ECONOMIA-ECOLOGIA:
LA RICERCA DI UN EQUILIBRIO

50’ **LA VISIONE DELL’ECOLOGIA**

Ruolo attivo e non passivo della natura: servizi ecologici
Scala locale-globale. Interconnessioni
Come quantificare gli usi di “natura”?
Limiti ecologici del pianeta e sostenibilità ambientale

80’ **LA VISIONE DELL’ECONOMIA**

Crescita economica e limiti ambientali
Interconnessioni economia-ambiente
Curve di Kuznets
Sostenibilità in economia

30’ **ECOLOGIA ED ECONOMIA**

Tecnologia e ambiente: pomodori, gamberetti, tilapia, … e altro ancora
Le curve di Kuznets ambientali riviste

IRIS

IL RUOLO DEGLI ECOSISTEMI: da supporto passivo a componente attiva

Contenitore passivo delle risorse naturali estratte dall’azione umana

Ricettacolo passivo dei rifiuti e delle emissioni prodotte dall’umanità

Il ruolo degli ecosistemi naturali è tutt’altro che passivo

IRIS

I SERVIZI DEGLI ECOSISTEMI

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Table 1
Functions, goods and services of natural and semi-natural ecosystems

	Functions	Ecosystem processes and components	Goods and services (examples)
	Regulation Functions	*Maintenance of essential ecological processes and life support systems*	
1	Gas regulation	Role of ecosystems in bio-geochemical cycles (e.g. CO_2/O_2 balance, ozone layer, etc.)	1.1 UVb-protection by O_3 (preventing disease). 1.2 Maintenance of (good) air quality. 1.3 Influence on climate (see also function 2.)
2	Climate regulation	Influence of land cover and biol. mediated processes (e.g. DMS-production) on climate	Maintenance of a favorable climate (temp., precipitation, etc) for, for example, human habitation, health, cultivation
3	Disturbance prevention	Influence of ecosystem structure on dampening env. disturbances	3.1 Storm protection (e.g. by coral reefs). 3.2 Flood prevention (e.g. by wetlands and forests)
4	Water regulation	Role of land cover in regulating runoff & river discharge	4.1 Drainage and natural irrigation. 4.2 Medium for transport
5	Water supply	Filtering, retention and storage of fresh water (e.g. in aquifers)	Provision of water for consumptive use (e.g.drinking, irrigation and industrial use)
6	Soil retention	Role of vegetation root matrix and soil biota in soil retention	6.1 Maintenance of arable land. 6.2 Prevention of damage from erosion/siltation
7	Soil formation	Weathering of rock, accumulation of organic matter	7.1 Maintenance of productivity on arable land. 7.2 Maintenance of natural productive soils
8	Nutrient regulation	Role of biota in storage and re-cycling of nutrients (eg. N,P&S)	Maintenance of healthy soils and productive ecosystems
9	Waste treatment	Role of vegetation & biota in removal or breakdown of xenic nutrients and compounds	9.1 Pollution control/detoxification. 9.2 Filtering of dust particles. 9.3 Abatement of noise pollution
10	Pollination	Role of biota in movement of floral gametes	10.1 Pollination of wild plant species. 10.2 Pollination of crops
11	Biological control	Population control through trophic-dynamic relations	11.1 Control of pests and diseases. 11.2 Reduction of herbivory (crop damage)
	Habitat Functions	*Providing habitat (suitable living space) for wild plant and animal species*	Maintenance of biological & genetic diversity (and thus the basis for most other functions)
12	Refugium function	Suitable living space for wild plants and animals	Maintenance of commercially harvested species
13	Nursery function	Suitable reproduction habitat	13.1 Hunting, gathering of fish, game, fruits, etc. 13.2 Small-scale subsistence farming & aquaculture
	Production Functions	*Provision of natural resources*	
14	Food	Conversion of solar energy into edible plants and animals	14.1 Building & Manufacturing (e.g. lumber, skins). 14.2 Fuel and energy (e.g. fuel wood, organic matter). 14.3 Fodder and fertilizer (e.g. krill, leaves, litter).
15	Raw materials	Conversion of solar energy into biomass for human construction and other uses	15.1 Improve crop resistance to pathogens & pests. 15.2 Other applications (e.g. health care)
16	Genetic resources	Genetic material and evolution in wild plants and animals	16.1 Drugs and pharmaceuticals. 16.2 Chemical models & tools. 16.3 Test- and essay organisms
17	Medicinal resources	Variety in (bio)chemical substances in, and other medicinal uses of, natural biota	Resources for fashion, handicraft, jewelry, pets, worship, decoration & souvenirs (e.g. furs, feathers, ivory, orchids, butterflies, aquarium fish, shells, etc.)
18	Ornamental resources	Variety of biota in natural ecosystems with (potential) ornamental use	
	Information Functions	*Providing opportunities for cognitive development*	
19	Aesthetic information	Attractive landscape features	Enjoyment of scenery (scenic roads, housing, etc.)
20	Recreation	Variety in landscapes with (potential) recreational uses	Travel to natural ecosystems for eco-tourism, outdoor sports, etc.
21	Cultural and artistic information	Variety in natural features with cultural and artistic value	Use of nature as motive in books, film, painting, folklore, national symbols, architect., advertising, etc.
22	Spiritual and historic information	Variety in natural features with spiritual and historic value	Use of nature for religious or historic purposes (i.e. heritage value of natural ecosystems and features)
23	Science and education	Variety in nature with scientific and educational value	Use of natural systems for school excursions, etc. Use of nature for scientific research

Adapted from Costanza et al. (1997), De Groot (1992), De Groot et al. (2000).

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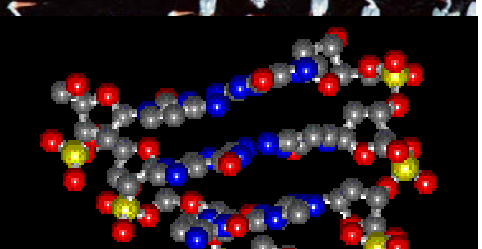
I SERVIZI DEGLI ECOSISTEMI



FUNZIONI DI REGOLAZIONE

- Regolazione composizione atmosfera (O_2/ CO_2), O_3, ecc.
- Regolazione clima (inclusa redistribuzione dell’umidità)
- Regolazione cicli biogeochimici, ciclo dell’acqua
- Formazione e stabilizzazione suolo, controllo erosione
- Regolazione nutrienti e fissazione azoto nei suoli
- Decomposizione e riciclo rifiuti organici
- Controllo biologico di organismi e malattie

FUNZIONI DI PRODUZIONE

- Conversione energia solare in biomassa
- Formazione ed evoluzione di materiale genetico
- Produzione di risorse medicinali

FUNZIONI DI HABITAT

- Creazione di habitat adatti alla vita e riproduzione di piante e animali

FUNZIONI DI CONOSCENZA E INFORMAZIONE

- Creazione di informazioni estetiche, culturali, ricreative, ecc.

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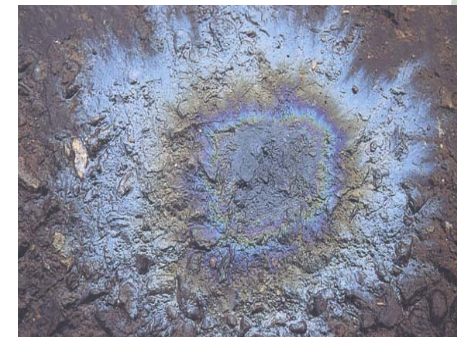
ECOSISTEMI E SCALA SPAZIALE: dal livello locale a quello globale

GLI ECOSISTEMI SONO SISTEMI SPAZIALMENTE LOCALIZZATI

Azioni di origine umana che provocano danni all'ambiente locale: inquinamento del suolo



Incendi localizzati

Piogge acide: distruzione di foreste

Emissione e diffusione di CO_2

Causata anche da emissioni "lontane"

Effetto serra:variazione globale della CO_2 atmosferica, bilanciata solo a livello globale

SOLO AL LIVELLO GLOBALE IL SISTEMA E' REALMENTE CHIUSO:
LA MAGGIOR PARTE DELLE RETROAZIONI SI CHIUDE *SOLO* A TALE SCALA

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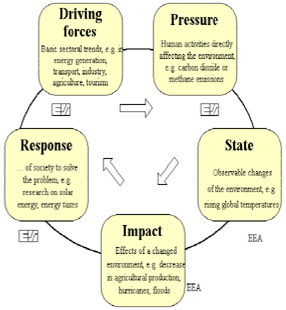
QUANTIFICARE I SERVIZI DEGLI ECOSISTEMI

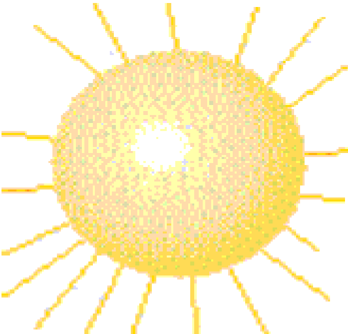


INDICATORI DPSIR
Driving forces-Pressure-State-Impact-Response
OCSE

INDICATORI BASATI SUI FLUSSI DI MATERIA
Material Flow Analysis
Wuppertal Institut, IFF, 2000

VALUTAZIONI MONETARIE
Valore economico
(Costanza et al., 1996)

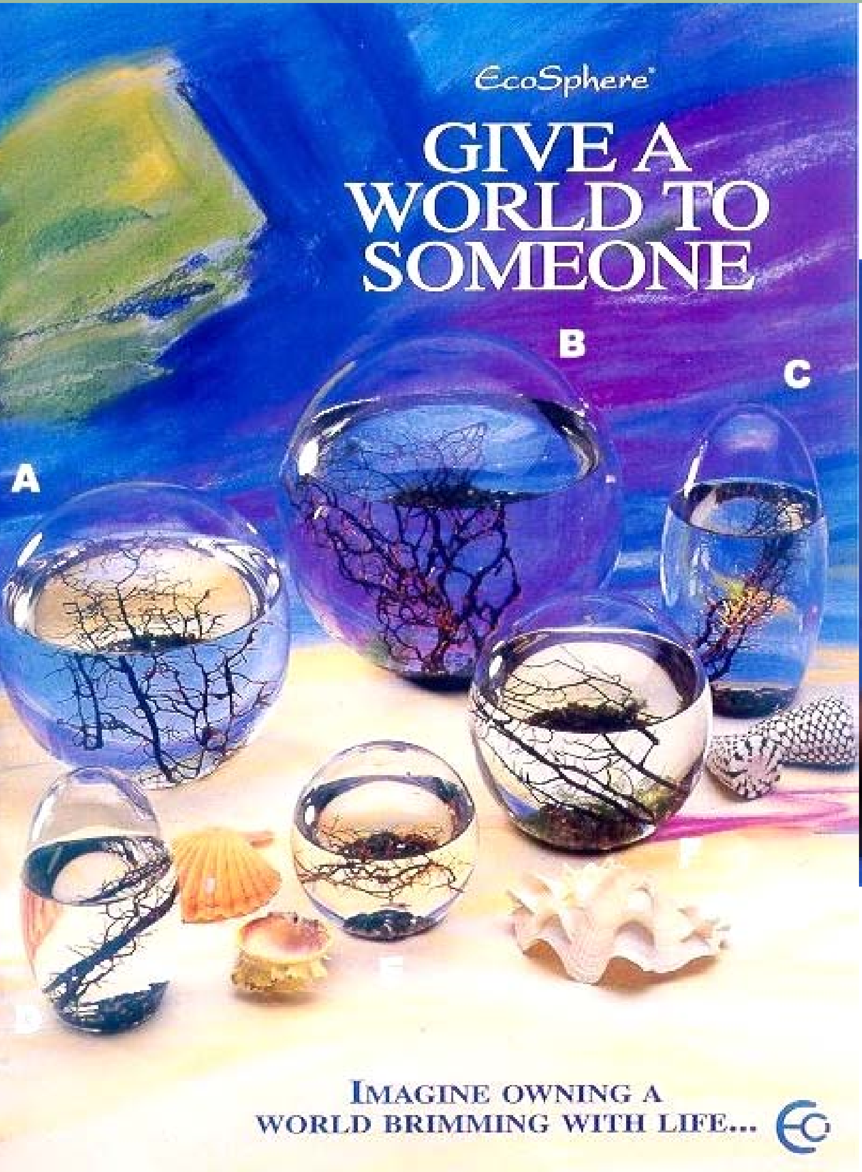
INDICATORI BASATI SULL'ENERGIA
LCA, eMergy (Odum, 1996);
exergy (Jorgensen,1998);
Energy Flow Analysis (IFF)



INDICATORI BASATI SULLA PRODUZIONE
NPP (Vitousek, 1986)
HANPP (IFF Austria)

INDICATORI DI AREA/ VOLUME
Spazio ambientale (Opshoor, 1995)
Superficie produttiva,
Impronta Ecologica
(Rees, Wackernagel, 1996)

IL MONDO IN UNA BOLLA
Per iniziare dal semplice: le ECOSFERE



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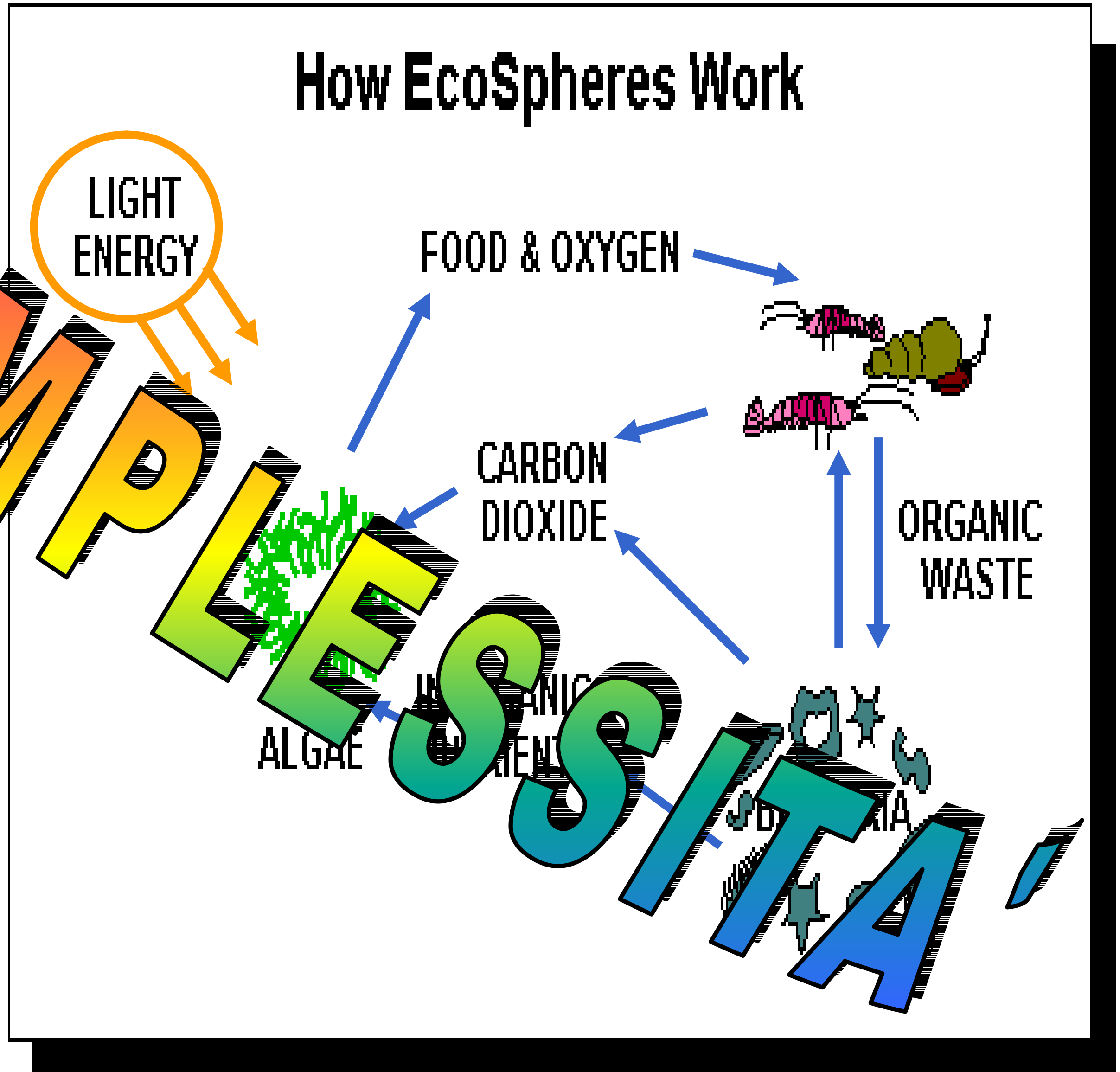
ECOSFERE:
ISTRUZIONI PER L'USO



COMPLESSITA'

IRIS

ECOSFERE: QUANTA “NATURA” CONSUMA UN GAMBERETTO?

ENERGIA

EMERGIA

$$E_m(t) = \int_{-\infty}^{t_0} E_x(\tau)\, d\tau$$

$$E_x(\tau) = \int_{D(\tau)} e_x(x, y, z, \tau)\; p(x, y, z, \tau)\; dx\, dy\, dz$$

VOLUME DELL’ACQUA

SUPERFICIE DELL’ACQUA

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IL MONDO IN UNA STANZA
Verso una maggiore complessità: BIOSFERA 2

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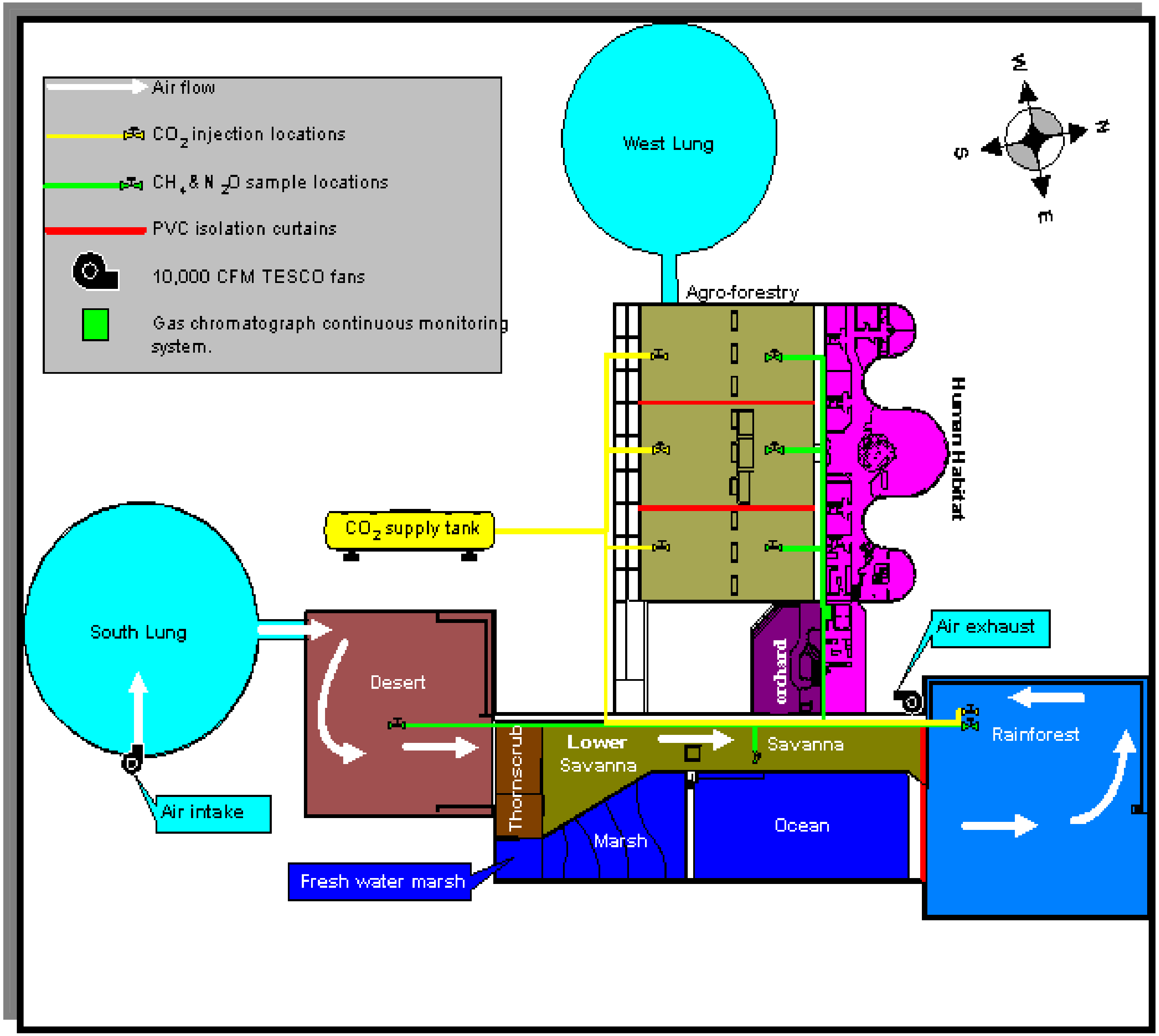
BIOSFERA 2: ISTRUZIONI PER L'USO

Superficie: 1,28 ha

Biomi:

Agricolo, foresta pluviale savana, deserto, palude, oceano



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BIOSFERA 2: QUANTA “NATURA” CONSUMA UN ABITANTE?

SUPERFICIE UTILIZZATA DIRETTAMENTE:

1,28 ha di SUP. ECOSISTEMI TERRESTRI E ACQUATICI

SUPERFICIE UTILIZZATA INDIRETTAMENTE:

ENERGIA: LUCE,
POMPE,
RISCALDAMNTO,
RAFFREDDAMENTO,
MONITORAGGIO,
COMPUTER

MATERIA: OSSIGENO,
CIBI,
SEMENTI

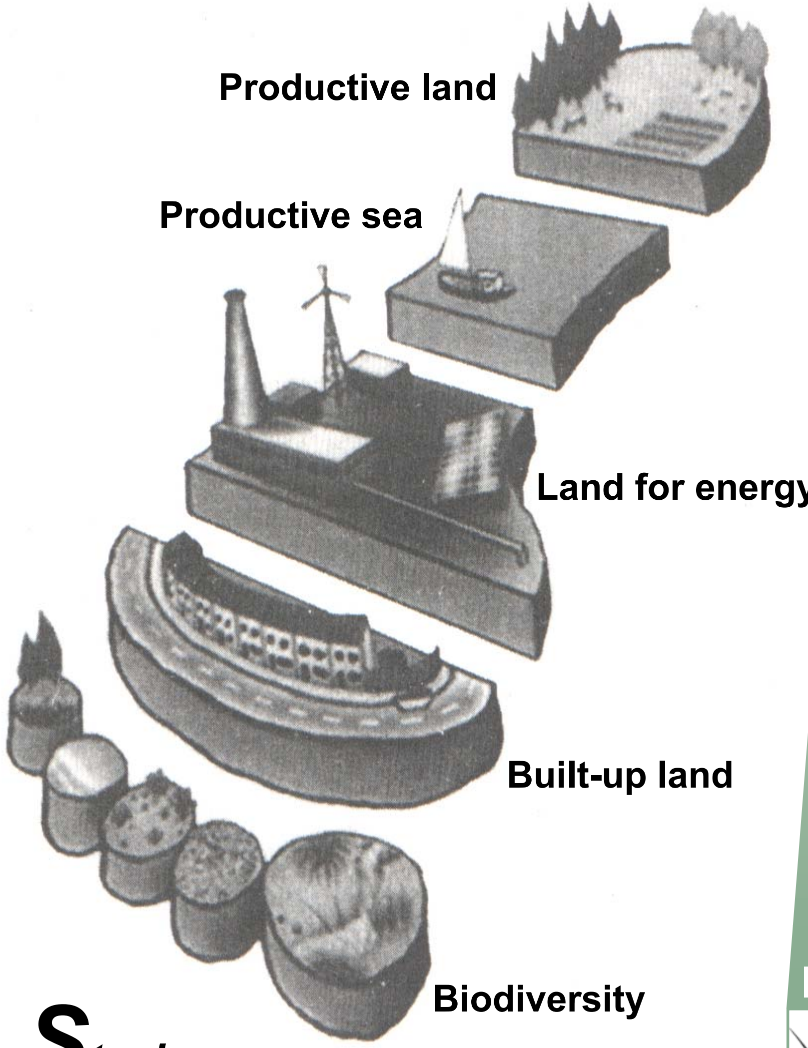
IRIS

IL MONDO IN UN PIANETA
Il trionfo della complessità: BIOSFERA 1

BIOSFERA 1: QUANTA "NATURA" CONSUMA UN ESSERE UMANO?

Stimare la quantità totale di risorse naturali e servizi degli ecosistemi che una popolazione utilizza, calcolando la SUPERFICIE DI ECOSISTEMI TERRESTRI E ACQUATICI necessaria per produrre, DIRETTAMENTE ED INDIRETTAMENTE, in modo sostenibile, tutte le risorse e per riassorbire, sempre in modo sostenibile, tutte le emissioni prodotte da quella popolazione per vivere

ECOLOGICAL FOOTPRINT



$$C_{ons} = P_{rod} + I_{mport} - E_{xport} - S_{tock}$$

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LIMITI PLANETARI E SOSTENIBILITA' AMBIENTALE

QUANTITA' LIMITATA DI ENERGIA SOLARE

QUANTITA' LIMITATA DI SUPERFICIE

QUANTITA' LIMITATA DI RISORSE NON RINNOVABILI

TASSI LIMITATI DI EROGAZIONE DELLE RISORSE RINNOVABILI E DEI SERVIZI DEGLI ECOSISTEMI

SOSTENIBILITA' AMBIENTALE

riguarda quelle azioni che coinvolgono un uso diretto e indiretto di servizi degli ecosistemi con tassi inferiori o uguali a quelli di rigenerazione da parte della natura

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ECONOMIA E AMBIENTE: LA VISIONE DELL’ECONOMIA

L’ECONOMIA IN CRESCITA

- Crescita economica = aumento dell’output, ottenibile con
  - -aumento negli input (lavoro, capitale, energia, altre materie prime)
  - -aumento nella produttività delle risorse grazie al progresso tecnico

- Aumento indefinito della produzione (= reddito) come rimedio alla povertà e sentiero di progresso.

LA VISIONE STANDARD (NEOCLASSICA)

- Dati: Tecnologia, preferenze (modelli di vita), distribuzione del reddito
- Obbiettivo: massimizzazione del benessere (= opportunità di consumo).
- Variabili fisiche (quantità di risorse naturali impiegate) devono adattarsi per soddisfare l’equilibrio.
- Capacità di autoregolamentazione del sistema di mercato (prezzi come indicatori di scarsità)

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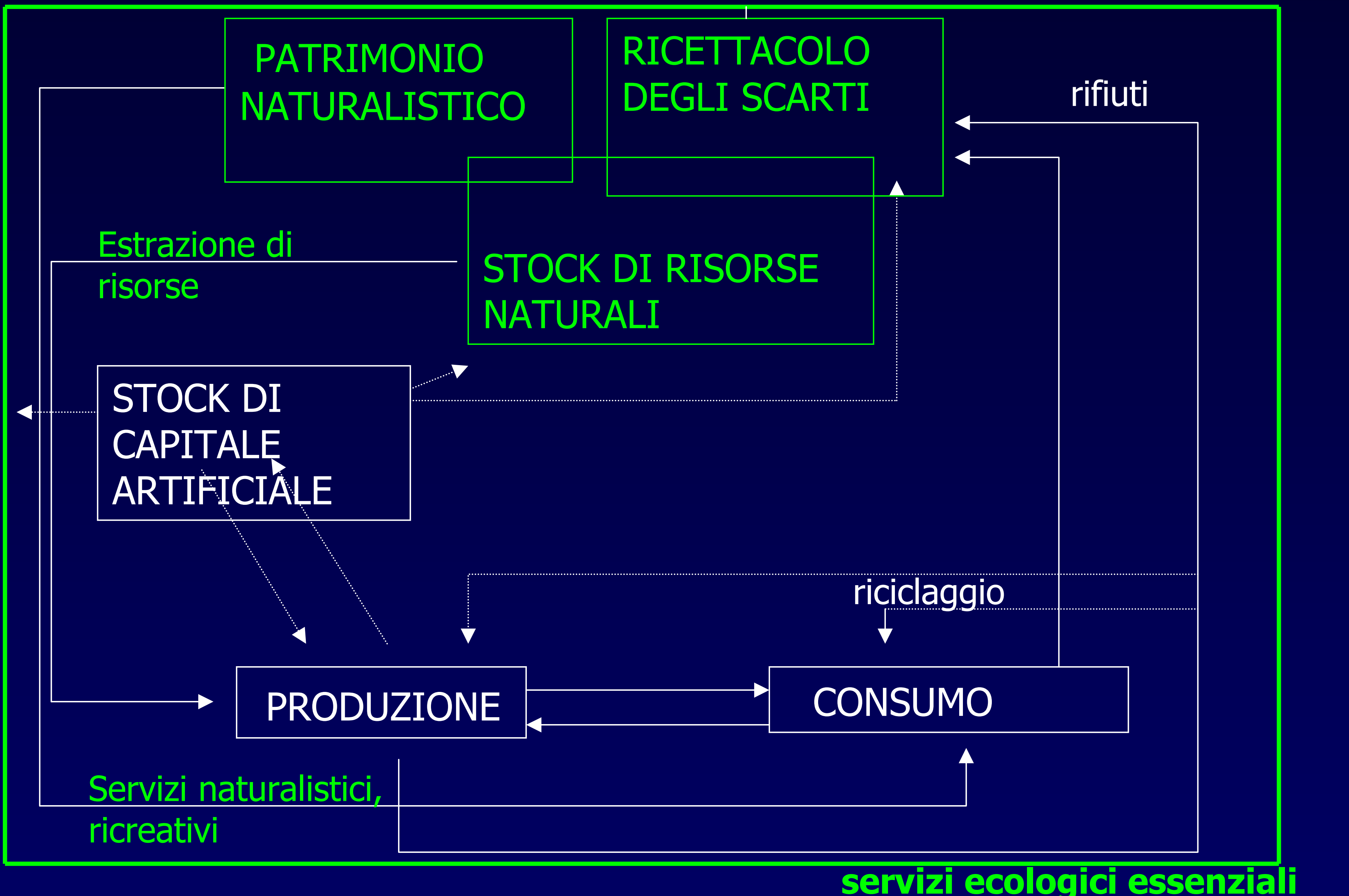
INTERCONNESIONI ECONOMIA-AMBIENTE



SCENARI

The argument regarding natural resource depletion is flawed in every respect. It is at variance with the whole of historical experience, and it takes no account of the way that societies adapt to change in the demands and supplies of materials. There are numerous examples of how the market has dealt with temporary resource shortages, such as the development of synthetic rubber during World War II and the creation of plastic as a replacement for various metals. […] Economic growth is the only way Third World Countries will be able to develop the technology and wealth needed to handle their environmental problems.

Wilfred Beckerman, *Small is stupid (1995), Through Green-Colored Glasses: Environmentalism Reconsidered (1996).*

But we can be fairly certain that no new technology will abolish absolute scarcity because the laws of thermodynamics apply to all possible technologies.

Herman Daly, *Beyond Growth* (1974)

When we look at the various functions of the natural environment it seems clear that some of these functions can be performed only by natural capital stocks, and so these functions are ones for which no substitutability with artificial capital is possible.

Perman et al., *Natural resource and environmental economics*, (1999)

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ALCUNE TIPICHE RISPOSTE DELL'ECONOMIA

- Progresso tecnologico
- Sostituibilità fra K_n e K_a
  - Elasticità di sostituzione (variazione % nel rapporto fra K/R utilizzati in risposta ad una data variazione % nel rapporto fra il prodotto marginale del K e quelo della R)
  - Beni intermedi e risorse estrattive Vs. servizi naturali

- Degrado ambientale dovuto a povertà, diritti di proprietà mal definiti, mancanza di libertà di iniziativa

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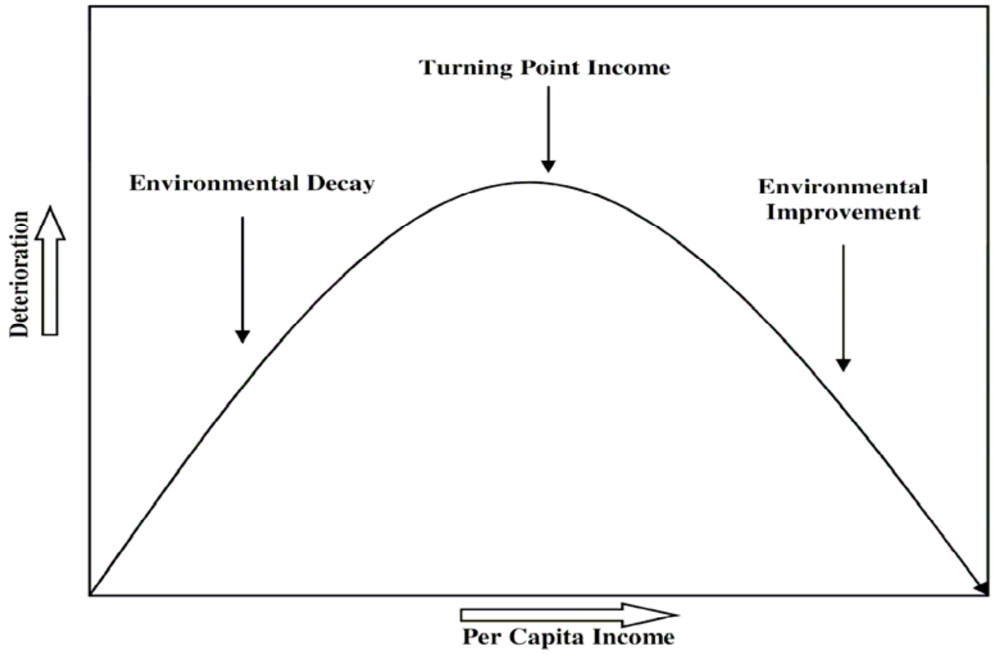
CRESCITA ECONOMICA E AMBIENTE: LE CURVE DI KUZNETS

- Aumentare il reddito per ridurre il danno all'ambiente?

Relazione empirica fra reddito pro-capite e alcuni indicatori di qualità ambientale (acqua potabile, particolato, SO_2, NO_x, CO, ..)
(Grossman & Krueger, 1991; World Bank 1992 *World Development Report;* Shafik & Bandyopadhyay 1992)



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ALTRI PROBLEMI APERTI

- FALLIMENTI DEL MERCATO (esternalità, beni pubblici, beni ad accesso libero)
- INCERTEZZA
- COSTI AMBIENTALI DIFFUSI E DI LUNGO PERIODO
- STOCK DI RISORSE NATURALI E FEEDBACK ECOLOGICI
- EFFETTI SISTEMICI, TRASFERIMENTI INTERNAZIONALI E INTERGENERAZIONALI
- NONLINEARITA' ED EFFETTI-SOGLIA

IRIS

Economic Growth, Carrying Capacity, and the Environment

Kenneth Arrow, Bert Bolin, Robert Costanza, Partha Dasgupta, Carl Folke, C. S. Holling, Bengt-Owe Jansson, Simon Levin, Karl-Göran Mäler, Charles Perrings, David Pimentel

National and international economic policy has usually ignored the environment. In areas where the environment is beginning to impinge on policy, as in the General Agreement on Tariffs and Trade (GATT) and the North American Free Trade Agreement (NAFTA), it remains a tangential concern, and the presumption is often made that economic growth and economic liberalization (including the liberalization of international trade) are, in some sense, good for the environment. This notion has meant that economy-wide policy reforms designed to promote growth and

In this article we discuss the relation between economic growth and environmental quality, and the link between economic activity and the carrying capacity and resilience of the environment (1).

Economic Growth, Institutions, and the Environment

The general proposition that economic growth is good for the environment has been justified by the claim that there exists an empirical relation between per capita income

So far the inverted U-shaped curve has been shown to apply to a selected set of pollutants only (2, 3). However, because it is consistent with the notion that people spend proportionately more on environmental quality as their income rises, economists have conjectured that the curve applies to environmental quality generally (4). But it is important to be clear about the conclusions that can be drawn from these empirical findings. While they do indicate that economic growth may be associated with improvements in some environmental indicators, they imply neither that economic growth is sufficient to induce environmental improvement in general, nor that the environmental effects of growth may be ignored, nor, indeed, that the Earth's resource base is capable of supporting indefinite economic growth. In fact, if this base were to be irreversibly degraded, economic activity itself could be at risk (5).

There are other reasons for caution in interpreting these inverted U-shaped curves. First, the relation

Science, 28 Aprile 1995, **268**:520-521

SOSTENIBILITÀ: SIGNIFICATO E DEFINIZIONI ECONOMICHE

- Utilità non decrescente nel tempo (orizzonte temporale infinito)
- Consumo non decrescente nel tempo (criterio di Hartwick-Solow)
- Risorse naturali gestite in modo tale da mantenere le potenzialità produttive nel futuro (coerente con *Rapporto Brundtland* (1987): soddisfare le necessità del presente senza compromettere le necessità delle future generazioni).
- Stock di capitale (naturale+artificiale) non decrescente nel tempo (‘sostenibilità debole’)
- Stock di capitale naturale non decrescente nel tempo (‘sostenibilità forte’)

IRIS

REGOLA DI HARTWICK-SOLOW

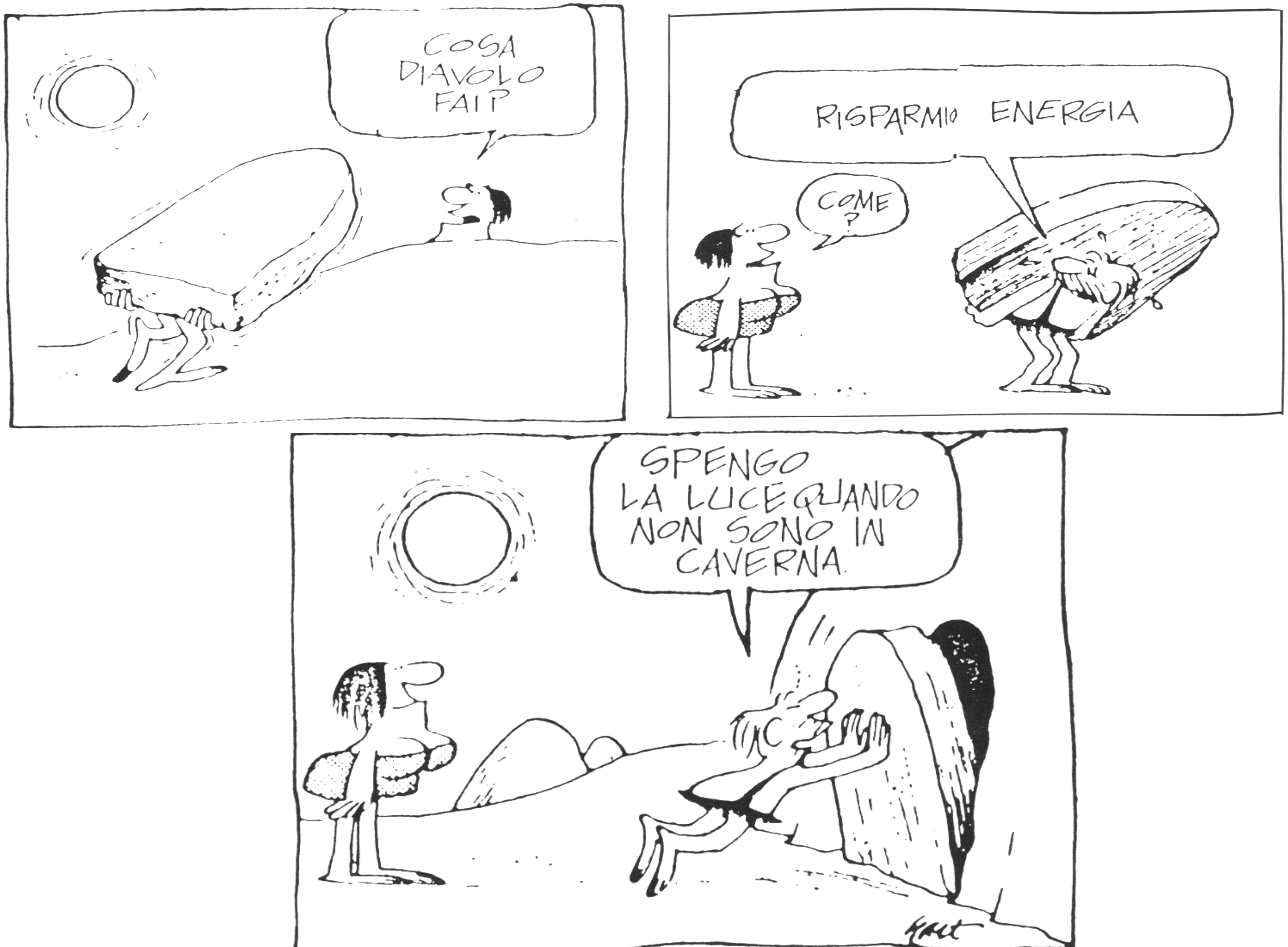
- **Regola pratica per ottenere la sostenibilità di un sistema economico nel senso di 'consumo non decrescente nel tempo':**

  Le rendite (surplus dei ricavi sui costi di produzione) generate dall'estrazione di risorse non-rinnovabili devono essere risparmiate e reinvestite in capitale artificiale (impianti, infrastrutture, capitale umano, etc.).

- **Per garantire sostenibilità, la regola di H-S deve essere accompagnata da altre due condizioni:**
  1. **deve esserci sostituibilità fra capitale artificiale e capitale naturale**
  2. **le risorse non-rinnovabili devono venir estratte secondo un piano efficiente**

- **Se le tre condizioni sono soddisfatte, si garantisce che lo stock aggregato di capitale produttivo sia mantenuto costante, e quindi si rende possibile un consumo non decrescente nel tempo.**

TECNOLOGIA E USO DEI SERVIZI NATURALI
La tecnologia ci salverà?



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IL CASO DEI POMODORI

SERRA

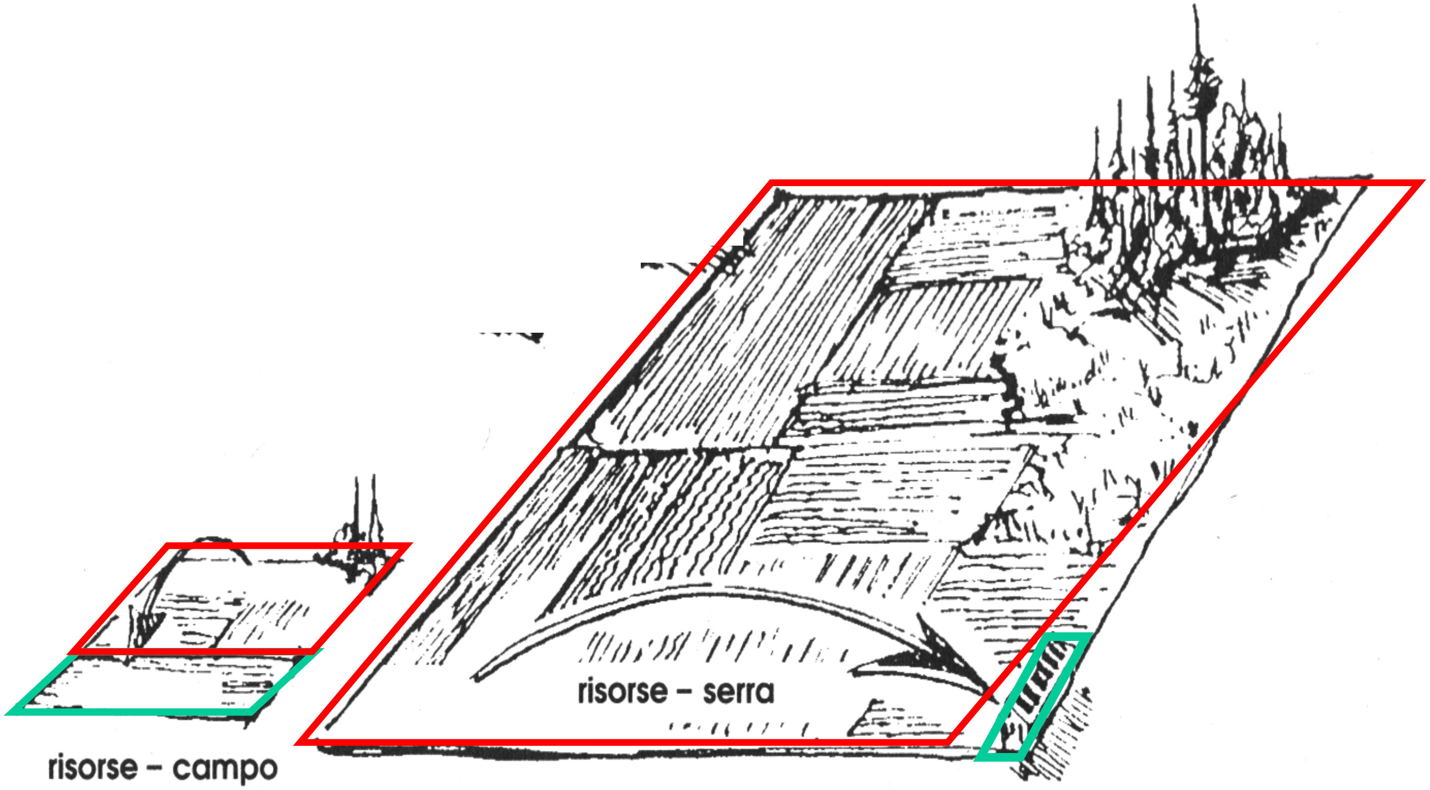
LIVELLO GLOBALE

EF/pomodoro
10-20 volte maggiore

SERRA

LIVELLO LOCALE

Produzione/ha
9 volte maggiore



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ACQUACULTURA E GAMBERETTI

Aquaculture Research, 1997, **28**, 753–766
Ecological footprint of tilapia and shrimp N Kautsky et al.

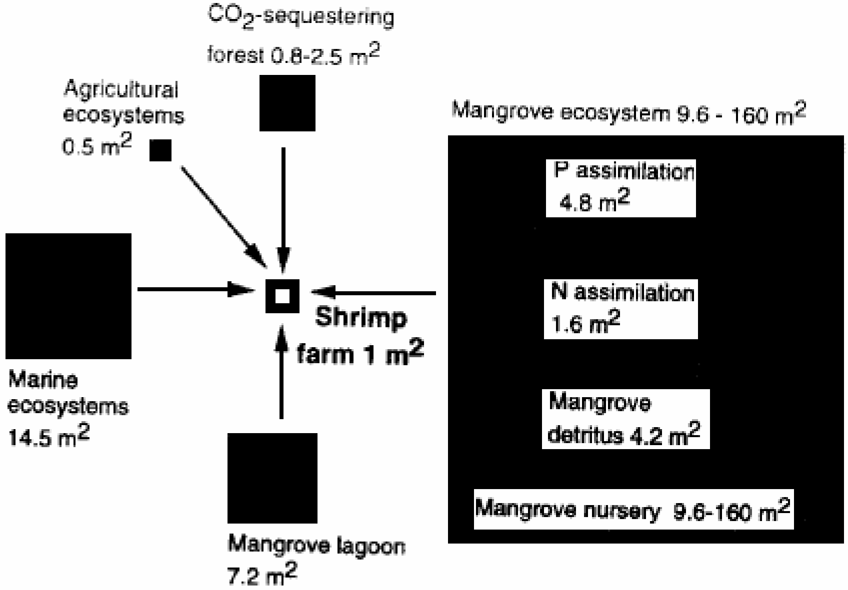

Figure 1 Ecosystem support areas (m^2 per m^2 cultured area) required to sustain a semi-intensive shrimp farm in a coastal mangrove area (partly redrawn from Larsson *et al.* 1994).

Notes to Fig. 1: semi-intensive shrimp farming. Marine upwelling ecosystems: fish yield 6.71 tC km^{-2}, 2.44 t fish used with a carbon content of 40% (Odum & Arding 1991); agricultural ecosystems yield 3.5 t ha^{-1} dry weight, 1.5 t used; postlarval density in mangroves 0.3–1 individual m^{-2} (Pedini 1981), assuming a pre-stocking mortality of 50% and the proportion of postlarvae derived from wild fry (as opposed to hatchery-raised and/or reared from eggs from gravid females) assumed to be between 10% and 50% (H. Cárdenas Mahecha, personal communication); mangrove area needed to yield enough litter (by carbon content) to provide 30% of feed for shrimp (as indicated by the 30–50% drop in productivity when no such litter is flushed into the ponds) estimated on basis of productivity measurements with an average mangrove litterfall of 5 t ha^{-1} and a 10% trophic efficiency in converting mangrove carbon into detrital organic matter available to shrimp (bacteria, fungi etc.) (Larsson *et al.* 1994); lagoon water area calculated as the area of the pumped yearly volume (10% daily, ponds 1.2 m deep, 300 days $year^{-1}$) assuming the source lagoon is on average 5 m deep. Mangrove areas needed to assimilate nutrients released from pond are based on ratio food input/nutrient output given pellet-fed shrimp ponds (Robertsson & Phillips 1995), but using 5.8 t FW ha^{-1} feed input. CO_2 sequestering area is calculated according to Rees & Wackernagel (1994) and Larsson *et al.* (1994).

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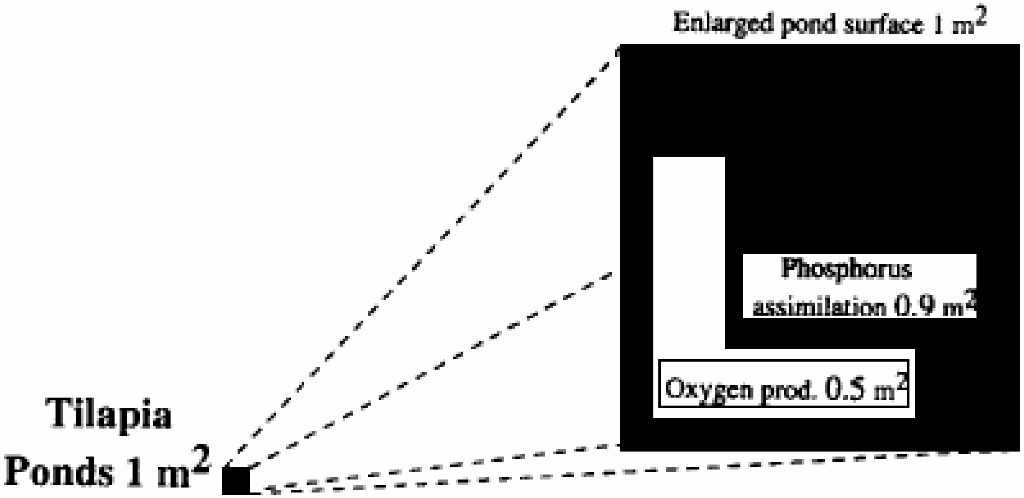
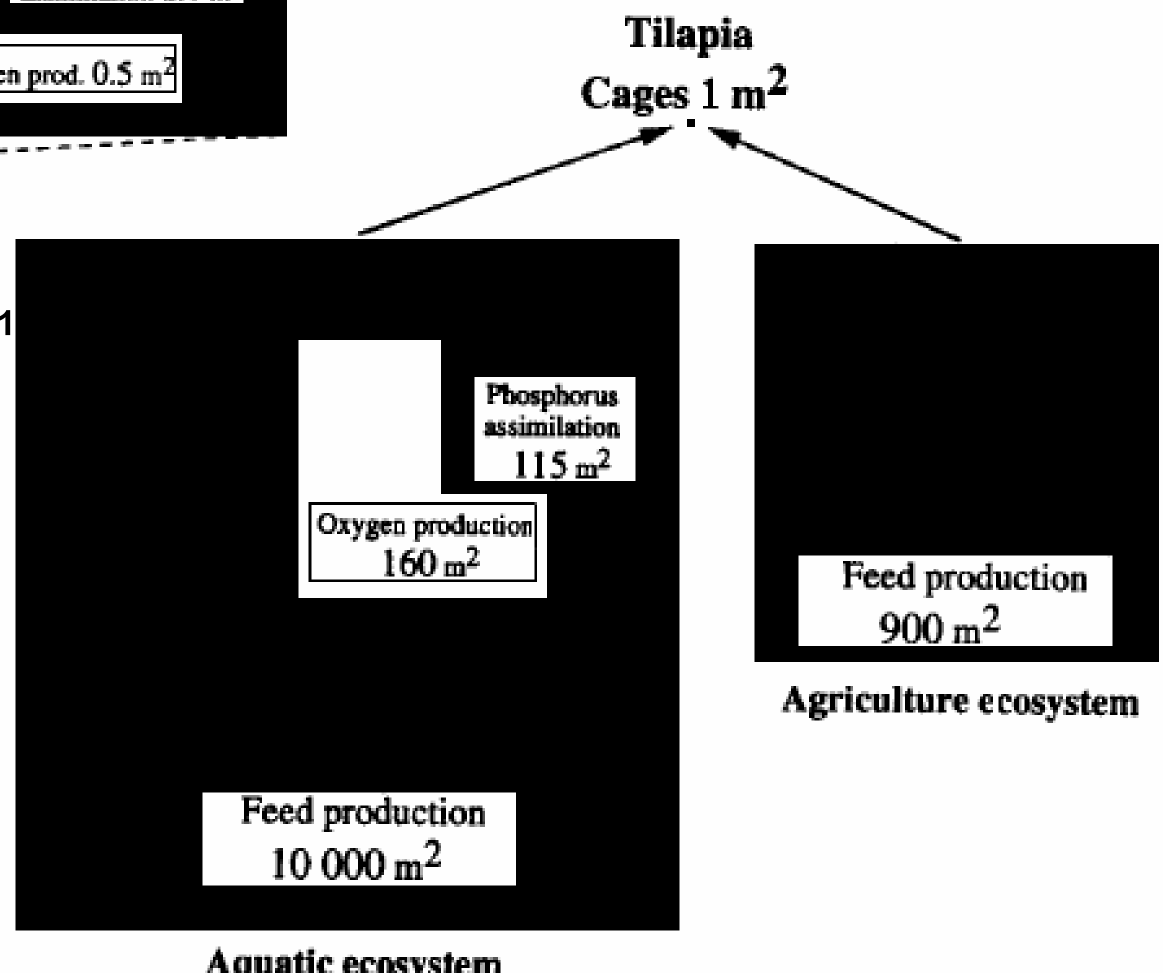
UN CASO AFRICANO: LA TILAPIA



PRODUZIONE: **1,3** g m^{-2} day^{-1}
EF: **1** m^2
RESA: **1,3** g m^{-2}

PRODUZIONE: **380** g m^{-2} day^{-1}
EF: **10.900** m^2
RESA: **0,035** g m^{-2}



Berg et al., Ecol.Econ, 1996

ACQUACULTURA E EF

The ecological footprint

a tool for assessing resource use and development limitations in aquaculture

Nils Kautsky, Carl Folke, Patrik Rönnbäck, Max Troell*

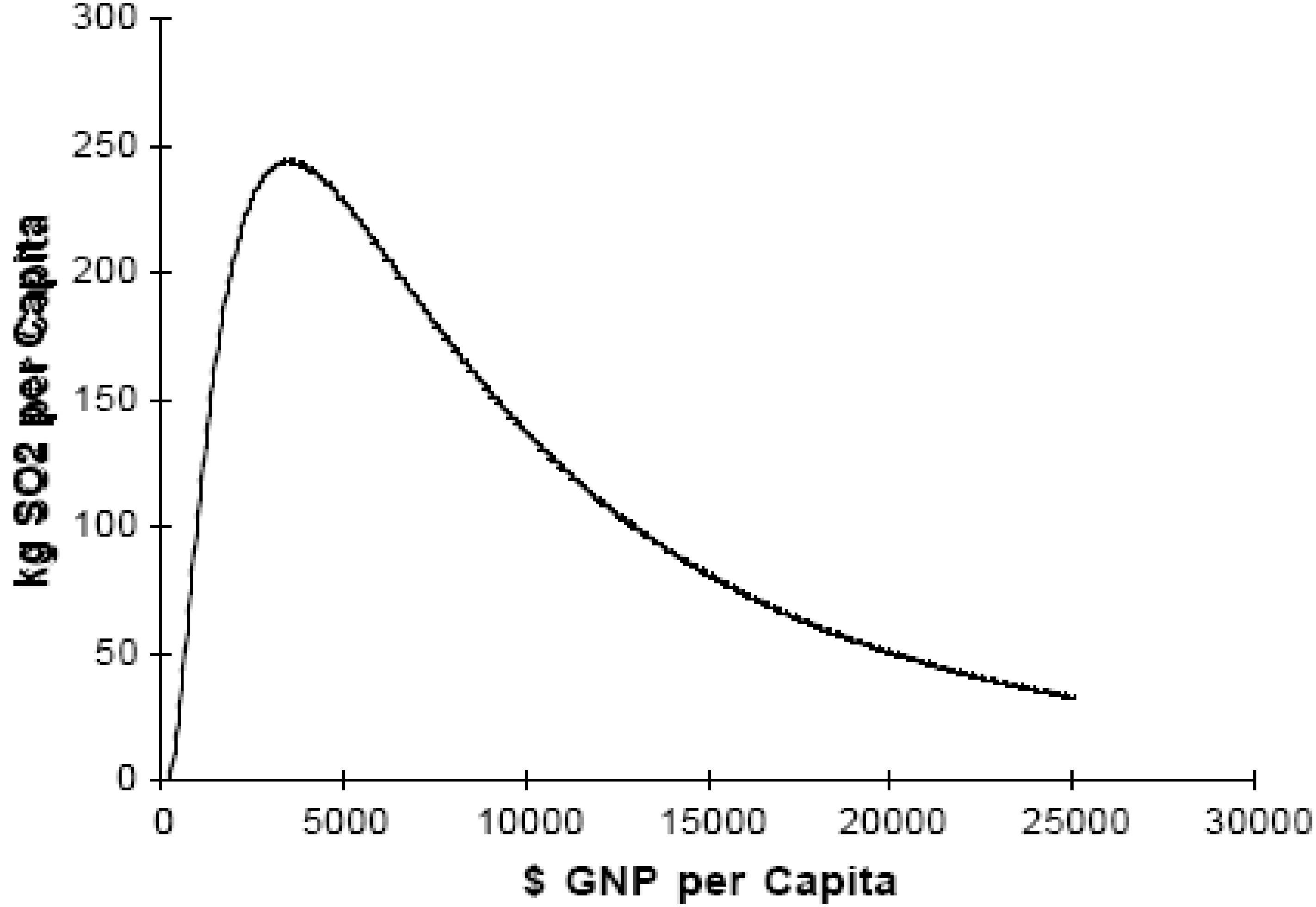
Table 1. The ecological footprint of seafood production. Values are area of footprint per area of activity $[m^2/m^2]$ in coastal and marine support areas (from Folke et al., 1998).

Activity	Resource production	Waste assimilation
Salmon cage farming, Sweden	40,000-50,000	-
Tilapia cage farming, Zimbabwe	10,000	115-275
Salmon tank system, Chile	-	16-180
Shrimp farming (semi-intensive) Colombia	34-187*	-
Shrimp farming (semi-intensive) Asia	-	2-22
Mussel rearing, Sweden	20	-
Tilapia pond farming, Zimbabwe	0	0

* calculated from level of fisheries. If recalculations are made to the primary production base as for other activities the support area will increase to about 10,000.

ENVIRONMENTAL KUZNETS CURVE

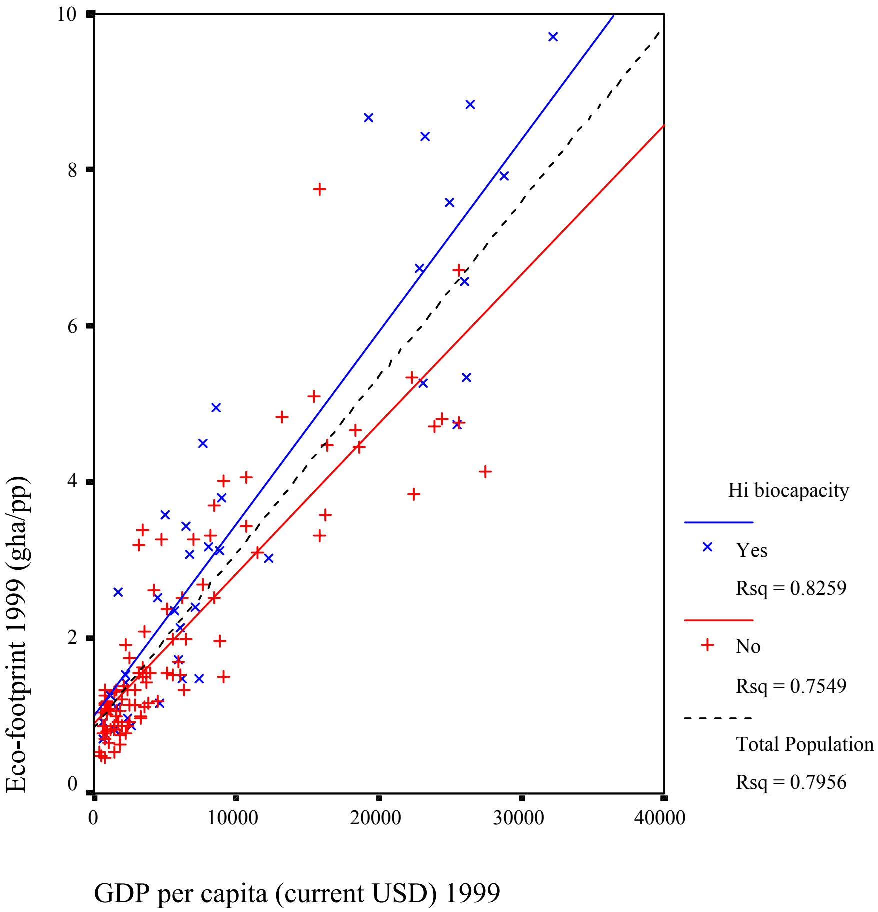
Figure 1: Environmental Kuznets Curve for Sulfur Emissions

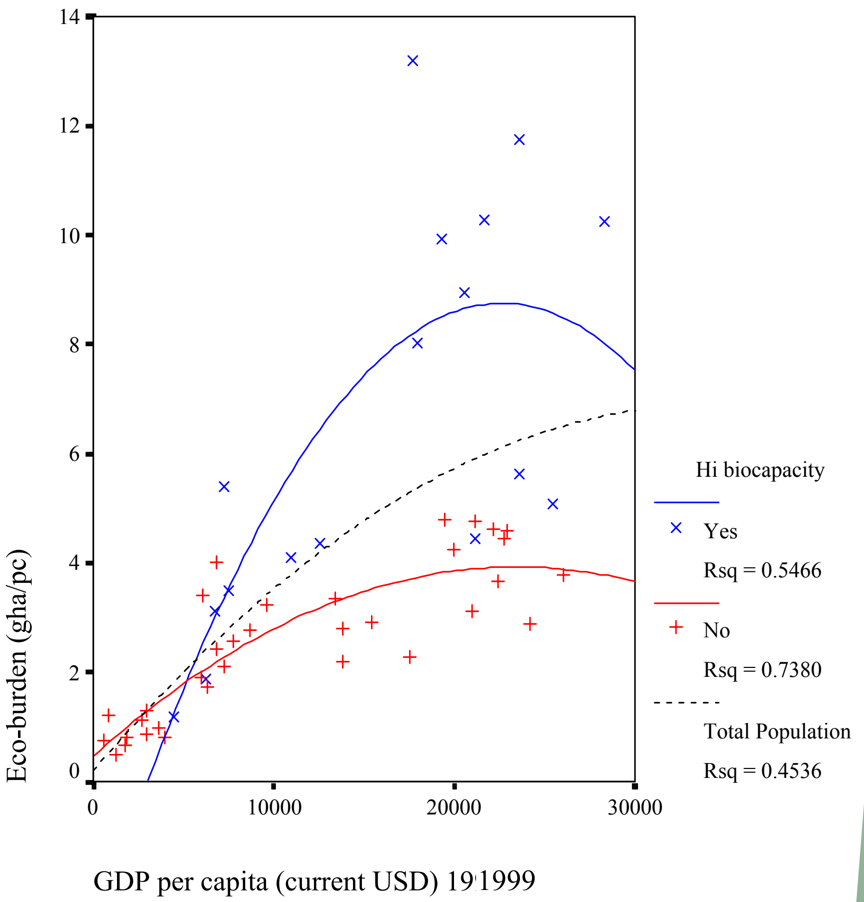


Source: Panayotou (1993), Stern *et al.* (1996).

IRIS

ECOLOGICAL FOOTPRINT E EKC?





IRIS

EKC PER DMI E CO2?

Â. Canas et al. / Ecological Economics 46 (2003) 217–229

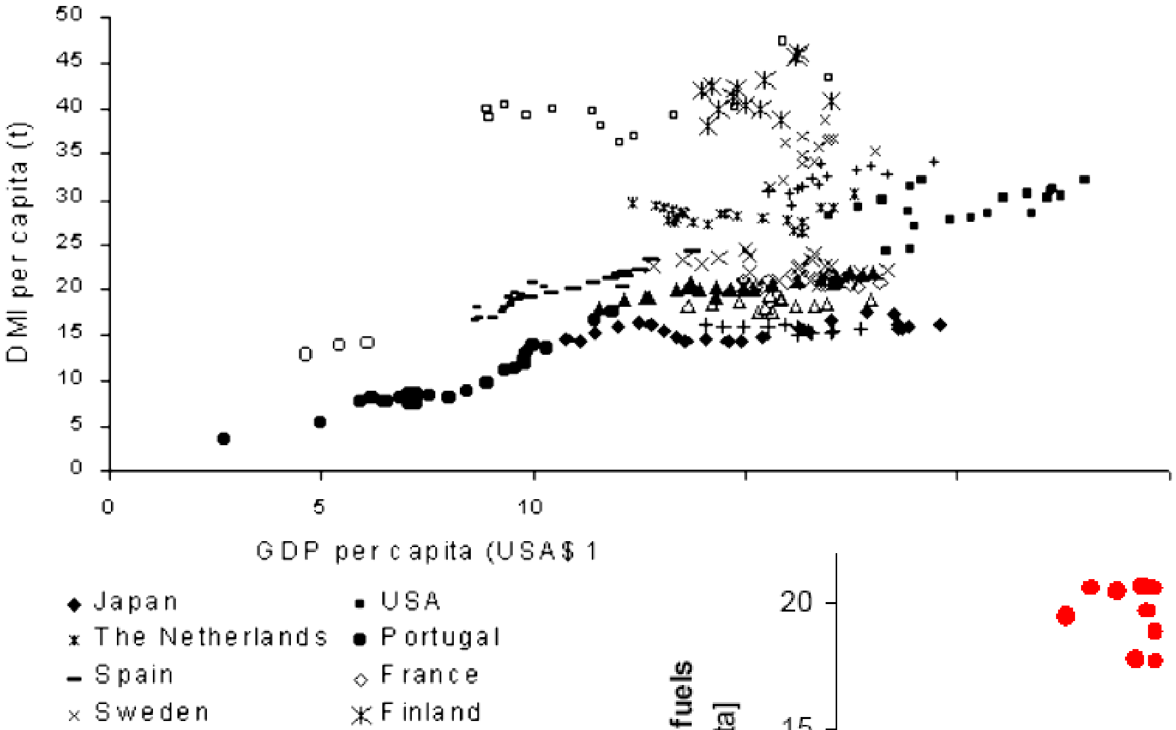
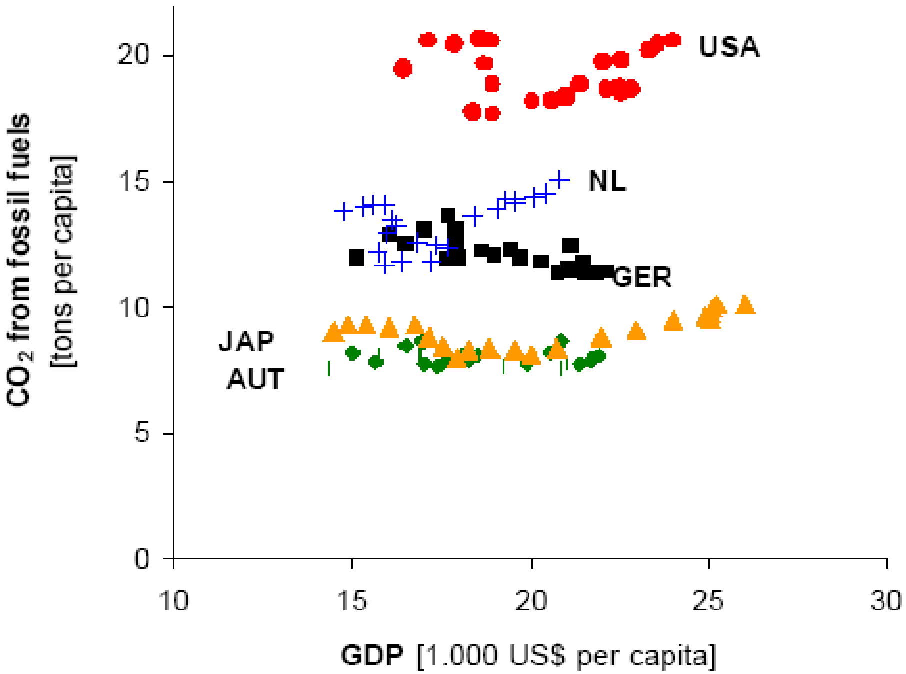


Fig. 1. Observations of DMI per capita in function of (



Quelle: Fischer-Kowalski, M. und C. Amann, 2001. Beyond IPAT and Kuznets Curves. *Population and Environment* 23, 7-47.