THE STIRPAT RESEARCH PROGRAM.**

3. **STIMULATE DISCUSSION OF RESEARCH NEEDS IN THE SOCIAL SCIENCES OF ENVIRONMENTAL CHANGE.**

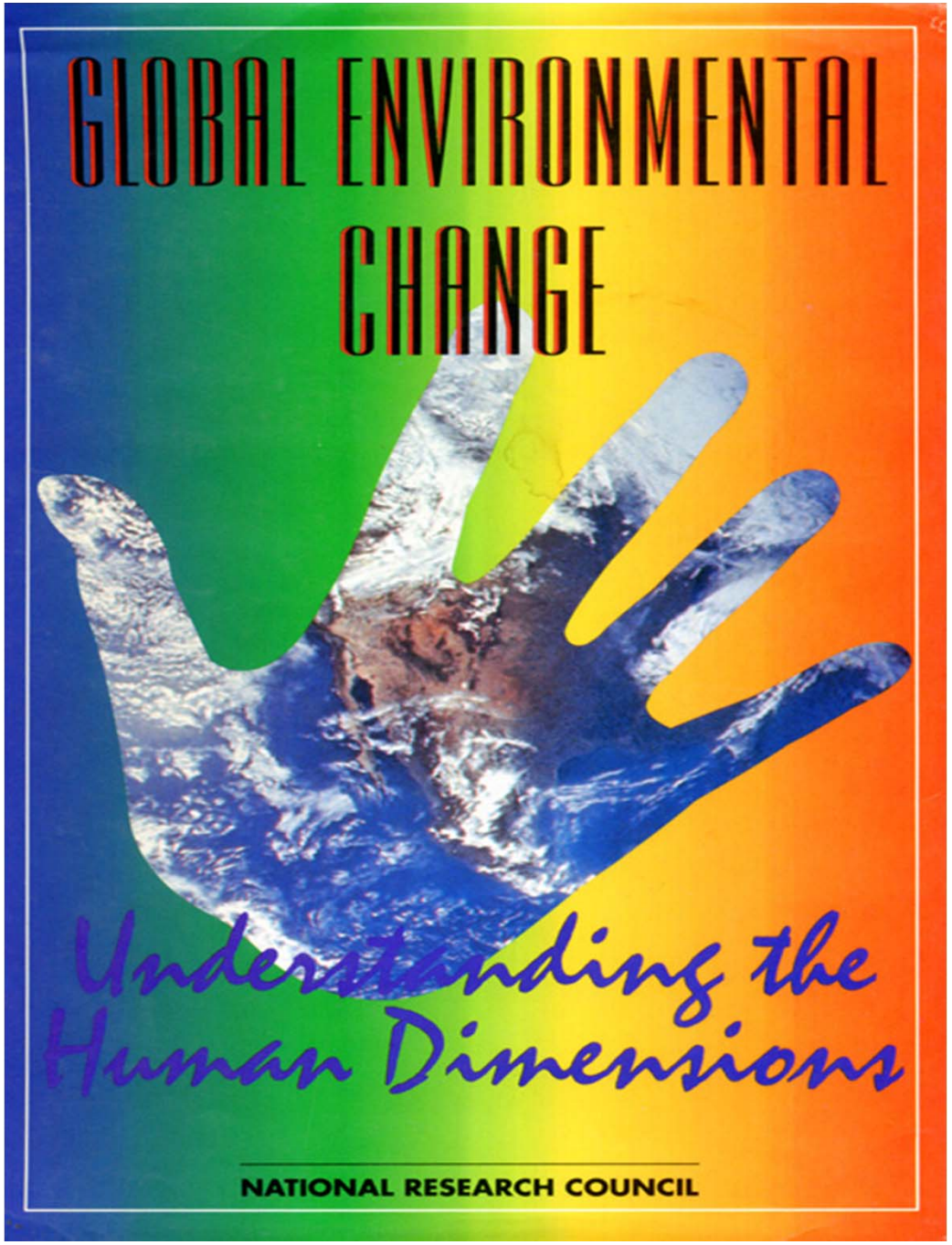

"WE HAVE MET
THE ENEMY
AND HE IS U.S."
POGO

Definition: Global Environmental Change

1. **CUMULATIVE EFFECTS** - EFFECTS THAT ARE LOCAL IN DOMAIN BUT SO WIDELY REPLICATED THAT IN SUM THEY HAVE GLOBAL CONSEQUENCES.

   EXAMPLES: TROPICAL DEFORESTATION, DESERTIFICATION, SPECIES LOSS, DAMAGED LOCAL ECOSYSTEMS, AND RESOURCE EXHAUTION.

2. **SYSTEMIC EFFECTS** - EFFECTS THAT OCCUR ON LARGE SPATIAL SCALES OR ALTER THE FUNCTION OF LARGE SYSTEMS.


GLOBAL ENVIRONMENTAL CHANGE
Understanding the Human Dimensions
NATIONAL RESEARCH COUNCIL

1992

FIVE ANTHROPOGENIC DRIVERS OF GLOBAL ENVIRONMENTAL CHANGE (GEC):

- **POPULATION**
- **AFFLUENCE (CONSUMPTION)**
- **TECHNOLOGY**
- **INSTITUTIONS (POLITICAL, ECON, SOCIAL)**
- **CULTURE (INCLUDING VALUES & BELIEFS)**

Human Footprints on the Global Environment

Threats to Sustainability

edited by Eugene A. Rosa, Andreas Diekmann, Thomas Dietz, and Carlo C. Jaeger

MIT Press, 2010

CHANS - COUPLED HUMAN AND NATURAL* SYSTEMS

THESE ARE INTEGRATED SYSTEMS IN WHICH PEOPLE INTERACT WITH NATURAL COMPONENTS

A. THEIR COMPLEXITY IS NOT WELL UNDERSTOOD

B. DUE TO TRADITIONAL SEPARATION OF SOCIAL AND ECOLOGICAL SCIENCES

C. MUCH GREATER UNDERSTANDING OF H->N THAN N->H

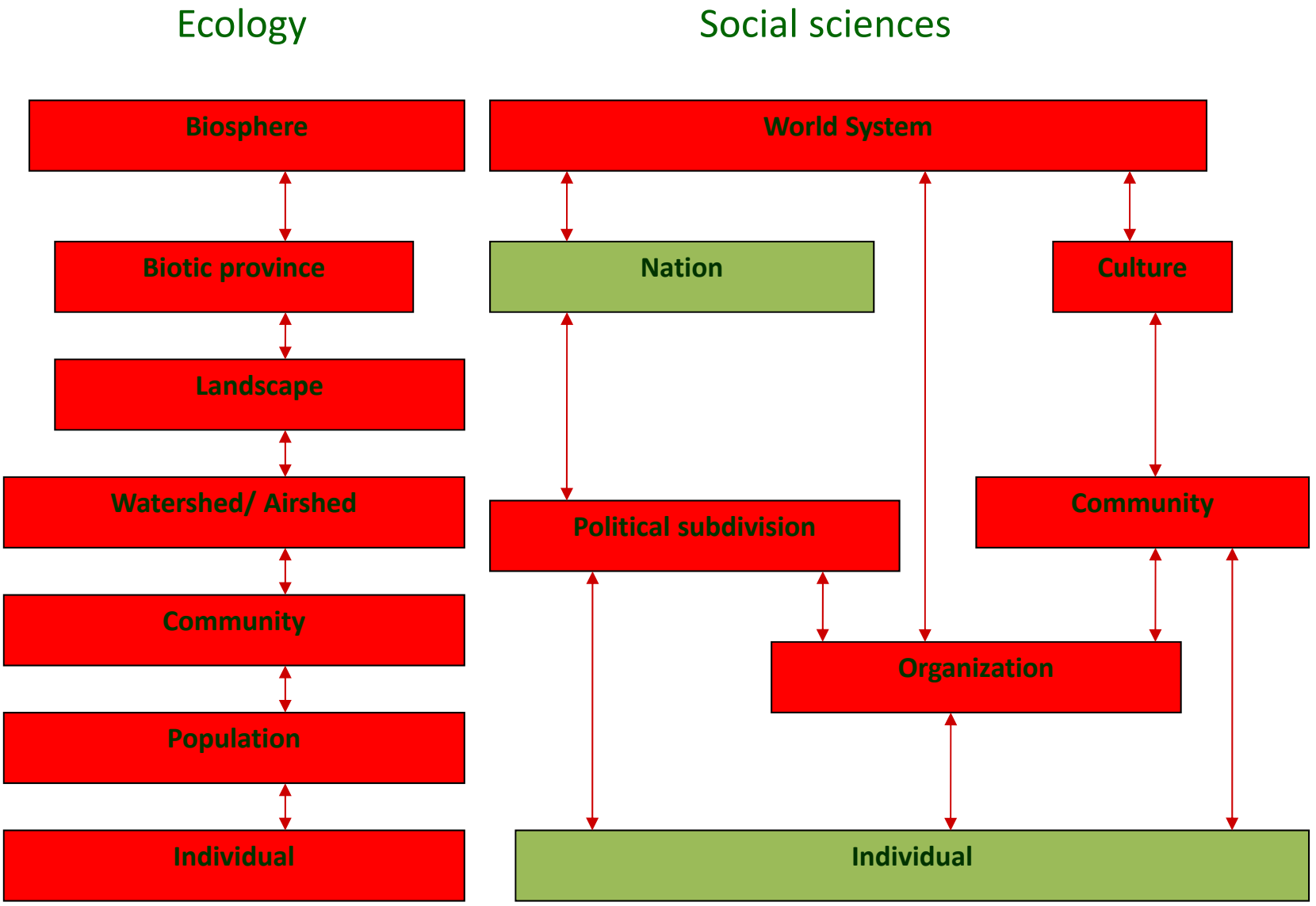
*OR ENVIRONMENTAL SYSTEMS

REFERENCES:

LIU, JIANGUO (JACK) ET AL.. 2007. "COMPLEXITY OF COUPLED HUMAN AND NATURAL SYSTEMS." *SCIENCE* 317: 1513-1516.

LIU, JIANGUO (JACK) ET AL.. 2007. "COUPLED HUMAN AND NATURAL SYSTEMS." *AMBIO* 36: 639-649.

Major Challenge: Candidate units of analysis/ scales



MAJOR TOPICS COVERED:

FRAMING PERSPECTIVES AND RETROSPECTIVES:

1. **INTRODUCTION: COUPLED HUMAN AND NATURAL SYSTEMS (CHANS)**
2. **THE RISK SOCIETY**
3. **CRITICAL REVIEW OF MAJOR PERSPECTIVES: ECOLOGY & SOCIAL SCIENCE**
8. **CONCLUSION: CUMULATIVE KNOWLEDGE AND CRITICAL GAPS**

RESEARCH PROGRAMS:

4. **LAND USE AND LAND COVER CHANGE**
5. **INTERNATIONAL ENVIRONMENTAL REGIMES**
6. **COMMON POOL RESOURCES**
7. **VULNERABILITY, RESLILIENCE, ADAPTATION TO ECOSYSTEM DISTURBANCE**

CHAPTER TWO: *World Risk Society as Cosmopolitan Society* by Ulrich Beck

- **LEADING SOCIOLOGICAL THEORIST**
  - **GERMAN/CONTINENTAL STYLE OF SCHOLARSHIP: INTERPRETIVE**

- ***THE RISK SOCIETY* (1986)**

- **KEY THEME: FROM INDUSTRIAL MODERNITY TO RISK LADEN MODERNITY**
  - **INDUSTRIAL MODERNITY: RISKS ARE CALCULABLE AND MANAGEABLE**
  - **RISK MODERNITY: RISKS ARE NEITHER CALCULABLE NOR MANGEABLE**
  - **EXAMPLES: GLOBAL CLIMATE AND ENVIRONMENTAL CHANGE, INTERNATIONAL FINANCIAL MARKETS, TERRORISM**

- **STRUCTURAL SHIFT: FROM A CONCERN WITH THE DISTRIBUTION OF GOODS TO A CONCERN ABOUT THE DISTRIBUTION OF "BADS;" THAT IS, RISKS.**
  - **SOCIAL CLASS IS NO LONGER PEOPLE'S PRINCIPAL IDENTITY**
  - **IT IS BEING REPLACED BY A COSMOPOLOITAN ATTITUDE THAT IS CENTERED ON A CONCERN OVER RISKS THAT TRANSCEND CLASS AND POLITICAL BOUNDARIES**

- **POLITICAL RESTRUCTURING:**
  - **NEW FORM OF POLITICS (CALLED SUB-POLITICS) THAT COMBINES ACTIONS AMONG TRADITIONAL POLITICAL BODIES WITH NON-POLITICAL BODIES (e.g. NGOs) AND DIRECT CITIZEN ACTION**

CHAPTER FOUR: ***Progress in the Study of Land Use/Cover Change and the Outlook for the Next Decade*** **by Emilio F. Moran**

- **CONSIDERABLE PROGRESS: GLOBAL LAND PROJECT (IHDP&IGBP), CENTER FOR THE STUDY OF INSTITUTIONS, POPULATION, AND ENVIRONMENTAL CHANGE AT INDIANA UNIVERSITY (CIPEC), AND CENTER FOR INTEGRATED REGIONAL ASSESSMENT (CIRA) AT PENN STATE**

- **BROADLY INTERDISCIPLINARY: COMBINING REMOTE SENSING WITH FIELD OBS.**

- **KEY ISSUES:**

1. **DEFORESTATION (ESPECIALLY IN THE AMAZON AND SE ASIA)**
2. **ROLE OF SPATIAL DISTRIBUTION IN NEW LAND USES/COVER**
3. **IMPACT OF CLIMATE CHANGE ON LAND USE PRACTICES**
4. **POPULATION VS. OTHER FACTORS IN LAND USE/COVER CHANGE**
5. **UNDERSTANDING THE IMPACTS ON CARBON EMISSIONS FROM TROPICAL DEFORESTATION**

- **KEY FINDINGS:**

    1. **PERCEPTION PLAYS A LARGE ROLE IN LAND USE CHOICES**

    2. **SEDENTISM IS A STRONGER PREDICTOR OF LAND USE INTENSIFICATION AND DEFORESTATION THAN POPULATION**

    3. **SMALL FARMERS CUT AND BURN YOUNG SECONDARY GROWTH FIRST —EMISSIONS OF CO_2 ARE LESS THAN PREDICTED BY GLOBAL MODELS**

    4. **INSTITUTIONAL FACTORS (E.G. COMMUNITY RULES) ARE CRITICAL**

- **FUTURE RESEARCH:**

    - **IMPROVE UNDERSTANDING OF DECISIONS TO CLEAR MATURE FORESTS**

    - **NEED TO BETTER UNDERSTAND THESE FACTORS:**
        1. **LAND TENURE PRACTICES**
        2. **AGE AND GENDER STRUCTURE OF HOUSEHOLDS**
        3. **CREDIT POLICIES**
        4. **SHIFTS IN INTEREST RATES**
        5. **SHIFTS IN GLOBAL COMMODITY PRICES.**

CHAPTER FIVE: ***The Effectiveness of International Environmental Regimes***
By Oran R. Young

- **INSTITUTIONAL POLITICAL SCIENTIST (RAINBOW BOOK EDITOR, CHAIR, SCIENTIFIC COMMITTEE- IHDP)**

- **RECENT INSTITUTIONAL CHANGES:**

  - **EMERGENCE OF NUMEROUS INSTITUTIONAL REGIMES FOR ADDRESSING ENVIRONMENTAL PROBLEMS AT A GLOBAL LEVEL**

  - **SEVERAL HUNDRED INSTITUIONS EXIST: COVERING CONCERNS FOR HUMAN USE OF NATURAL RESOURCES & ANTHROPOGENIC THREATS TO ECOSYSTEMS**

  - **THEY DIFFER GREATLY ON A WIDE VARIETY OF DIMENSIONS**

- **KEY QUESTION: HOW EFFECTIVE ARE THESE GLOBAL REGIMES?**

  - **ABSENT EXPERIMENTAL CONTROLS THE QUESTION POSES ESPECIALLY DIFFICULT METHODLOGICAL CHALLENGES**

  - **CAN POINT TO JUDGED SPECIFIC SUCCESSES:**

    1. **THE ANTARTIC TREATY SYSTEM**
    2. **GREAT LAKES WATER QUALITY REGIME**
    3. **DUMPING REGULATIONS IN THE NORTH SEA**
    4. **REGIME FOR PROTECTING THE OZONE LAYER**

  - **CONCLUDES: A WIDELY AGREED UPON METHOD AND MEASURE OF EFFECTIVENESS ELUDES THE FIELD AND REMAINS ITS PRINCIPAL CHALLENGE**

  - **FUTURE RESEARCH: FURTHER DEVELOPMENT OF METHOD**

    ONE APPROACH: BUILD UPON SUCH EFFORTS AS THE INTERNATIONAL REGIMES DATA BASE (IRD) – LARGE DATA BASE CREATED BY HAVING EXPERTS JUDGE THE ROLE OF REGIMES IN ENVIRONMENTAL PROBLEM SOLVING

CHAPTER SIX: *Uncommon Ground: Critical Perspectives on Common Property* By Bonnie J. McCay and Svein Jentof

- **CORE QUESTION: HOW IS THE ALLOCATION OF COMMON PROPERTY OR COMMON POOL RESOURCES DETERMINED? (E.G. FISHERIES, FORESTS, IRRIGATION SYSTEMS)**

- **CONVENTIONAL WISDOM: THE ALLOCATION TAKES PLACE BY THE EXERCISE OF INDIVIDUAL RATIONAL CHOICE TO MAXIMIZE ONE'S OWN UTILITY WITHOUT REGARD FOR OTHERS**

- **THE INEVITABLE RESULT IS THE OVEREXPLOITATION OF RESOURCES**

- **THE "CLASSIC" FORMULATION: ECOLOGIST GARRETT HARDIN WHO APPLIED IT TO OVERPOPULATION (*SCIENCE* 1968).**
  - **IGNORES THE REALITY THAT ECONOMIC TRANSACTIONS ARE EMBEDDED IN SOCIAL RELATIONS**

- **ALTERNATIVE WISDOM: SELF-GOVERNANCE REVISIONIST APPROACH:**

  - **THE PREDICTIONS OF THE HARDIN NEO-LIBERAL VIEW ARE INFREQUENTLY REALIZED IN PRACTICE**

  - **SOCIAL AND CULTURAL NORMS (SUCH AS THE VALUE OF MODERATION) ARE OFTEN SUFFICIENT TO AVOID UNTOWARD IMPACTS**

  - **INSTITUTIONAL PRACTICES OF DECENTRALIZED AND PARTICIPATORY MANAGEMENT OFTEN EMERGE—PRESERVING KEY RESOURCES**

  - **FUTURE RESEARCH: FUTHER UNDERSTANDING OF THE CONTINGENCIES THAT LEAD TO SUSTAINABLE OR UN-SUSTAINABLE PRACTICES**

CHAPTER SEVEN: ***Vulnerability of Coupled Human-Ecological Systems to Global Environmental Change*** **By Jeanne X. Kasperson, Roger Kasperson, and Billie Turner**

- **WORLD COMMISSSION ON ENVIRONMENT AND DEVELOPMENT (1987):**

  NEED FOR FOR A GLOBAL RISK ASSESSMENT (ROOTS AND STRESSES OF HUMAN ACTIONS ON ENVIRONMENTAL CHANGE)

- **THE ACADEMIC RESPONSE: THE VULNERABILITY, RESILIENCE, AND ADAPTATION APPROACH**

  - **ADOPTION: IPCC, MEA, GLOBAL LAND PROJECT**

- **VARIETY OF INFLUENCES: (1) AMARTYA SEN'S ENTITLEMENT THEORY (FAMINES)**

  (2) C.S. (BUZZ) HOLLING'S RESILIENCE THEORY

  (3) ROBERT CHAMBER'S COPING AND EMPOWERMENT (EMPHASIZING PARTICIPATORY ASSESSMENTS)

- **KEY CONCEPTS:**

  (1) VULNERABILITY (LIKELIHOOD OF INIDIVDUAL, SYSTEM, UNIT TO BE HARMED)

  (2) EXPOSURE (CONTACT BETWEEN SYSTEM AND A STRESSOR)

  (3) RESILIENCE (ABILITY OF SYSTEM TO ABSORB STRESSES)

  (4) ADAPTATION (SYSTEM RESPONSE TO STRESSOR THAT CHANGES THE SYSTEM)

- **STATE OF THE FIELD:**

  - **"THE EXISTING RESEARCH AND ASSESSMENT CUPBOARD IS FILLED WITH LOTS OF THINGS, BUT IT IS UNNECESSARILY CLUTTERED AND BEREFT OF AN INTEGRATED FRAMEWORK OF THEORY AND ANALYSIS" (P. 235).**

- **FUTURE RESEARCH:**

  - **FURTHER DEVELOPMENT OF AN INTEGRATED FRAMEWORK THAT PLACES MORE EMPHASIS ON THE SOCIAL FEATURES OF VULNERABILITY**

  - **POTENTIAL FOR BETTER INTEGRATION COULD BE REALIZED WITH CHANS APPROACH**

STIRPAT RESEARCH PROGRAM:

THOMAS DIETZ – MICHIGAN STATE UNIVERSITY

EUGENE A. ROSA – WASHINGTON STATE UNIVERSITY

RICHARD YORK – UNIVERSITY OF OREGON

KYLE KNIGHT – WASHINGTON STATE UNIVERSITY

I = PAT

<u>Accounting Version</u>

Impacts **(I)**

Population **(P)**

Affluence **(A) or C**onsumption

Technology **(T)**

IPAT: ACCOUNTING VERSION (OR IDENTITY)

IMPACTS TO THE ENVIRONMENT = f(P, A, T)

STIRPAT: STOCHASTIC VERSION (ACCOUNTING FOR ERROR)

IMPACTS TO THE ENVIRONMENT = f(P, A, T) + ε

STIRPAT RESEARCH PROGRAM (NATION STATES)

STRESSORS EXAMINED (PUBLISHED):

CO^2 (CARBON DIOXIDE)

CH^4 (METHANE)

NO_X (NITROGEN OXIDES)

SO^2 (SULFUR DIOXIDE)

ODS (OZONE DEPLETING SUBSTANCES)

ECOLOGICAL FOOTPRINT (FT) - (TOTAL)

ECOLOGICAL FOOTPRINT (FT) - (PARTS)

ADDITIONAL STRESSORS EXAMINED (NOT YET PUBLISHED):

CARBON MONOXIDE

NON-METHANE VOLATILE ORGANIC COMPOUNDS

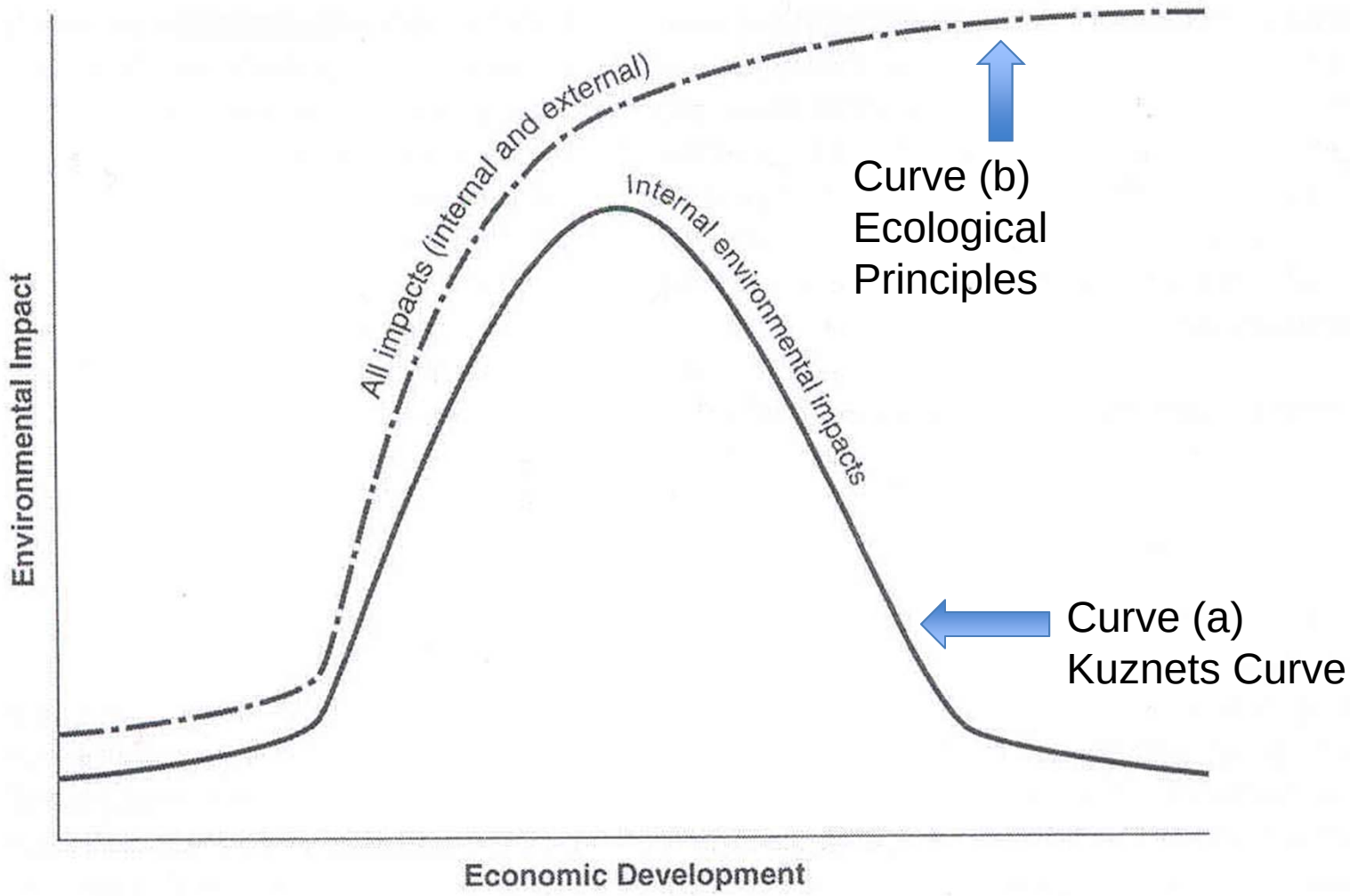
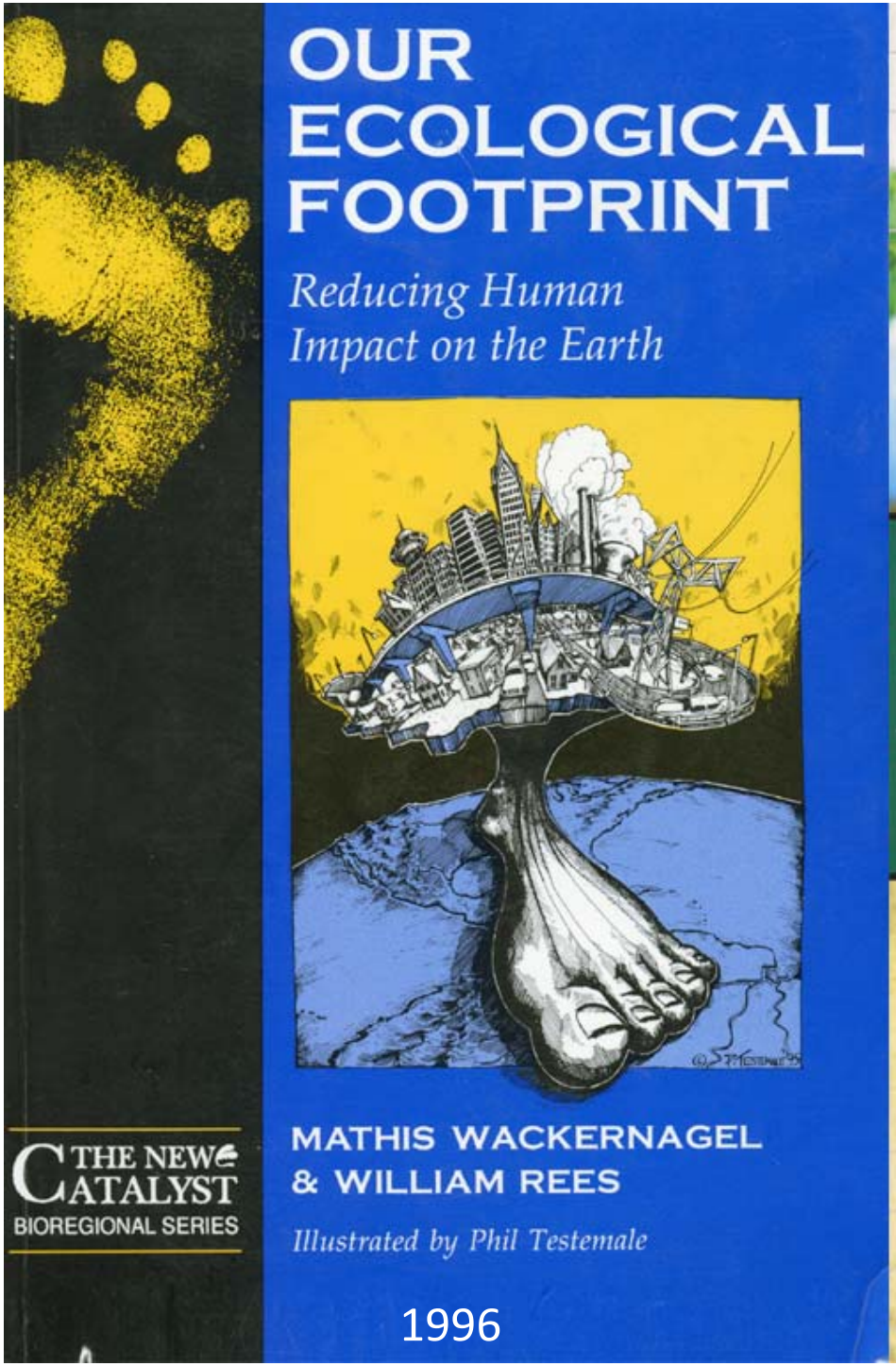
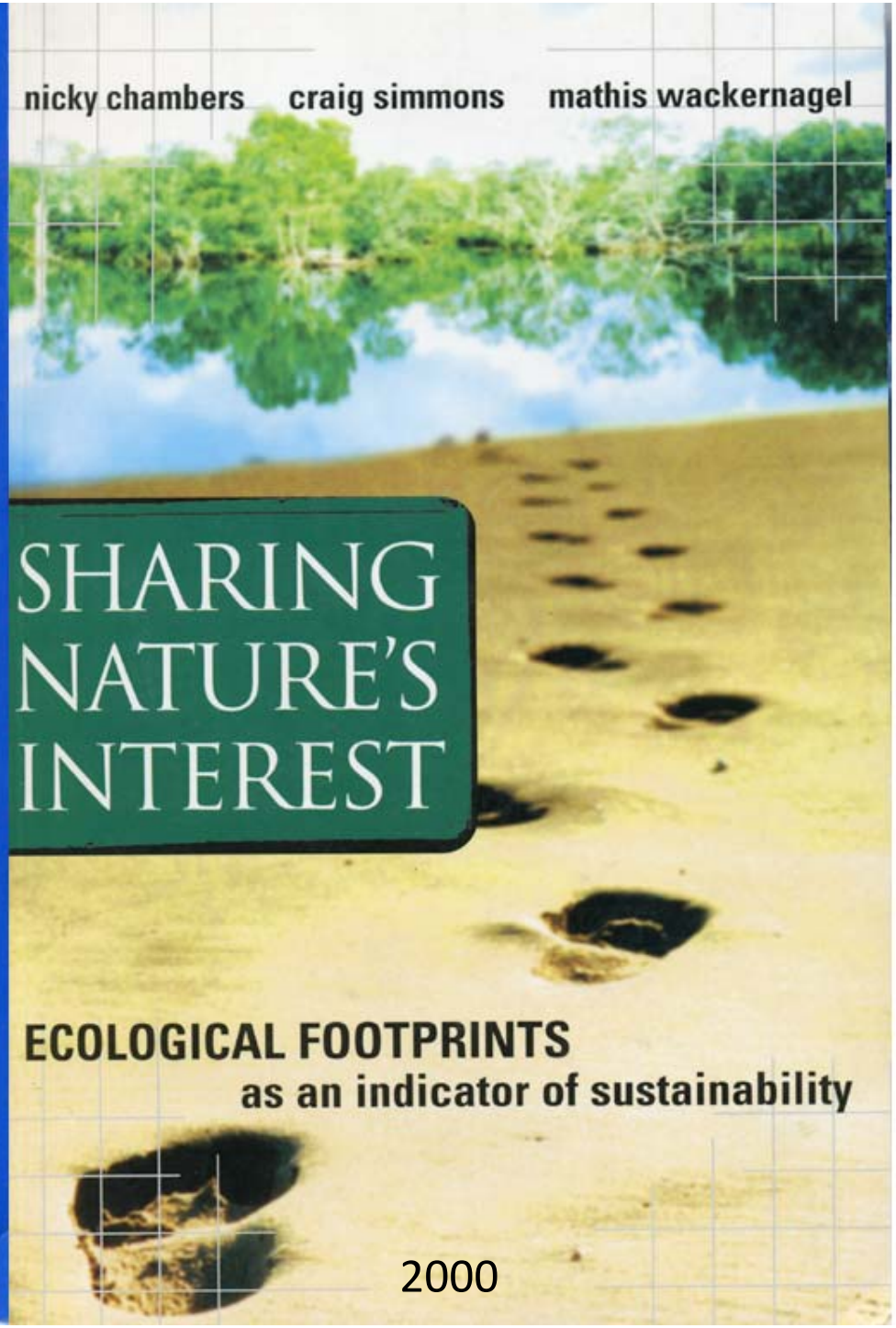


Figure 1. The Theoretical Effect of Economic Development on Environmental Impact


OUR ECOLOGICAL FOOTPRINT
Reducing Human Impact on the Earth
MATHIS WACKERNAGEL & WILLIAM REES
Illustrated by Phil Testemale
THE NEW CATALYST
BIOREGIONAL SERIES
1996


nicky chambers craig simmons mathis wackernagel
SHARING NATURE'S INTEREST
ECOLOGICAL FOOTPRINTS
as an indicator of sustainability
2000

THE ECOLOGICAL FOOTPRINT (EF):

THE ECOLOGICAL FOOTRPRINT (EF) IN ANY GIVEN YEAR IS THE AMOUNT OF BIOLOGICALLY PRODUCTIVE LAND (NATURE'S CAPITAL) NEEDED TO REGENERATE HUMAN CONSUMPTION, LIVING SPACE, AND TO ABSORB WASTES.

IMPORTANT CAVEAT:

THE EF MEASURES STRESS, PRESSURE OR LOADS ON NATURAL CAPITAL AND SERVICES, NOT THE ACTUAL IMPACT TO THE INVENTORY OF RESOURCES.

ECOLOGICAL FOOTPRINT (EF): ELEMENTS OF CONUMPTION*

<u>FIVE COMPONENTS</u>

1. **FOOD**
2. **HOUSING**
3. **TRANSPORTATION**
4. **CONSUMER GOODS**
5. **SERVICES**

INCLUDING AN ACCOUNTING FOR WASTES

ECOLOGICAL FOOTPRINT (EF):BIOPHYSICAL UNITS

SIX COMPONENTS:

1. ARABLE LAND (GROWING CROPS)
2. PASTURE LAND (ANIMAL GRAZING)
3. FORESTED LAND (TIMBER PRODUCTS)
4. SEA SPACE (PRODUCTIVE FISHING GROUNDS)
5. BUILT-UP LAND (INFRASTRUCTURE FOR HOUSING, TRANSPORTATION, INDUSTRY, HYDROELECTRIC POWER)
6. ENERGY OR CARBON LAND (TO SEQUESTER CO_2 EMISSIONS)

AGGREGATE EF: THE SEPARATE MEASURES CAN BE SUMMED INTO AN OVERAL ECOLOGICAL FOOTPRINT

Table 1. STIRPAT RESEARCH PROGRAM: EMPIRICAL STUDIES

Publication Date	Publication Outlet	Dependent Variables	Number of Nations	Data Year	Kuznets Curve	Noteworthy Features
1997	PNAS[1]	CO_2 Emissions	111	1989	>$10K	GDP/PC<$5K for 75% of Nations
2003	International Journal of Sociology & social Policy	1. CO_2 2. CH_4 3. GWP*	1. 137 2. 137 3. 137	1. 1991 2. 1991 3. 1991	n.s. n.s. + Quadratic	
2003	American Sociological Review	Total Ecological Footprint (EF)	142	circa 1996	+ Quadratic	No support for neo–liberal modernization theories
2003	Ecological Economics	1. CO_2 Emissions 2. Energy Footprint	1. 146 2. 138	1. 1996 2. 1999	>$61K[1] + Quadratic	[1]Turning point is well beyond the range of observations
2004	AMBIO	1. ODS** 2. CO2 3. CH4 4. Total EF 5. Forest EF 6. Grazing EF 7. Arable EF 8. Fishing EF 9. Built-up EF	1. 131 2. 146 3. 147 4. 142 5. 142 6. 142 7. 142 8. 142 9. 142	1. 1997 2. 1996 3. 1991 4. 1996 5. 1996 6. 1996 7. 1996 8. 1996 9. 1996	>$13K[1] >$34.8[2] n.s. + Quadratic + Quadratic n.s. n.s. n.s. n.s.	[1]Beyond the range of a vast majority of nations [2]Beyond the range of observations
2004	JIE	EF/GDP/Md***	139	1998-9	N.A.	Sensitivity analyses reveal the need for extraordinary gain in efficiency to counter footprint effects
2005	Globalization & The Environment	1. SO_2 2. NO_x	1. 138 2. 138	1. 1995 2. 1995	>$14.4K[1] >$23.3K[2]	[1]85% of nations are below this [2]99% of nations are below this
2007	Frontiers in Ecology and the Environment[3]	Total Ecological Footprint (EF)	128-135	2001	+Quadratic	

[1]Proceedings of the National Academy of Sciences
[2]Journal of Industrial Ecology
* GWP = Global Warming Potential (A combination CO_2 and CH_4)
** ODS = Ozone Depleting Substances (Chlorofluorocarbons (CFCs), halons, other fully halogenated CFCs, carbon tetracholoride, methyl, chloroform, HCFCs, and methyl bromide)
*** Md = The median of the EF/GDP Ratio

GENERAL FINDINGS:

FOR EVERY IMPACT EXAMINED WE FIND:

- **SUPPORT FOR CONTINUED IMPACT THEORIES (CURVE b)**
- **REJECTION OF NEO-LIBERAL /MODERNIZATION THEORIES OR THE KUZNETS CURVE (CURVE a)**

SPECIFIC FINDINGS:

FOR EVERY IMPACT EXAMINED:

- **POPULATION IS ALWAYS A LEADING DRIVER OF IMPACTS**

  (1) **CONSISTENTLY A PROPORTIONAL RELATIONSHIP (UNIT ELASTICITY)**

- **AFFLUENCE IS ALWAYS ALSO A LEADING DRIVER**

  (1) **FOR CO_2 THE RELATIONSHIP IS ALWAYS ELASTIC (COEFICIENT ≈ 1.5)**

  (2) **FOR OTHER IMPACTS THE RELATIONSHIP IS INELASTIC (COEFICIENTS OF .26 TO .94)**

ELEVEN INDEPENDENT AND CONTROL VARIABLES: (* = SMALL, SIGNIFICANT EFFECTS)

- ***NON-DEPENDENT POPULATION (% OF POPULATION BETWEEN 15 AND 65)**
- **LAND AREA PER CAPITA**
- ***LATTITUDE (CLIMATIC ZONES)**
- **% OF GDP IN NON-SERVICE SECTORS**
- **WHETHER SOCIETY IS CAPITALIST (VS. MIXED CAPITALIST OR CAPITALIST-STATIST)**
- ***% URBAN POPULATION**
- **COUNTRY'S POSITION IN WORLD SYSTEM (CORE, SEMI-PERIPHERY, PERIPHERY)**
- **DIRECT FOREIGN INVESTMENT**
- **POLITICAL RIGHTS (FAIR AND OPEN ELECTIONS)**
- **CIVIL LIBERTIES (FREEDOM OF THE PRESS AND ASSEMBLY)**
- **INCOME INEQUALITY (USE OF GINI INDEX)**

Longitudinal Analysis: Panel Analysis of Pooled Cross-Sections (Ecological Footprint EF)

	Population	Dep.Ratio	GDPpc	GDPpc^2	%Urban	%Urban^2	Exports %GDP	Imports %GDP	Const.	Within R^2	Number Observ.	Number Countr.
Total EF	0.98* (0.19)	-0.31* (0.07)	-0.21* (0.08)	0.03* (0.01)	-0.72* (0.13)	0.12* (0.02)	-0.06* (0.01)	0.07* (0.01)	1.31* (0.44)	.848	2247	65
Energy[1] EF	0.99* (0.03)	-0.48* (0.13)	-0.28 (0.16)	0.05* (0.01)	-1.60* (0.27)	0.23* (0.04)	-0.06* (0.02)	0.09* (0.02)	0.22 (0.83)	.824	2247	65
Material[2] EF	1.00* (0.19)	-0.12* (0.05)	0.18* (0.15)		-0.33* (0.10)	0.08* (0.02)	-0.05* (0.09)	0.05* (0.01)	-0.92* (0.36)	.813	2247	65
Food EF[3]	0.99* (0.18)	-0.12* (0.06)	0.25* (0.07)	-0.01* (0.00)	-0.40* (0.11)	0.10* (0.02)	-0.05* (0.01)	0.05* (0.01)	-0.85* (0.39)	.790	2247	65
Forest EF[4]	1.10* (0.05)	-0.11 (0.16)	-0.58* (0.21)	0.06* (0.01)	-0.18 (0.10)		-0.08* (0.03)	0.09* (0.03)	-1.82 (1.04)	.348	2247	65

[1]Amount to sequester CO_2 + Fuelwood + Nuclear

[2]Total EF minus Energy EF +

[3]Cropland + Pasture Land + Fishing Area

[4]Timber + Fuelwood

Years: 1961 - 2003

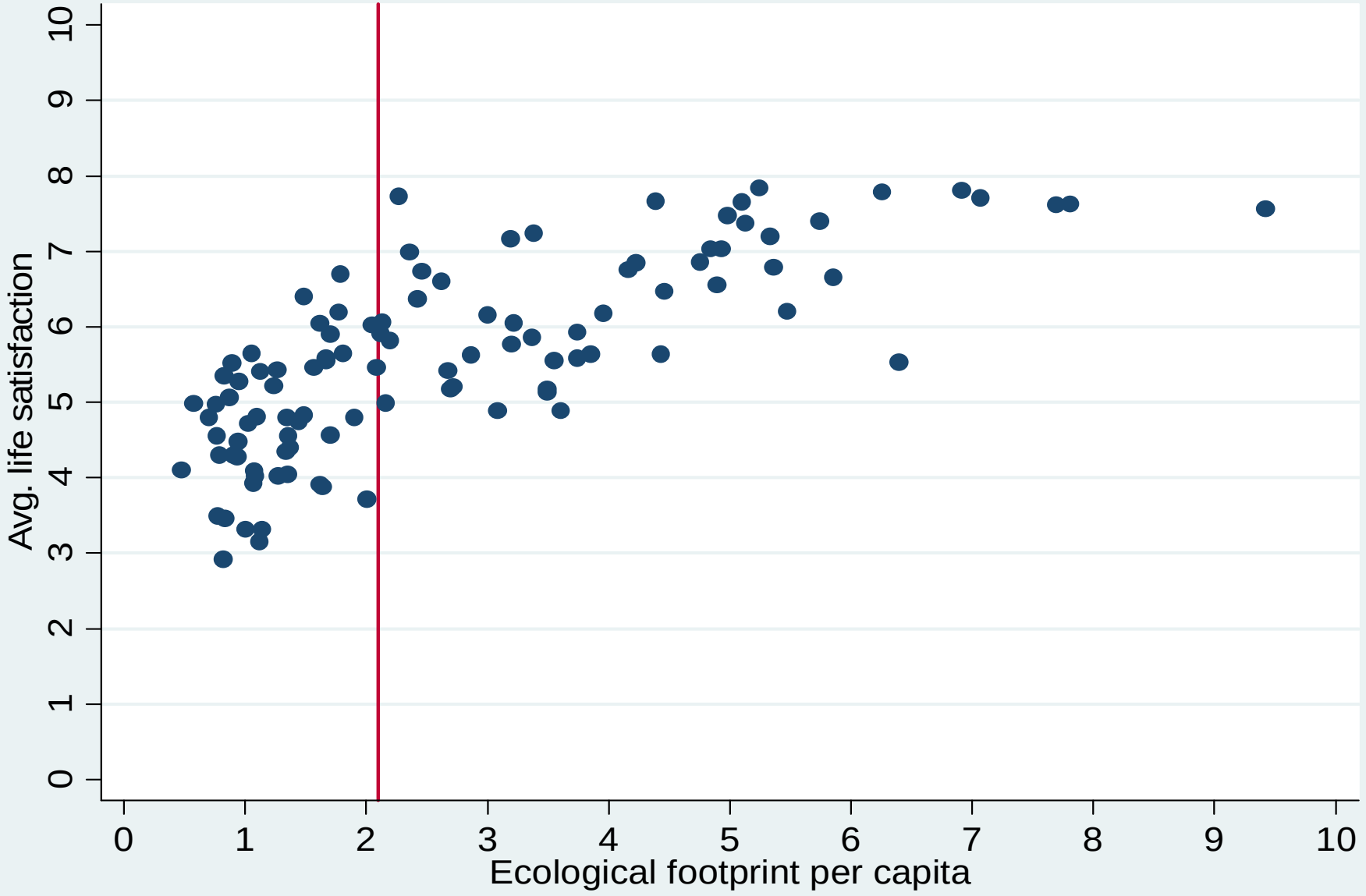
***P ≤.05**

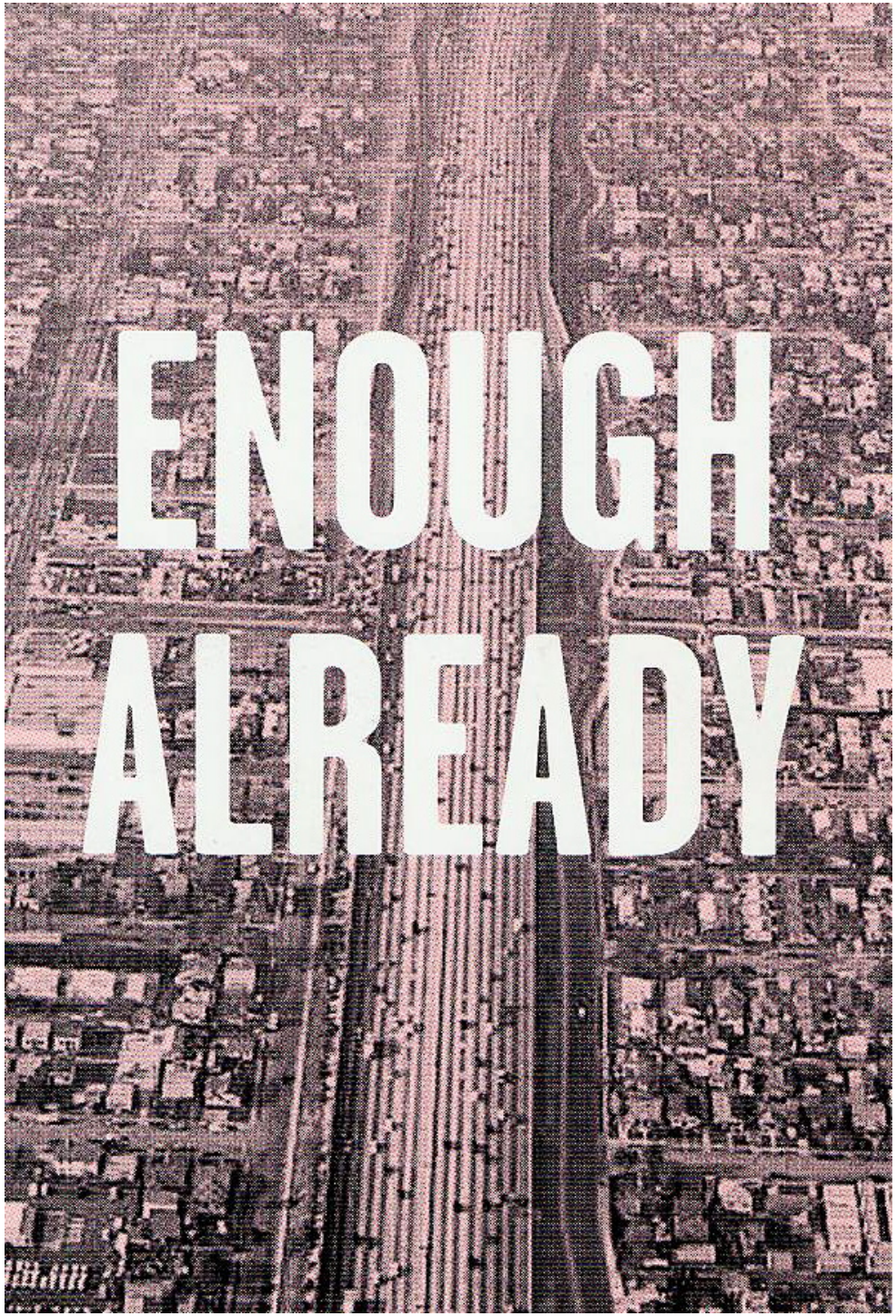
TRANSITION (TIPPING POINT) TO ACCELERATED CONSUMPTION?

Population of the "New Consumer" Countries (2006)	
China	1,328,474,000
India	1,151,751,000
Brazil	189,323,000
Russia	143,221,000
Mexico	105,342,000
Turkey	73,922,000
South Korea	48,050,000
Argentina	39,134,000
Malaysia	26,114,000
Total	3,105,331,000

Source: United Nations Statistics Division

Scatterplot of Average Life Satisfaction Regressed on Ecological Footprint per capita.




ENOUGH
ALREADY

FUTURE RESEARCH: (FROM US) BROAD STROKES

HORIZONTAL DIMENSIONS:

- **RESEARCH PROGRAMS IN PROGRESS—ADDRESS GAPS IDENTIFIED IN EACH OF THE SUBSTANTIVE CHAPTERS**

- **STIRPAT (ANO OTHER RESEARCH) NEED FOR DIRECT IMPACT MEASURES**

VERTICAL DIMENSIONS:

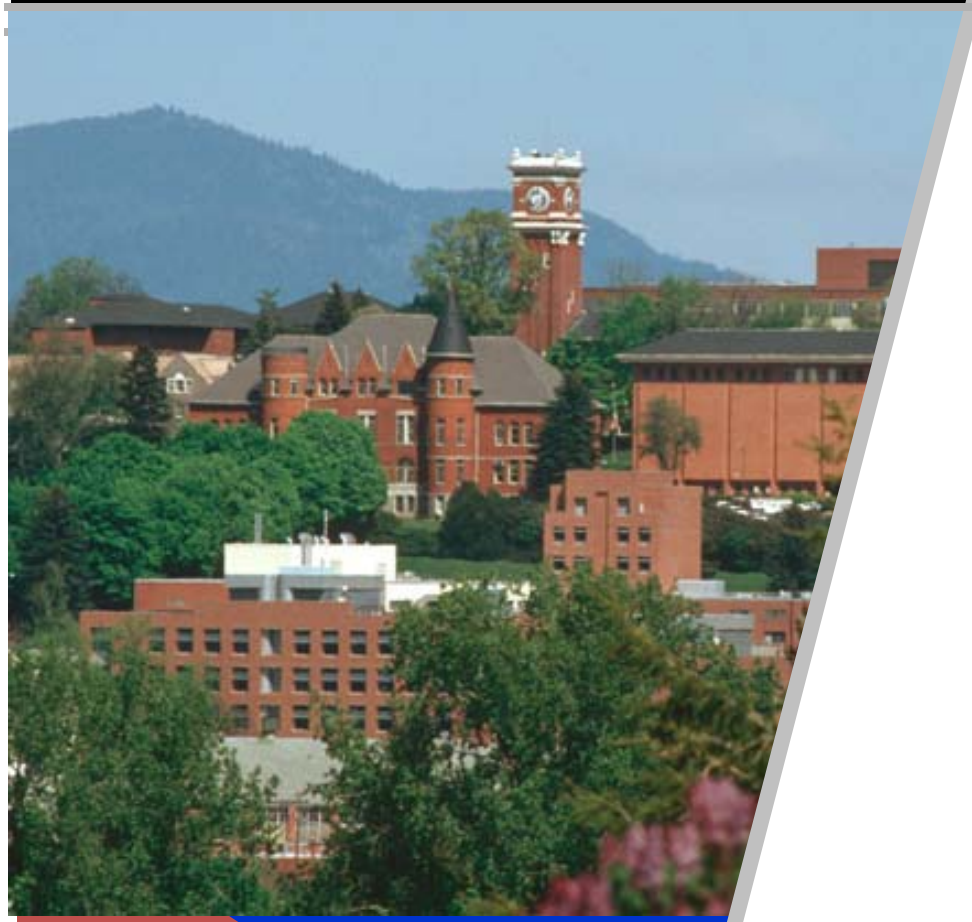
- **BETTER INTEGRATION OF EMPIRICAL SOCIAL SCIENCE FINDINGS (INCLUDING INSTITUIONAL PROCESSES) WITH THE GRAND MODELING EFFORTS (CARBON, HYDROLOGICALAL, CIRCULATION MODELS) IN THE TRADITIONAL SCIENCES**

FUTURE RESEARCH: (FROM YOU)

- **OTHER MAJOR GAPS**

WASHINGTON STATE UNIVERSITY

World Class. Face to Face.



Social Science and Global Environmental Change: Broad and Narrow Looks

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THE LIMITS OF MODELS:

IT IS IMPOSSIBLE TO SIMULTANEOUSLY MAXIMIZE GENERALITY, REALISM, AND PRECISION IN ANY MODEL.

THIS LIMITATION RESULTS IN THREE OPTIONS:

(1) SACRIFICE GENERALITY TO REALISM AND PRECISION

(2) SACRIFICE REALISM TO GENERALITY AND PRECISION

(3) SACRIFICE PRECISION TO REALISM AND GENERALITY

Source: Levins, Richard. 1966. "The Strategy of Model Building in Biology. *American Scientist* 54:421-431.